Direct validation of black drum (*Pogonias cromis*) ages determined from scales

Gary C. Matlock
Robert L. Colura
Lawrence W. McEachron
Texas Parks and Wildlife Department
4200 Smith School Road
Austin, Texas 78744

In the 1980's increased harvest of black drum (*Pogonias cromis*) in the Gulf of Mexico raised concerns about the possibility of overfishing (Anonymous[1]; Murphy and Taylor, 1989). Growth information necessary to examine the effects of fishing on population size was limited to rate estimates based primarily on temporal changes in length-frequency distributions (Pearson, 1929; Simmons and Breuer, 1962) and length changes in recaptured tagged fish (Osburn et al., 1980; Doerzbacher et al., 1988). Age information was limited to scale analysis of fish in Texas and Virginia (Pearson, 1929; Richards, 1973). Consequently, scales and otoliths became the focus of study for estimating age and growth rates (Cornelius, 1984; Music and Pafford, 1984; Murphy and Taylor, 1989; Beckman et al., 1990; Peters and McMichael, 1990), but, age data were not directly validated. For example, Beckman et al. (1990) used the intra-year progression of annulus formation on otoliths to conclude that one annulus forms per year. While their indirect evidence is compelling, age was not directly validated, and no attempt has been made to validate age by using the scale method. Thus, the reliability of conclusions concerning the effect of fishing on black drum may be suspect. More cost-efficient studies would result from using scales instead of otoliths for ageing if reliable data could be obtained from scales. The objectives of this study were to validate directly the formation of annuli (one growth check per year) on scales, the time of annulus formation, and the effect of tagging on annulus formation.

Methods

Black drum were caught in gill nets at randomly selected sites in nine Texas bay systems (Dailey et al., 1991) during spring (April–June) and fall (Sept.–Nov.) 1985–1991. Captured fish were measured for total length (TL) to the nearest mm, tagged with internal abdominal tags with external plastic streamers (Osburn et al., 1980), and released. Prior to release, at least two scales were removed from the area beneath the distal end of the left pectoral fin immediately ventral to the lateral line (Matlock et al., 1987). Scales were removed from a total of 9,088 released tagged black drum (195–1,257 mm TL) between April 1985 and December 1991. Anyone capturing a tagged fish was requested through posters and news-media advertisements to report date, location, and TL of each recaptured tagged fish, and to return at least one scale collected from the same area from which scales were removed at release. Scales from 22 recaptured tagged fish (354–635 mm TL) were returned to the Texas Parks and Wildlife Department (TPWD) by fishermen between May 1985 and December 1991. All reported data were assumed accurate.

Scales were prepared by washing in soapy water and impressing on a cellulose acetate slide with a roller press (Smith, 1954). The impressions were examined at 32 diameters magnification with a microprojector by using incandescent light. Annuli, characterized by breaks in circuli and new radii, were identified following Pearson's (1929) description and separately counted by two examiners without collaboration. Scales were read blind (i.e., without knowing TL or date each scale was obtained). Agreement between readers was obtained for all scales on the first reading. Scale radii and distances from the focus to successive annuli were measured along a diagonal line (Fig. 1) to the right antero-lateral scale corner (Klima and Tabb, 1959). Magnified (32×) scale measurements are reported unless otherwise noted. Sixteen of the 22 fish had both usable scales and TL measurements at both release and recapture; 17 had usable scales at both times but one fish lacked TL data at recapture (Table 1). The usable data from the remaining five fish were used to accomplish some of the objectives.

Annulus formation was validated by comparing the number of scale growth checks observed at release to those at recapture (Fig. 2). The difference in number of annuli was compared to the expected difference under the null hypothesis: number of scale growth checks per year ≠ 1.

[1]Anonymous. 1989. Saltwater finfish research and management in Texas, a report to the Governor and the 71st Legislature. Tex. Parks Wildl. Dep., PWD R-3400-061-12/88, Austin, TX, 65 p.

