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OVERVIEW OF AN EXPERIMENTAL STOCK ENHANCEMENT PROGRAM FOR RED DRUM IN SOUTH CAROLINA

Theodore I. J. Smith, Wallace E. Jenkins and Michael R. Denson

South Carolina Department of Natural Resources
Marine Resources Research Institute
P. O. Box 12559, Charleston, S.C. 29422-2559 USA.

ABSTRACT

Programs to supplement the wild population of red drum, (*Sciaenops ocellatus*), through stocking, are being conducted in several states in the southeastern U. S. In South Carolina, research focused on stocking large (≥100 mm TL) fish which could be externally tagged and reported by anglers. Tagged fish were divided into 3 size categories (≤160, 160-199 and ≥ 200 mm TL) and stocked during different times of the year. During the project (1988-1993), 60,198 fish were stocked. Fishery dependant tag returns demonstrated that spring (March-May) stockings yielded the highest returns with means of 7.2, 3.4 and 2.5% of the fish in the large, medium, and small size categories, respectively, being returned. In contrast, summer (June-August) and winter (December-February) releases resulted in very low returns (≤ 2%) for all size groups stocked. Fishery independent sampling conducted regularly in a stocked estuary, indicated that the contribution of stocked fish to the wild population ranged from 0.3-4.1% during 1989-1994.

A study examined angler reporting of captured tagged red drum. Results indicated that there was no significant difference between the inscriptions "Reward" and "$50 Reward" however, tags with "No Reward", were reported significantly less than either reward inscription.

Results of studies evaluating two tag types showed that abdominal anchor tags were superior to T-bar tags for long term (> 1 yr) retention.

An economic model which calculated production and stocking costs for various stocking strategies estimated that the cost per return to the creel ranged from $3.52-$15.71 for stocking fish in the small size class. Overall, program results indicated that stocking fish could be considered an acceptable fishery management tool.

INTRODUCTION

The red drum, *Sciaenops ocellatus*, is one of the most important marine recreational fish species along the south Atlantic and Gulf coasts of the United States.[1] During the late 1980's, stocks of this species especially in the Gulf of Mexico, were reduced to low levels primarily due to over-fishing.[1,2] As a result, the National Marine Fisheries Service implemented management plans for federal waters along the Gulf and Atlantic coasts, designed to protect against further over-exploitation and to start rebuilding the spawning population.[3] Similarly, the Gulf States Marine Fisheries Commission and the Atlantic States Marine Fisheries Commission instituted regulations to conserve the fish in state waters.

The management plan in South Carolina (SC) has complied with federal recommendations aimed at eventually establishing a 30% escapement rate of juveniles to rebuild the spawning stock biomass. State law has changed a number of times in recent years. Currently, commercial fishing is prohibited and recreational anglers can take 5 fish/day in a slot range (minimum size, 356 mm, maximum, 686 mm TL).

During 1988-1993, the SC Department of Natural Resources initiated a project to examine the biological and logistical issues associated with conducting a stock enhancement program for red drum. This program was based in part on information being collected in Texas and Florida where stock enhancement programs were underway.[4,5] These programs utilized, temperature and photoperiod manipulation to induce spawning of captive red drum,[6,7] as well as intensive pond management for production of juveniles.[8] By 1990, the Texas program was producing 16-30 million, 25-30 mm TL unmarked fingerlings annually, for release in the wild.[4] In contrast, Florida's pilot-scale program was releasing 200-300,000

fish/year in the size range 60-120 mm TL. Each fish was marked with an internal coded wire tag before release.

In SC, the research scale program was focused on releasing larger fish and evaluating this approach as a possible management tool. Specific program objectives included determining: (1) effect of fish size at release on return of stocked fish; (2) optimum season of release; (3) effect of different tag types on retention and fish survival; (4) angler non-reporting level of captured tagged fish; (5) contribution of stocked fish to the local wild population; (6) an estimate of the cost ($) per fish captured. A number of studies were conducted to address each of these objectives.

