Evaluation of small T-anchor and dart tags for use in marking hatchery-reared juvenile red drum, *Sciaenops ocellatus*

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Red drum, *Sciaenops ocellatus*, is an estuary-dependent marine species found in coastal and nearshore waters in the western Atlantic Ocean from Maine to Florida and in the Gulf of Mexico from Florida to Vera Cruz, Mexico (Yokel, 1966, 1980). Red drum are highly sought after as food and gamefish. Annual commercial landings in Florida averaged nearly 1.0 million pounds from the early 1960s until 1986, when the sale of red drum was prohibited. Recreational fishing effort directed toward red drum in Florida has more than doubled since 1989 on both the Atlantic and Gulf coasts (Murphy[1]). Increased fishing pressure on red drum stocks has led to the implementation of various management strategies, such as closing the commercial fishery and reducing the recreational catch by means of bag limits, size limits, and closed seasons. In the 1970s, methods were developed for culturing red drum in controlled hatchery environments, providing a pathway for the use of stock enhancement for managing the fishery (Arnold et al., 1977; Roberts et al., 1978a, 1978b). Red drum stock enhancement has been conducted extensively in Texas and, to a lesser degree, in Florida and South Carolina (Matlock et al., 1986; Willis et al., 1995; Smith et al.[2]).

Monitoring stocked fish populations in the wild is critical in determining the impact of stocked fish on the fishery and the natural population. Red drum are stocked at various sizes: (phase-1 (25–50 mm SL); phase-2 (50–100 mm SL); and phase-3 (100–200 mm)). Stocking larger size red drum (phase-2 or -3), facilitates the use of tagging as a method of tracking these fish in the wild. Tagged fish can provide valuable data on stock identity, fishing pressure, movements, abundance, age and growth, mortality, and stocking-program success (Ricker, 1956; Hilborn et al., 1990; McFarlane et al., 1990). However, the usefulness of these data depends on knowledge of tag-retention rates and of the effects of tagging on fish growth and survival.

A variety of tag types have been tested on red drum of various sizes. Several studies have evaluated the use of coded wire tags in juvenile red drum (phase-2, 50–100 mm SL, Bumguardner et al., 1990, 1992; Szedlmayer and Howe, 1995). Because coded wire tags are not externally visible, recreational and commercial fishermen are not likely to see them and therefore are not likely to submit capture data to authorities; externally visible tags are better suited for obtaining capture information from recreational and commercial fishermen.

Externally visible tags are typically restricted to use in red drum larger than 100 mm (phase-3 fish). Retention of externally visible tags in phase-3 red drum (100–200 mm SL) has not been rigorously tested, and little is known of the effects of these tags on survival or growth in this size of red drum. Some studies have tested the effects of various external tags on large red drum (>300 mm SL; Elam, 1971; Weaver, 1976; Hein and Shepard, 1980a; Gutherz et al., 1990). Matlock et al. (1984) reported using Monel jaw tags and Willis et al. (1995) reported using internal-anchor tags in fingerling red drum (100–200 mm SL), but neither report addressed tag-retention rates or effects of tags on growth or survival.

The Florida Department of Environmental Protection's Stock Enhancement and Research Facility (SERF) has the capability of rearing phase-1, -2, and -3 red drum for release. Data from this study were used to evaluate the efficacy of two types of external tags in hatchery-reared phase-3 juvenile red drum, and to provide tag-retention and survival estimates, which are necessary for correctly interpreting capture information.

Materials and methods

Retention of T-anchor and dart tags in hatchery-reared red drum (102–173 mm SL) was evaluated over a 423-day period. Mortality associ-

[1] Murphy, M. D. 1994. A stock assessment for red drum, *Sciaenops ocellatus*, in Florida. Florida Marine Research Institute. Report to the Fla. Mar. Fish. Comm., Tallahassee, FL, 28 p.

