Long-term coded wire tag retention in juvenile *Sciaenops ocellatus*

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Red drum *Sciaenops ocellatus*, a popular sport fish in the Gulf of Mexico and associated estuarine systems, have been subjected to increasing fishing pressure in recent years which has led to declining population size in Texas (Matlock 1982) and poor annual survival in Texas bays (Green et al. 1985). Commercial harvest of both inshore stocks of red drum in Texas prior to 1981 (Matlock 1982) and offshore stocks in the Gulf of Mexico prior to 1987 (Goodyear 1987) contributed to the apparent population decline in red drum. Documented commercial landings in the Gulf of Mexico were less than 50% of estimated recreational harvest prior to 1984. However, documented commercial landings increased to more than double the estimated recreational harvest from 1984 to 1986, primarily due to expansion of an oceanic purse seine fishery which began in 1978 (Goodyear 1987).

In Texas, reported commercial landings of red drum were more than double estimated recreational landings for 1976–77, then declined to slightly more than recreational landings for 1978–80. Estimated recreational landings were relatively stable, with a general downward trend, during 1976–80 (Matlock 1982). The sale of red drum harvested from Texas public waters was prohibited by legislative action as of 1 September 1981 (Maddux et al. 1989), while the purse seine fishery for offshore stocks of adult red drum was closed by the Gulf of Mexico Fisheries Management Council in 1986. Increasing sportfishing pressure and catastrophic freezes, which caused extensive fish kills in bays along the northern Gulf of Mexico (Maddux et al. 1989), have also contributed to imposition of increasingly restrictive sport bag and size limits for red drum in Texas.

Development of controlled spawning and pond culture techniques for red drum has allowed large-scale production and stocking of red drum fingerlings to enhance declining populations (Colura et al. 1976, Arnold et al. 1977, McCarty et al. 1986). Over 68 million red drum fingerlings have been stocked for population enhancement in Texas coastal waters since 1975, with the majority of fingerlings stocked since 1983 (Dailey 1990). Development of a reliable method for identifying stocked fish would allow evaluation of this stocking program. The fish, which are typically <50 mm total length (TL) when stocked (Dailey 1990), are frequently released in spring and summer when no small red drum (≤100 mm TL) occur naturally in bays (McEachron and Green 1986), as red drum spawn in the fall (Comyns et al. 1991). Survival of fish stocked in spring and summer can be monitored by analysis of length-frequencies for about 9 months, at which time variation in growth masks the initial length differences. Fish stocked in fall cannot be monitored by length-frequency methods due to onset of the spawning season and resultant confusion of stocked and wild fish of similar size (Dailey and McEachron 1986, Matlock et al. 1986).

For stocking to be considered successful, hatchery fish must survive long enough to be recruited to the fishery and then to offshore schools of mature red drum. When evaluation of stocking success is based on recapture of tagged fish which must grow large enough to enter the fishery, determination of long-term tag retention and detection rates is necessary for accurate evaluation of fingerling stocking success. Appreciable tag loss or nondetection would result in underestimation of the proportion of hatchery fish in the population (Heimbach et al. 1990).

Tagging of hatchery fish has had little success (Matlock et al. 1984 and 1986, Gibbard and Colura 1980, Bumguardner et al. 1990). Only 10 of 5942 hatchery-reared red drum ($\bar{x}$ 452 mm TL) tagged with monel jaw tags on the opercula were recaptured within 8 months of release (Matlock et al. 1984). Three fish from over 38,000 fingerlings (40–120 mm TL) tagged in the snout with coded wire microtags and released in St. Charles Bay, Texas, were recaptured (Matlock et al. 1986). The low recapture rate of microtagged fish was probably due to tag loss. Gibbard and Colura (1980) reported 27% retention of coded wire tags placed in the nose of red drum fingerlings (50 mm mean TL) after 1 year. Bumguardner et al. (1990) conducted a short-term study (114 days) of red drum fingerlings ($\bar{x}$ 52 mm TL) tagged in the adductor mandibularis (cheek

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muscle) with coded wire microtags. Loss of coded wire tags was initially high (32.7% after 24 hours), but the rate of tag loss declined substantially 23 days post-tagging.