In contrast to the programs in other states, all red drum released in SC were greater than 100 mm TL and all were externally tagged with individual identifying tags. Fishery dependant (angler participation) and fishery independent data were used to determine capture and contribution levels of the stocked fish. This manuscript provides a summary of the findings of the SC experimental stocking program for red drum.

MATERIALS AND METHODS

General

All fish used in studies were produced from native broodstock which had been conditioned to spawn in captivity using temperature and light control. Fertilized eggs were incubated until hatch in 24℃, 29 g/L saline water and stocked (800,000-1,000,000 fry/ha) in fertilized ponds at the Waddell Mariculture Center in Bluffton, SC. Most fish were spawned in March and April, 4-6 months before the natural spawning season (August-September), to take advantage of favorable outdoor growing conditions in ponds in spring and summer. Fish were harvested after 45-60 days and restocked at lower densities in adjacent ponds for rearing to the size required for particular experiments. Fish were harvested by seining or after pond drainage and mechanically or manually graded into desired size classes. During tagging, fish were maintained in flow-through Colleton River water (25-30 g/L salinity) and anesthetized in a 0.1 g/L solution of Tricaine Methanesulfonate. After tagging, fish were placed in insulated hauling tanks at biomass densities of 60 g/L for transport to their respective stocking site. Water was aerated using compressed oxygen. At the stocking site, fish were acclimated (~15-30 minutes) to ambient conditions before being stocked. Except as noted otherwise, all fish were released in the Charleston Harbor estuary which was approximately 177 km from the production facility (actual tagging and transport time ~4-5 hours).

Two types of tags were used and each tag was inscribed with an individual number and an address for reporting captures. In addition, signs describing the program were placed at all public access points adjacent to the estuary and in local fishing tackle shops. Anglers reporting tags received a hat with the program logo embroidered on it as a reward, and they were also eligible to win a cash reward.

Evaluation of tag types

Two tag types (T-bar and abdominal anchor) were utilized during the program. Both had 45 mm long monofilament streamers (15 mm at base uncovered, 30 mm covered orange message portion) and were manufactured by HallPrint Pty. Ltd. (Australia). The T-bar tag had an 8 mm T-shaped monofilament anchor and was applied with a tagging gun and inserted between the pterigiophores in the dorsal musculature of the fish. This tag could be quickly inserted into the fish. The abdominal anchor tag was inserted in the fish's peritoneal cavity through a hole punched just posterior to the left pectoral fin. The anchor portion was a 17 mm covered T-shaped section of monofilament. This tag required additional time to insert. The two types of tags were tested under actual field conditions and in controlled tank studies.

Field study

Both tags were used during the entire stocking program (1989-1993). A total of 25,738 T-bar and 34,460 anchor tagged fish were released during the program. A subset within the overall program was set up with replicate groups of fish (250-300/tag type/release) with nearly equal numbers of each tag type being stocked between October 1990-September 1992. This was done so that return data from each tag type could be statistically compared. During this period 45 stocking events occurred, encompassing different size classes of fish as well as different seasons of the year. A total of 23,895 fish were stocked of which 11,971 contained T-bar tags and 11,924 had abdominal anchor tags.

Controlled tank studies

The two tag types were tested in two studies conducted in outdoor 3.7×0.9 m deep cylindrical tanks. These tanks received ambient temperature flow-through water (25-30 g/L salinity) from the adjacent Charleston Harbor estuary. During both studies, fish were fed a 38% protein sinking trout ration daily and all fish were individually weighed and measured monthly. The first study was run for four months and examined tag retention and post-tagging survival for smaller fish (mean, 175±SE 1.8 mm TL). These fish were in the small and medium size classes released in the stocking program. Each tag type was applied to three groups of fish (75 fish/tag type/replicate). Three control groups (75 fish/replicate) had an

anal fin clipped for identification. Each tank was stocked with both types of tagged fish and controls (225 fish/tank).

The second study examined long term tag retention and survival among the fish in the largest size class (200-250 mm TL). The study was run for 14 months which is the time period during which the majority of tagged fish released into the wild are reported by anglers. In this study, three replicate groups of 100 fish (mean 249 mm TL ± 2.3 mm), with each tag type, plus 50 fin clipped controls, were stocked in three tanks. Thus, each tank contained fish with both tags and control fish (250 fish/tank). The fish were sampled monthly.