Manuscript accepted 24 June 1993.
Fishery Bulletin: 91:558-563 (1993).

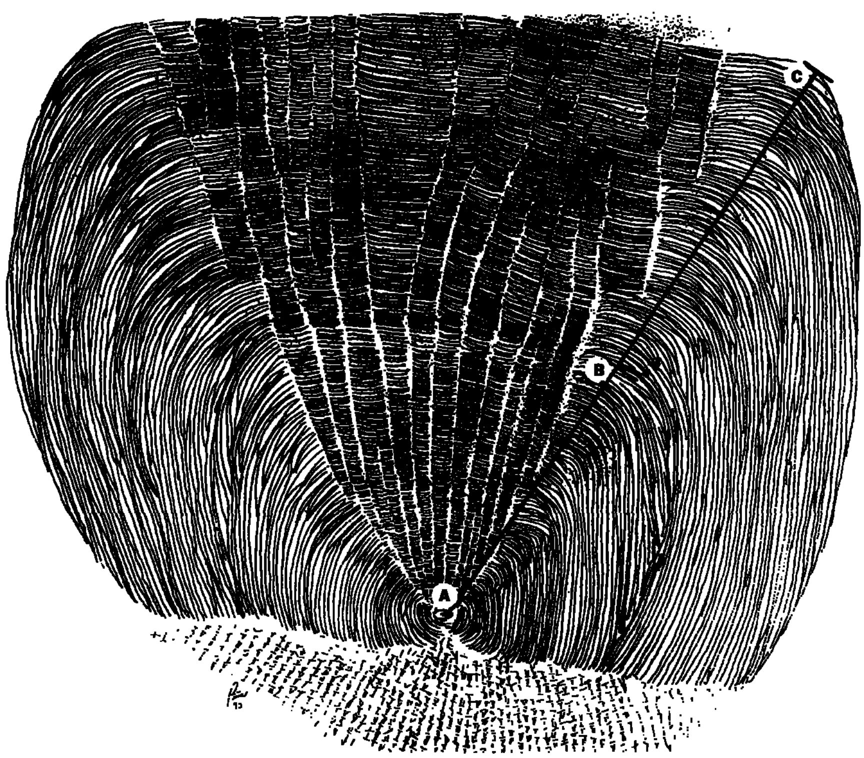

Figure 1
Black drum scale indicating morphological features used to measure radii and annuli: A = focus, B = annulus, and C = scale margin.

The time of annulus formation was estimated by narrowing the possible time(s) using the fish with increased numbers of scale annuli. The longest period between release and recapture defined the possible period of formation. This estimate was refined by using the fish free the next longest period, and so on. Fish with no annuli increases were then used to confirm or refine the possible period of annulus formation.

The effect of tagging on scale growth was examined by comparing the relationship between scale radius (Y) and total length (X) and the mean distances from scale focus to each annulus at release to those at recapture. Least-squares linear regression for single Y at each X and analysis of covariance (Sokal and Rohlf, 1981) were used to compare relationships. One-way analysis of variance (Sokal and Rohlf, 1981) was used to compare distances from focus to each of the first three annuli. The lack of scales with more than three annuli at release precluded comparison of other annuli. The probability level for all statistical analyses was set at 0.05.

Results and discussion

The scale method for aging black drum <4 years old is valid. Only one opaque zone was formed each year, between April and May. Eight of the 17 fish with usable scales at release and recapture had scales with more annuli (1) at recapture than at release (Table 1). All fish except one (B71764) were free during May; the one exception was free through 21 April. This suggests that annulus formation is completed between late April and late May. Data from the five fish not free during April or May support this conclusion; the number of annuli did not increase between release and recapture. Two fish free for 1 day in May provided little information; both showed no change in number of annuli. Two other fish released in late April and early May did not show an increase in number of annuli. One fish (F31261) released in late April may have formed an annulus just prior to initial capture, since the second annulus was located 154 mm from the scale focus, and the scale radius was 163 mm (Table 1).