Tag retention by the same group of fish initially tagged by Bumguardner et al. (1990) was monitored 115–464 days post-tagging to determine if additional tag loss occurred. Tag detection rates using two methods of tag detection—a Northwest Marine Technology Field Sampling Device, and examination of X-ray negatives—were also determined and contrasted with tag detection rates reported for the two methods by Bumguardner et al. (1990). Our primary objective was to determine if tag retention rates declined between 114 and 464 days post-tagging, and to what extent tag loss and nondetection affected estimates of tag retention rates. While Bumguardner et al. (1990) considered mortality a component of tag loss and reported differential mortality between tagged and untagged fish, we limited the scope of this project to investigation of tag loss and nondetection rates. We did not consider mortality a component of tag loss because the facilities to maintain a group of control fish were not available.

Table 1

Coded wire microtag retention for red drum *Sciaenops ocellatus* through 464 days post-tagging, determined with the NMT Field Sampling Device.

Activity	No. fish	Interval (days)	No. fish examined	No. fish retaining tags	Tag retention (%)	Cumulative tag retention (%)
Tagged	2124	0–1	220[a]	148	67.3	67.3
Stocked in 0.1-ha ponds	1500	2–23	844[b]	397	69.8[c] ±31.2	47.0[c] ±20.2
Restocked in 0.2-ha ponds	599	24–114	238[b]	108	96.6[c] ±25.8	45.4[c] ±12.1
Held in tank[d]	52	115–285	33[b]	31	93.9	42.6 (93.9)[e]
Stocked in 0.4-ha pond	32	286–464	31[b]	26	89.3	38.0 (83.9)[f]

[a] Fish selected randomly from the total number of fish tagged.
[b] Number of fish surviving at the end of the interval.
[c] Reported as weighted average for three ponds with standard error.
[d] First 52 fish encountered while monitoring tag retention were overwintered in indoor tanks.
[e] Cumulative percent tag retention for days 115–285 used to calculate percent tag retention for 286–464 day interval.
[f] Cumulative percent tag retention for days 115–464 used to calculate percent tag retention for 286–464 day interval.

Materials and methods

Coded-wire microtag retention for red drum was monitored from tagging to 464 days post-tagging. About 2100 red drum fingerlings ($\bar{x}$ 52 mm TL) were tagged with coded wire microtags on 13 July 1987. Tags (1.07 × 0.25 mm) were inserted horizontally in the cheek muscle using a Northwest Marine Technology (NMT) Model MK2A tagging unit (Northwest Mar. Technol., Shaw I., WA) equipped with a plastic side mold to orient fish for consistent tag placement. An NMT Quality Control Device was used to magnetize tags and separate tagged from untagged fish.

Tagged fish were held in a 3.0 × 0.6 × 0.6 m tank for 24 hours, stocked in three 0.1-ha ponds at 500 fish/pond for 23 days, then transferred to three 0.2-ha ponds for 91 days (Table 1). Surviving fish harvested from each 0.1-ha pond were restocked as a group in separate 0.2-ha ponds. Fish were fed a commercially-prepared trout feed daily while in ponds. Tag retention was determined at 24 hours (prestocking), 23 days (harvest from 0.1-ha ponds), and 114 days (harvest from 0.2-ha ponds) post-tagging with an NMT Field Sampling Device (FSD) (Bumguardner et al. 1990). Fish were harvested from 0.2-ha ponds 114 days post-tagging, and 52 fish ($\bar{x}$ 220 mm TL) confirmed by the FSD as retaining tags were placed in a 4200 L circular fiberglass tank on 11 October 1987 for overwintering. As available tank space was limited, overwintering was restricted to 52 fish confirmed as retaining tags. Experience has shown indoor overwintering is required to insure survival of red drum in hatcheries during episodic freezing conditions on the Texas coast. Fish were fed 300 g chopped fish and shrimp daily. Fish were treated with a 0.25 mg/L Cu^{++} bath on four occasions for a protozoan parasite infestation tentatively identified as *Amyloodinium* sp. Fish were immersed in a 20 mg/L oxytetracycline HCl bath, and about 10 mL of injectable oxytetracycline solution (50 mg oxytetracycline HCl/mL solution) was placed in chopped shrimp and fish offered as feed to combat a bacterial infection. Surviving fish (n 33) were removed from the tank on 22 April 1988 (285 days after tagging), measured and checked for tag presence with the FSD.