Evaluation of size and season of release

Fish were graded into three size classes prior to tagging and release: small (100-160 mm TL, <40 g); medium (161-199 mm TL, 40-60 g) ; and, large (200-250 mm TL, >60 g). Experimental protocol was that equal numbers of fish in the different size classes would be released during each season of the year. However, small fish were not available for stocking in the summer or fall due to production constraints. Also, only one stocking of large fish was completed in the fall season. Further, number of fish stocked per event varied substantially. For the purpose of this experiment winter=December-February, spring=March-May, summer=June-August and fall=September-November. During handling, water quality parameters (dissolved oxygen, temperature, pH and ammonia) were closely monitored. Post-stocking mortality was evaluated by holding sub-samples of fish from groups to be stocked in the 3.7 m diameter tanks used in the tagging studies for 7 days. Fishery dependant data (angler reports of captures) were correlated with size and season of release to evaluate results.

Determination of non-reporting rate

Information on the reporting level of captured tagged fish by anglers is needed to properly assess return data. A reward study was used to determine the level of non-reporting. One thousand two hundred legal size (≥356 mm TL) fish were separated into four replicate groups (300 fish/group). All fish received abdominal anchor tags inscribed with one of the following messages: No Reward; Reward (message used in marine tagging programs in SC); or $50 Reward (100 fish/message/replicate). The four groups (replicates) were stocked at three sites in Port Royal Sound and one site in Calibogue Sound in Beaufort County, SC. Fish were stocked from boats at each site and dispersed over a wide geographic area (~8 nautical miles/site) in an attempt to limit bias which might occur in the event of multiple captures by a single angler.

Contribution of stocked fish to local wild population

Fishery independent sampling was used to determine the contribution of stocked fish to the wild fishery between 1989 and 1994. Monthly sampling with gill, stop, and trammel nets was part of an ongoing life history project focused on inshore game fish including red drum. Contribution to the wild population was calculated based on the ratio of wild fish to tagged stocked fish present in each sample.

Economic estimates

Estimates of cost/fish returned to the creel were made based on data obtained from size and season of release studies, and combined with cost of production estimates provided by commercial growers. The costs of stocking fish were based on estimates to produce 250,000-2,000,000 juveniles in 2.54 cm size increments with delivery to Charleston Harbor.

Statistical analysis

Data from the tag retention and reward studies were analyzed using analysis of variance. Differences in means were detected with Tukey's test. The tag return data for the abdominal anchor and T-bar tags on fish released in the wild were compared using a T-test. All percentage data were arc-sin transformed prior to analysis. Differences were considered significant at $p < 0.05$.

RESULTS

Evaluation of tags

Field study

Because of unequal sample sizes and other variables, return data from all fish stocked between 1989 and 1993 could not be statistically compared. Returns for the two external tags used indicated that, abdominal anchor tags were returned (1,026/34,460; 2.98%) nearly twice as frequently as T-bar tags (452/25,738; 1.76%). Of the reported captures of T-bar tagged fish, 89.2% occurred within the first year after release, 9.3% returned in year 2, and 1.3% in year 3. In contrast, 77.2% of the abdominal anchor tags reported were returned within the first year with 16.7% occurring during year 2. An additional 6.1% were reported during years 3-5.

The percentage of fish reported captured in the more controlled 2 year field study (October 1990-September 1992) was lower for both types of tags. Returns ranged from 0.0-5.2% with a mean of 1.02% (number returned /release, 3.02 ± SE 0.48) for the T-bar tagged fish and

1.55% (number returned/release, 3.93±SE 0.55) for the abdominal anchor tagged fish. Statistical analysis of the number of returns / replicate release (paired t-tests), indicated that abdominal anchor tags were returned significantly more often than T-bar tags ($p=0.043$).

Controlled tank studies

Analyses of the monthly samples and harvest data for the first four month study indicated that there were no differences in growth among control and tagged fish. Mean retention for abdominal anchor (94%) and T-bar (96%) tags was similar at four months. No differences in mean survival were detected. Control fish exhibited a mean survival of 99% (range, 97-100%) while, tagged fish had a mean survival of 96% (range, 92-100%).