[2] Smith T. I. J., M. R. Denson, D. B. White, and W. E. Jenkins. 1993. Evaluation of a preliminary red drum stock enhancement program in South Carolina. SC Wildl. Mar. Res. Dep., Mar. Resour. Res. Inst. Annu. Performance Rep. Charleston, SC, 21 p.

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ated with tagging was monitored for the first 111 days of the experiment.

T-anchor tags (IEX tags[3], Fig. 1) had an 18-mm "T" with molded polyethylene on both sides for support. Attached to the "T" portion of the tag was a 42-mm streamer, the distal two-thirds of which was encased in polyethylene. T-anchors were inserted through a 1-mm-diameter hole made with a pointed, stainless-steel rod. Tags were inserted on the left ventral side of the fish near the distal end of the pelvic fin. Once inserted, the tag streamer was pulled so that the T-anchor rested along the body cavity wall, with the streamer protruding.

Dart tags (PDX tags[2], Fig. 1) had a 9-mm, semi-rigid plastic barb attached to a 45-mm plastic streamer that was encased in polyethylene. Dart tags were inserted into the pterygiophores of the spinous dorsal fin by using a stainless-steel canula.

We dipped all tags and applicators in Betadyne before tagging each fish to minimize the possibility of infection. The streamer of each tag was imprinted with a unique tag number so that we could identify individual specimens.

All red drum used in this experiment were spawned and maintained in ponds at the Florida Department of Environmental Protection's Stock Enhancement Research Facility (SERF) in Port Manatee, Florida. The holding ponds were drained at 290 days after spawning and fish were dip-netted to a small holding tank, where they were anesthetized (Tricaine menthanesulphonate, MS222, 100 ppm). Fish were measured (SL mm) and randomly assigned to one of three treatment groups: dart tagged, T-anchor tagged, and controls (handled but not tagged). Each treatment group contained 100 fish (mean SL=140 mm, mean weight=40 g), divided equally between two 1.5-m-diameter net pens with a volume of 2.12 m^3. Net pens were constructed of 6.25-mm knotless nylon mesh and were submerged within a closed aquarium system (>79,000 liters) with supporting aeration, bio-filter, and rapid sand filter. Salinity (‰), dissolved oxygen (mg/L), and temperature (°C) were monitored daily. Ammonia concentration (NH_3^+, mg/L) was monitored periodically. Fish were fed a combination of cut squid and commercially prepared pelletized fish food at a rate of 2–5% of body weight per day.

Net pens were checked daily for fish mortalities and shed tags. Standard length (SL mm), date, tag type, tag number, and pen number were recorded for all fish mortalities. At 66, 111, and 423 days after tagging (DAT), fish from all net pens were measured (SL mm), tag numbers checked, and tag wounds observed for degree of healing (wound open or closed). Control fish were removed from the study at 111 DAT. We continued to monitor tagged fish from 111 to 423 DAT so that we could evaluate long-term tag retention. All fish were treated for *Amyloodinium* sp. and parasitic copepods at 21 DAT.

Standard length measurements of red drum were compared between net pens at 0, 66, and 111 DAT by using a nonparametric Kruskal-Wallis one-way ANOVA on ranks test (α=0.05). Instantaneous survival rates of red drum were compared between treatments by using a two-way (% of fish alive) repeated measures ANOVA (α=0.05) on arcsine-transformed data. Net pen was used as the subject, with tag type as a group factor and days as a level factor (Fox et al., 1995).

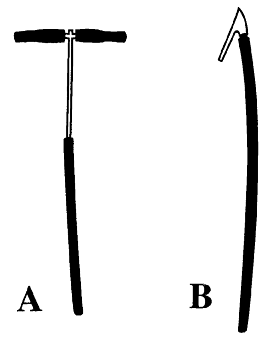

Figure 1

External tags used to mark hatchery-reared red drum: (**A**) T-anchor (IEX tags) and (**B**) dart (PDX tags). Both tags are manufactured by Hallprint Ltd., Holden Hill, Australia. Shown at 75% of actual size.