The 33 surviving fish ($\bar{x}$ 352 mm TL) were placed in a 0.4-ha pond, with the exception of one fish that had lost the caudal fin, presumably as the result of a bacterial infection. These fish were fed a a 35% protein

floating fish ration (Texas Farm Products, Nacogdoches, TX), 0.45kg/day, 5 days/week, as a supplement to natural forage available in the pond. Fish were harvested on 11 October 1988, 464 days post-tagging. Microtag retention was determined with the FSD, fish were measured ($\bar{x}$ 473mmTL), and 10 of 31 surviving fish were selected at random and preserved in 50% formalin for X-ray analysis of tag retention. X-ray negatives of the preserved fish were visually inspected to confirm the presence or absence of tags as determined by the FSD.

Tag retention was determined for each interval, and overall or cumulative tag retention was determined at the end of each interval. As mortality was not considered tag loss in this study, cumulative tag retention reflects only the percentage of tag losses from shedding and nondetection of tags. A problem encountered in the course of this program was the calculation of tag retention rates when fish which had shed tags were not removed from the group at the end of the interval (2–23 days, 24–114 days, and 286–464 days). The percent decrease in cumulative tag retention was selected as an estimate of the percentage of fish losing tags in these intervals. Conversely, when fish that had lost tags were removed from the group, determination of tag retention for that interval (days 115–285) was simple (no. fish with tags/total no. fish examined), but cumulative tag retention had to be calculated. Tag retention for the interval in question was multiplied by cumulative tag retention from the previous interval to determine cumulative tag retention for the interval. The relationship used in these calculations was

$$TR_i = \frac{CTR_i}{CTR_{i-1}} \times 100,$$

where TR_i is percent tag retention for interval i, CTR_i is percent cumulative tag retention for interval i, and CTR_{i-1} is percent cumulative tag retention for the interval prior to interval i. Percent tag retention and percent cumulative tag retention for 1–23 and 24–114 day intervals for fish from individual ponds were used to calculate weighted means reported in Table 1. The weighting factor used was the number of fish harvested from each pond.

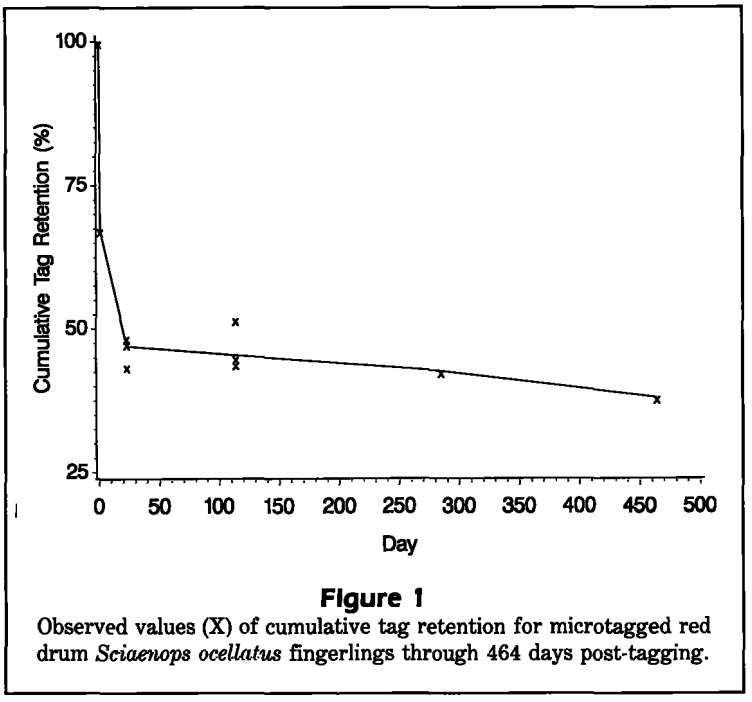

Figure 1
Observed values (X) of cumulative tag retention for microtagged red drum *Sciaenops ocellatus* fingerlings through 464 days post-tagging.