During the initial two months of the second study, mean tag retention for T-bar tagged fish was 84% as compared to 100% for the abdominal anchor tagged fish. During months 3-7, retention remained relatively constant with no further losses of either tag type. However, retention of T-bar tags declined sharply after month seven. At the conclusion of the study (month 14), mean retention of T-bar tags was significantly ($p=0.014$) lower (17.2%, range, 15.4-19.0%) than abdominal anchor tags (100%). Mean survival for the tagged (91.5%, range, 90-94) and control groups (90.0%, range, 89-91%) was similar.

Evaluation of size and season of release

Due to production space limitations, all sizes of fish were not available for every release. The medium size fish were the only category of fish stocked in each season of the year but number of releases varied widely. Because basic statistical assumptions were not met, strict analysis of the size and season data could not be performed. However, the return data for releases of 29,831 (3,650 small, 13,545 medium and 12,636 large) abdominal anchor tagged fish were examined to determine if any trends were apparent.

Season of release appeared to have an effect on return level. In general, highest returns were recorded for fish released in spring. Releases of medium and large fish during this period yielded mean returns of 3.4% (range, 1.1-8.4%) and 7.2% (range, 1.1-17.6%), respectively, while a mean of 2.5% (range, 0.2-8.0%) of small fish were returned (Table 1). Mean returns for all size groups released in the winter were less than 1.6% (Table 1). Summer releases also yielded low mean returns for fish released in the medium (2.0%) and large (2.1%) size classes (Table 1). Subsequent post-stocking mortality studies indicated that most fish died when harvested and released in mid-summer at water temperatures ≥ 25℃. This finding explains the poor results from stockings conducted in the summer. The one group of large fish released in the fall were returned at a level (9.2%) slightly higher than that recorded for fish released in late spring (Table 1). Medium size fish released during the fall were returned at a level (mean, 3.9%, range, 2.2-5.1%) comparable to similar sized fish released in the spring (Table 1).

Size of fish at release was directly related to return level. Fish from the large size category were returned at higher levels than fish from either the medium or small categories. Maximum returns of 17.6%, 8.4%, and 8.0% for the large, medium, and small size classes, respectively, were recorded for groups of fish harvested, tagged, and released during the spring when water temperature was between 18-24℃. Releasing small fish in the spring provided a greater mean return than releasing medium or large fish in the summer or winter (Table 1).

Determination of non-reporting level

Sixty four percent of the fish returned were caught by anglers who reported catching more than one tagged fish.

Table 1. Mean return rates (%) ±SE for 85 groups (n=29,831) of anchor tagged fish of various sizes (small, 100-160 mm TL; medium, 161-199 mm TL; and, large, 200-250 mm TL) stocked during different seasons of the year. In the table, n=the number of stocking events.

Season	Size Class		
	Small	Medium	Large
Winter	0.5 ± 0.20 n=6	1.0 ± 0.30 n=11	1.6 ± 1.23 n=5
Spring[1]	2.5 ± 0.86 n=8	3.4 ± 0.56 n=17	7.2 ± 1.48 n=13
Summer	··	2.0 ± 0.64 n=7	2.1 ± 0.44 n=12
Fall	··	3.9 ± 0.50 n=5	9.2 ± ·· n=1

[1] Includes data for fish stocked through June 10.

Of the 99 participating anglers, 9% reported 31% of the 182 fish captured. Analysis of variance was performed on the pooled return data by tag message and site. No difference in mean reporting level was detected among the "Reward" (19.3%, range, 11-41%) and "$50 Reward" (23.3%, range, 15-42%) messages, but both were significantly greater than the "No Reward" (11.7%, range, 4-22%) message (Table 2).

Returns from fish stocked at three sites (range, 10.0-15.0%) were not statistically different. However, significantly ($p=0.0013$, $n=3$) more returns (35%) came from the site which was near the town of Port Royal and which had higher fishing pressure.