Results and discussion

Tag-retention rates in red drum in this study were similar for both T-anchor and dart-tagged fish (Table 1). Average retention rates for T-anchor and dart tags were, respectively, 98% and 99% at 66 DAT; 97% and 95% at 111 DAT; 91% and 89% at 423 DAT. No tags were shed until 41 DAT, and nearly all shedding stopped by 150 DAT (Fig. 2). Both tag types were retained in some red drum as large as 485 mm SL. Wallin et al. (1997) also reported high short-term (30 days) retention rates (100%) of T-anchor tags in ju-

[3] Hallprint Ltd., 27 Jacobsen Crescent, Holden Hill, South Australia 5088, Australia.

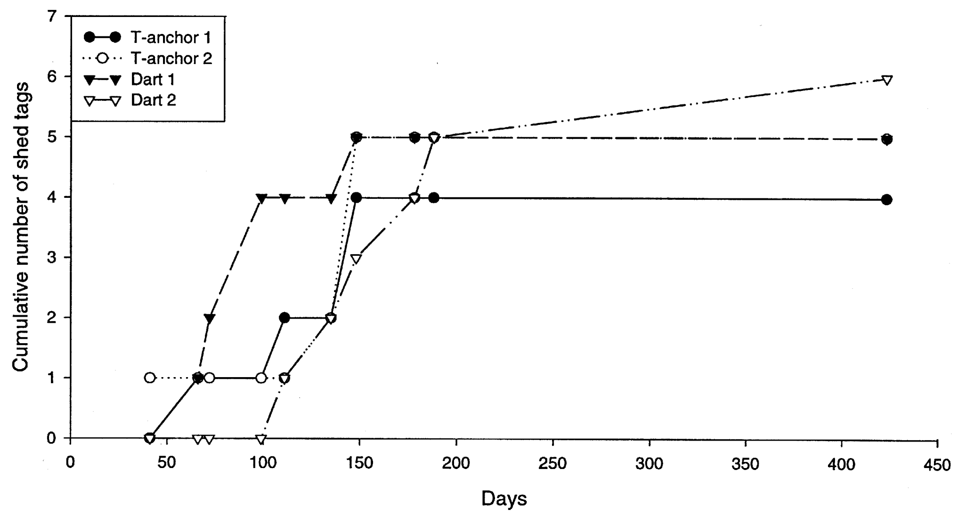

Figure 2

Cumulative number of tags shed by hatchery-reared red drum over a 423-day period. Each tag type was tested in two separate mesh-net pens, each holding 50 fish at start of test.

venile *Centropomus undecimalis*. Collins et al. (1994) found that T-anchor tags had higher long-term retention rates than did dart tags in juvenile *Acipenser brevirostrum* (T-anchor: 92% at 306 DAT; Dart: 50% at 154 DAT). The low retention rates of dart tags in their study may be explained by the fact that the posterior position of the dorsal fin in these fish subjected the tags to the constant motion of the caudal fin and thus enlarged the wound around the tag insertion point (Collins et al., 1994).

Compared with other external tags, T-anchor and dart tags appear to have superior retention rates in small red drum (<380 mm SL). Floy dorsal, Monel metal operculum, Monel metal jaw, Petersen operculum, Petersen dorsal, streamer dorsal, and Carlin dangler tags all yielded lower retention rates (<50% after 154 DAT, Hein and Shepard, 1980a) than did the T-anchor and dart tags tested in this study.

At 66 and 111 DAT, none of the T-anchor tag wounds had healed. Other studies have also shown that tag rotation and movement irritated the incision site, inhibited healing, and left an opening into the body cavity (Smith et al., 1990; Collins et al., 1994). Wallin et al. (1997) suggested that long-term retention of T-anchor tags may be reduced because of the open tag wounds; this was not observed in the 423 days of our study. The anchor portion of some of the T-anchor tags protruded through a hole in the abdominal wall that was separate from the tag insertion point. This may have been an early stage of tag shedding, although it was never verified that the protruding tags were actually shed. Similar results have also been reported in studies with disk-type internal-anchor tags (Vogelbein and Overstreet, 1987; Mattson et al., 1990).