Results and discussion

Tag retention for surviving fish at 115–464 days post-tagging was 83.9%. Tag retention was 93.9% at 115–285 days post-tagging, and 89.3% at 286–464 days post-tagging (Table 1). Cumulative retention of coded wire microtags for red drum was 38.0% at 464 days post-tagging (Table 1, Fig. 1). Lack of replication at all intervals prevented statistical comparison of tag retention for different intervals. However, tag retention values of 96.6% for 24–114 days, 93.9% for 115–285 days, and 89.3% for 286–464 days post-tagging indicate cumulative tag retention decreased in the interval 24–464 days post-tagging, although at a slower rate than for the period 0–23 days (Table 1). Numerous authors (Gibbard and Colura 1980, Klar and Parker 1986, Fletcher et al. 1987, Williamson 1987, Bumguardner et al. 1990, and Dunning et al. 1990) have reported that the majority of coded-wire tag losses occur within a relatively short period (14–90 days) post-tagging. Our results agree with this generalization, but indicate tag losses may continue at a much reduced rate for extended periods after tagging. While our results are based on a small unreplicated sample (n 31 fish at study end), we believe they indicate long-term tag loss may be important when estimating the contribution of hatchery fish to a population. Accounting for this continued tag loss would prevent underestimation of the proportion of tagged fish occurring in the population (Heimbach et al. 1990).

Although Bumguardner et al. (1990) reported the FSD failed to detect tags present in 9% of live fish 114 days after tagging as determined by examination of X-ray negatives (n 186), no difference in tag detection between the FSD and X-ray negatives was found in this

study. Both X-ray negatives and the FSD indicated that 3 of 10 preserved fish lost tags. The criteria used to select fish for this study, i.e., confirmation of tag presence by the FSD, may have biased the comparison by eliminating fish with weakly magnetized tags.

Inserting coded wire tags horizontally in the cheek musculature of red drum fingerlings resulted in low tag retention. The site of tag insertion and tag orientation may affect tag retention. Tags implanted in striped bass *Morone saxatilis* and largemouth bass *Micropterus salmoides* cheek musculature resulted in higher retention rates than tags placed in snouts of striped bass and largemouth bass (Klar and Parker 1986, Fletcher et al. 1987, Williamson 1987). Changing the plane of tag insertion in the cheek muscle may increase tag retention. Dunning et al. (1990) reported coded-wire microtag retention in striped bass (65–100 mm TL) was greater when tags were inserted vertically rather than horizontally in the cheek muscle. A possible explanation of poor retention and high initial loss of wire microtags implanted horizontally in the cheek muscle of small fish may be the small margin of error in depth placement of the tag, due to size and thickness of the target area. Tags may be implanted too deeply, penetrate the muscle, and lodge in the buccal cavity. Anesthetized fish could retain the tag in the buccal cavity while passing through the Quality Control Device which magnetizes the tag and confirms tag presence, but then eject the tag after regaining equilibrium in the recovery tank. Changing tag orientation in the cheek muscle from horizontal to vertical would provide a thicker target for tag insertion and may be responsible for higher reported retention of microtags inserted vertically rather than horizontally in the cheek muscle of small fish.

Stocked red drum fingerlings are typically harvested at about 25 mm TL. Attempts to tag red drum of that size with wire microtags have resulted in high mortality (Gene McCarty, Texas Parks Wildl. Dep., Austin, unpubl. data). Tagging larger fish might improve retention rates and would reduce tagging mortality, but the fish would not be representative of the size of fish normally stocked. These factors would complicate any attempt to evaluate the effectiveness of stocking hatchery-reared red drum fingerlings using fish tagged with coded wire microtags.

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