When data for fish reported singularly by anglers were grouped and analyzed, results were similar to that of fish reported from multiple captures.

Contribution of stocked fish to local wild population

Randomized fishery independent samples in the Charleston Harbor estuary between 1989 and 1994 verified that stocked fish contribute to and occur with wild stocks. Annual percentages of stocked fish in samples ranged from 0.3-4.1% (mean, 1.4%) (Table 3). The peak number of captures of stocked fish occurred in 1992 when 94 tagged stocked fish were captured during sampling (Table 3).

Economic estimates

Two commercial hatcheries responded to questionnaires requesting delivered prices for quantities of juvenile red drum ranging from 250,000-2,000,000 in 2.54 cm increments between 5.1-12.7 cm. One respondent was a hatchery in Texas and the other in South Carolina. Due to the longer distance involved, the prices quoted for the Texas supplier were higher. Price per individual ranged from $0.14 for 2,000,000 5.1 cm fish from a South Carolina hatchery to $0.45 for 250,000 12.7 cm fish shipped from Texas. There was approximately a 14% discount for purchasing the largest quantity.

Estimated stocking cost data (for fish in 10.2 and 12.7 cm TL size classes) were combined with return data based on these size fish (smallest size group released) and season of release. Based on abdominal anchor tagged fish, the highest mean (2.5%, range, 0.1-8.0%) returns for the small size class occurred in late spring. Using the quantity discount cost and the highest return level (8%) recorded for this size class, cost/return was $3.52 for 10.2 cm TL fish and $4.43 for 12.7 cm TL fish. However, if the mean (2.5%) return level was used, cost/return increased to $12.90 and $15.71 for the 10.2 and 12.7 cm TL fish, respectively.

DISCUSSION

Interpretation of results from this research study are conservative as the return levels no doubt did not include all captured stocked fish (e.g. tags shed, not observed, not reported). Fishery independent data clearly indicated that the stocked red drum grew and behaved similarly to wild fish and provided a contribution of up to 4.1% to the wild population. Weaning from a strictly pelleted ration to

Table 2. Mean return rates (%) for red drum ($n=1,200$, 401 cm TL) released in replicate groups at three sites in Port Royal Sound and one site in Calibogue Sound with tags inscribed with one of three reward messages.

Reward Message	Mean[1]	Range	±SE
$50 Reward	23.3 A	15.0 - 42.0	6.4
Reward	19.3 A	11.0 - 41.0	7.3
No Reward	11.8 B	4.0 - 22.0	3.8

[1] Means followed by the same letter are not significantly different ($p \leq 0.05$).

Table 3. Contribution of stocked red drum to the wild population in Charleston Harbor estuary.

Year	released (#)	sampled (#)	Contribution (#)	Contribution (%)
1989	4,145	897	7	0.8
1990	5,961	784	30	3.8
1991	11,279	1,209	4	0.3
1992	15,409	2,265	94	4.1
1993	14,957	2,496	33	1.3
1994	0	2,246	22	1.0

Table 4. Estimated cost ($) per returned fish based on the mean (2.5%) and maximum (8.0%) returns recorded for similar size fish stocked in the spring and estimated costs provided by a SC commercial hatchery. Prices for larger size fish were not quoted.

Quantity (#)	Total Length (cm)	Cost ($) /return	
		2.5%	8.0%
250,000	10.2	12.90	4.03
	12.7	16.18	5.06
2,000,000	10.2	12.90	3.52
	12.7	15.71	4.43

natural foods occurred rapidly as some fish were captured within 1-2 days of release by anglers using natural baits and artificial lures.

Selection of proper tags to externally mark fish for long term identification is extremely important. Results of our studies showed the value of conducting long term studies (> 1 year) and indicated that the abdominal anchor tag provided much better long term retention than the T-bar tag. This was supported by field testing which showed that almost all fish, reported after 3-5 years at large, contained abdominal anchor tags. Neither tag type affected growth or survival under controlled tank conditions.