All dart-tag wounds appeared to be healed by 66 DAT. Increases in fish body size during the course of the study caused the streamer portion of some dart tags to become engulfed by the body-wall tissue. This made the tags difficult to detect and impossible to read without dissection. A longer tag streamer could minimize this effect, but it could increase stress on smaller fish during tagging. Simmons and Breuer (1982) also reported tissue growth over tags, which reduced the ability to identify tagged red drum.

Tagging did not appear to adversely affect red drum survival. There was no significant difference in instantaneous survival estimates between treatments (F=2.2, P=0.26). Mean percent survival of control, T-anchor, and dart-tagged fish was, respectively, 79%, 68%, and 79% at 66 DAT and was 67%, 65%, and 77% at 111 DAT (Table 1). Nearly all mortality occurred during the first 40 days of the experiment; 67% of all T-anchor and 83% of all dart-tag mortalities occurred during this time period (Fig. 3). These results are consistent with those of other studies in which these tag types were used (Collins et al., 1994; Szedlmayer and Howe, 1995; Wallin et al., 1997).

Initial lengths of red drum were not significantly different between treatments (H=3.1, P=0.68, df=5, Table 1). Red drum lengths at 66 and 111 DAT were also not significantly different between treatments (66 DAT: H=3.9, P=0.56, df=5; 111 DAT: H=6.4, P=0.27, df=5), suggesting that tagging did not ad-

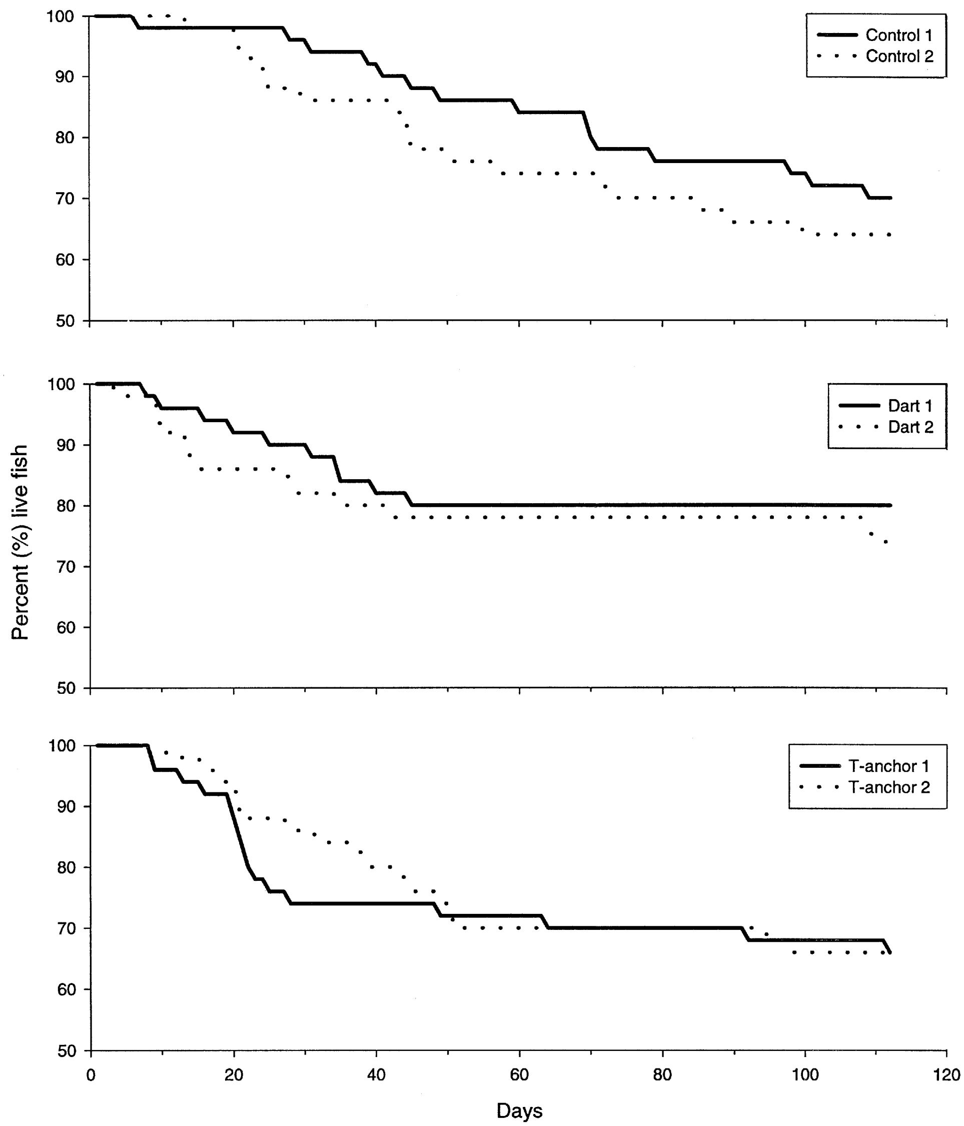

Figure 3

Survival of red drum in each treatment group during the first 112 days of the study.

versely affect fish growth. It is important that a tagging method not affect growth (Ricker, 1956; Wydoski and Emery, 1983), especially when tagging is being used to verify aging methods (e.g. oxytetracycline injection) or to estimate survival rates in the wild (Green et al., 1985; McFarlane et al., 1990). Growth-rate estimates of red drum in our study (0.41–0.50 mm/day) were lower than those for this size of red drum reported in other studies (Colura and Hysmith, 1975; Hein and Shepard, 1980b), possibly because of the high stocking densities in the net pens.

In summary, dart and T-anchor tags are well suited for marking juvenile phase-3 red drum (102–173 mm SL) and are usually retained until the fish are large enough to enter the fishery (Florida minimum size limit for red drum is 368 mm SL). Both tag types were easy to apply and did not affect red drum growth or survival. Although tag retention, survival, and growth rates did not differ between tag types, our results did reveal some potential problems associated with the long-term use of T-anchor tags. The wound around the insertion point of the T-anchor tags did not heal during the 423 days of our experiment, and late in the study, some tags showed signs of expulsion (anchor protrusion through abdominal wall). Both tag types could be used to track releases of

Table 1

Cumulative percent red drum survival (66 and 111 days after tagging (DAT) and tag retention (66, 111, and 423 DAT) for all treatments. Each treatment was replicated in two separate mesh-net pens, each of which held 50 hatchery-reared red drum. Mean standard lengths (mm) and associated standard errors (in parentheses) are also listed for 0, 66, and 111 DAT.

		% Survival DAT		% Tag retention DAT			Mean standard length, mm (standard error) DAT		
Treatment/Pen#		66	111	66	111	423	0	66	111
Control	1	84	50	—	—	—	140 (2.21)	166 (2.87)	195 (3.65)
	2	74	64	—	—	—	136 (2.12)	160 (3.13)	191 (3.23)
T-anchor	3	70	66	98	96	92	138 (1.57)	167 (2.60)	191 (3.05)
	6	66	64	98	98	90	141 (1.88)	163 (2.68)	188 (3.91)
Dart	4	80	80	98	92	90	140 (1.84)	165 (2.70)	184 (3.71)
	5	78	74	100	98	88	138 (1.60)	161 (2.22)	184 (2.28)

hatchery-reared phase-3 red drum and thus allow scientists to monitor and accurately determine the effects such releases have on naturally occurring stocks.

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