Since much of the data collected was from fishery dependent sources it was necessary to evaluate level of angler non-reporting of captured tagged fish. Studies in other states have observed non-reporting rates by marine anglers of > 50%.[9,10] Our angler non-reporting study indicated that, the offer of a reward was very important. This finding has also been reported by Butler[11]. Offering no reward resulted in significantly fewer returns than offering either a non-specific reward or a $ 50 reward. The returns for tags inscribed "Reward" were not significantly different from the offer of "$ 50 Reward". This finding was encouraging as most marine fish tagging programs in SC offer a "Reward" for captured fish. The previously assumed 50% non-reporting level did not appear to be valid based on our results. However, a study with ducks suggests that $ 50 is too low a reward to expect a 100% reporting level.[12] Our study also demonstrated the influence of stocking location on return level. Stocking near an urban area resulted in a 35% return level while stocking in less accessible fishing areas provided lower return levels. The return levels observed for legal size stocked fish released in this experiment are similar to those observed for wild fish which are tagged and released in SC.[13]

Due to production constraints caused by limited pond space and avian predators, studies focused on evaluation of size and season of release could not always follow rigorous experimental protocols. However, the trend was clear that larger fish are returned more frequently than smaller size fish, a finding similar to that reported by Willis et al.[5]. We also found that spring and fall releases provided higher returns than stocking during winter or summer.

Based on reports of economic impacts of fishing for red drum in Texas, Matlock[14] estimated cost per returned fish in SC appeared acceptable. It was not possible to obtain comparable data for stocking fish in the medium and large size classes. From a cost standpoint, production of smaller fish seems more efficient and less risky and is the approach considered most beneficial in Texas.[4,15] As mentioned earlier, bird predation of pond reared fish became an increasing problem,[16] as was concern about low temperature induced kills,[17] during over-wintering of fish in outdoor ponds. Shorter duration of captive rearing used to produce small fish may also have some beneficial genetic considerations. However, a program based on stocking very small fish can not be accurately assessed without a method of identifying the contribution of stocked fish to the wild population.

Efforts have been undertaken to develop the use of natural marks on otoliths and scales for marking small fish. Otolith microstructure has been used as a "natural tag" and to distinguish hatchery reared and wild fish.[18, 19, 20] Recently, we observed that the growth pattern on the otoliths of out-of-season spawned red drum could be used as a mark to identify stocked fish.[21] In fact, this technique was recently used to examine archived otoliths from two year classes of "wild" fish collected during routine fishery independent sampling. This examination revealed that 4% of red drum formerly classified as "wild", were actually stocked fish that had lost their tags prior to capture. Recently, in SC, a stocking experiment has been initiated where 200,000 to 500,000 small juveniles (25-40 mm TL) are being marked with oxytetracycline HCL,[22] and stocked in the fall and spring to evaluate seasonal effects and to validate utility of using the otolith marks for long term identification.

In summary, stocking red drum was shown to be a valuable management tool for use by fishery managers. However, issues relative to the interaction of stocked fish on wild populations (e.g. supplementation, competition, replacement) and ecosystem carrying capacity still need to be addressed.

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REFERENCES

1) G. C. Matlock, R. L. Colura, A. F. Maciorowski and L. W. McEachron: Use of on-going tagging programs to validate scale readings, in "The age and growth of fish" (ed. by R. C. Summerfelt and G. E. Hall), The Iowa State University Press, Ames, Iowa, 1987, pp. 279-285.
2) C. P. Goodyear: Status of the red drum stocks in the Gulf of Mexico. National Marine Fisheries Service, Southeast Fisheries Center, Coastal Resources Division Contribution MIA-90/91-87, Miami, Florida, 1991.
3) L. P. Mercer: A biological and fisheries profile of red drum *Sciaenops ocellatus*. NC Department of Natural Resources Commission, Division of Marine Fisheries, Special Science Report 41, 1984, 89p.
4) L. W. McEachron and K. Daniels: Red drum in Texas: A success story in partnership and commitment. Fisheries 20, 3: 6-8 (1995).
5) S. A. Willis, W. W. Falls, C. W. Dennis, D. E. Roberts and P. G. Whitchurch: Assessment of season of release and size at release on recapture rates of hatchery reared red drum. American Fisheries Society Symposium 15: 354-365 (1995).
6) D. E. Roberts Jr., B. V. Harpster and G. E. Henderson: Conditioning and induced spawning of the red drum (*Sciaenops ocellatus*) under varied conditions of photoperiod and temperature. Proceedings of the World Aquaculture Society 9: 311-332 (1978).
7) C. R. Arnold, W. H. Bailey, T. D. Williams, A. Johnson, and J. L. Lasswell: Laboratory spawning and larval rearing of red drum and southern flounder. Proceedings Southeastern Association of Fish and Wildlife Agencies 31: 437-440 (1979).
8) J. G. Geiger and C. J. Turner: Pond fertilization and zooplankton management techniques for production of fingerling striped bass and hybrid striped bass, in "Culture and propagation of striped bass and its hybrids" (ed. by R. M. Harrell, J. H. Kerby and R. V. Minton), American Fisheries Society, Southern Division, Striped Bass Committee, Bethesda, Maryland, 1990, pp.79-98.
9) G. C. Matlock: Nonreporting of recaptured tagged fish by saltwater recreational boat anglers in Texas. Transactions of the American Fisheries Society 110: 90-92 (1981).
10) A. G. Woodward: Evaluation of fish tag reporting by marine boating anglers in Georgia. Georgia Department of Natural Resources, Brunswick, Georgia 1992.
11) L. Butler: Recognition and return of trout tags by California anglers. California Fish and Game 48: 5-18 (1962).
12) J. D. Nichols, R. J. Blohm, R. E. Reynolds, R. E. Trost, J. E. Hines and J. P. Bladen: Band reporting for mallards with reward bands of different dollar values. Journal of Wildlife Management. 55 (1) : 119-126 (1991).
13) C. A. Wenner, W. A. Roumillat, J. E. Moran, Jr. M. B. Maddox, L. B. Daniel, III, and J. W. Smith: Investigations on the life history and population dynamics of marine recreational fishes in South Carolina: South Carolina Department of Natural Resources, Charleston, SC, 1990, 55p.
14) G. C. Matlock: Estimating the direct market economic impact of sport angling for red drum in Texas. North American Journal of Fisheries Management 6: 490-493 (1986).
15) L. W. McEachron, C. E. McCarty, and R. R. Vega: Beneficial uses of marine fish hatcheries: enhancement of red drum in Texas coastal waters. American Fisheries Society Symposium 15: 161-166 (1995).
16) M. L. Baird, T. I. J. Smith and W.E. Jenkins: Evaluation of control techniques for avian predators of pond reared fishes. Proceedings Southeastern Association of Fish and Wildlife Agencies. 47: 580-587.
17) J. S. Hopkins, T. I. J. Smith, A. D. Stokes and P. A. Sandifer: Winter survival of fingerling red drum (*Sciaenops oscellatus*) in South Carolina culture ponds. Contributions in Marine Science. Supplement to Vol 30: 5-10 (1988).
18) E. C. Volk, S. L. Schroder and K. L. Fresh: Inducement of unique otolith banding patterns as a practical means to mass-mark juvenile Pacific salmon. American Fisheries Society Symposium 7: 203-215 (1990).
19) M. L. Hendricks and D. L. Torsello: Use of otolith microstructure to distinguish wild from hatchery-reared American shad in the Susquehanna River. North American Journal of Fisheries Management 14: 151-161 (1994).
20) MacLellan, S. E. and M. W. Saunders: A natural tag on the otoliths of Pacific hake (*Merluccius productus*) with implications for age validation and migration, in "Recent developments in fish otolith research" (ed. by D. H. Secor, J. M. Dean, S. E. Campana and A. Miller), University of South Carolina Press, Columbia, 1995, pp. 567-580.
21) W. E. Jenkins, M. R. Denson, M. R. Collins and T. I. J. Smith: Differentiating between hatchery and wild red drum (*Sciaenops ocellatus*) using position of first annulus on sagitta. North American Journal of Fisheries Management, in press, (1997).
22) B. W. Bumguardner: Marking subadult red drums with oxytetracycline. Transactions of the American Fisheries Society 120: 537-540 (1991).