Table 1

Release and recapture data for each black drum tagged in Texas bays during April 1985 through December 1991.

Tag No.	When measured[1]	Date	Bay system	Total length (mm)	Scale radius[2] (mm)	Distance (mm) to annulus 1	2	3	4	5
B71575	Release	10-28-86	Aransas	388	155	60				
	Recapture	06-26-87	Aransas	471	192	65	160			
B71764	Release	10-28-87	Aransas	533	181	63	92	133		
	Recapture	04-21-88	Aransas	522	227	69	108	183	213	
F21080	Recapture	05-02-85	Galveston	468	186	75	153	170		
F24845	Release	10-02-85	Lower Laguna Madre	548	210	65	130	160		
	Recapture	01-07-86	Lower Laguna Madre	555	200	55	100	165		
F24355	Recapture	04-29-86	Lower Laguna Madre	635	219	62	91	156	172	201
F27341	Release	04-18-89	East Matagorda	463	174	71	169			
	Recapture	10-16-90	East Matagorda	632	245	78	172	213		
F27765	Release	05-30-90	East Matagorda	507	200	78	174			
	Recapture	12-02-90	Gulf of Mexico	554	219	85	180	208		
F28057	Recapture	09-10-85	Matagorda	558	250	145	172	210		
F28641	Recapture	11-16-87	Matagorda	572	177	111	150			
F28988	Release	10-22-87	Matagorda	485	200	85	130			
	Recapture	01-18-89	Gulf of Mexico	620	230	80	115	183		
F29119	Release	05-03-88	Matagorda	418	172	63	127	156		
	Recapture	03-14-90	Matagorda	610	204	71	134	175	194	
F29583	Release	10-24-89	Matagorda	343	136	54				
	Recapture	05-24-90	San Antonio	441	142	54	113			
F29867	Release	05-09-90	Matagorda	374	151	61	128			
	Recapture	08-14-90	Matagorda	384	165	81	134	160		
F31261	Release	04-27-89	Corpus Christi	444	163	74	154			
	Recapture	03-07-90	Corpus Christi	526	218	88	179			
F31642	Release	10-25-89	Corpus Christi	511	194	73	150			
	Recapture	12-15-89	Corpus Christi	Not provided	210	65	157			
F31801	Release	05-02-90	Corpus Christi	484	181	82	180			
	Recapture	01-22-91	Corpus Christi	457	143	80	118			
F34101	Release	10-08-87	Galveston	370	124	62				
	Recapture	02-12-88	Galveston	354	135	66				
F37668	Release	05-22-90	Upper Laguna Madre	417	161	68	158			
	Recapture	05-23-90	Upper Laguna Madre	417	161	63	158			
F37671	Release	05-22-90	Upper Laguna Madre	417	158	65	153			
	Recapture	05-23-90	Upper Laguna Madre	417	164	62	159			
F42134	Release	06-01-88	San Antonio	468	164	65	103	140		
	Recapture	12-02-88	San Antonio	584	232	65	154	210		
F42489	Release	09-28-89	San Antonio	398	155	79	116			
	Recapture	01-29-90	Aransas	438	173	81	138			
F71439	Recapture	10-28-86	Aransas	560	253	90	185	215		

[1] Data from all fish with TL measured at release were used to estimate scale radius-TL relationship at release in Table 2; data from all fish measured at recapture (excludes tag F31642) were used to estimate scale radius-TL relationship at recapture in Table 2. All scale radius and TL data in this table (except recapture data for tag F31642) were used to estimate the "combined" regression in Table 2.

[2] 32× magnification

Tagging did not appear to influence scale growth or annulus formation, based on scale radius-TL relationship, mean distance from focus to annuli, and similar research with a related sciaenid, red drum (*Sciaenops ocellatus*). The relationship between scale radius and TL (Table 2, Fig. 3) at release was not significantly different from that at recapture (slopes: F=0.14, df=1,34; P=0.80; y-intercepts: F=0.37; df=1,35; P=0.80). The regression for all data combined explained 74% of the variation (r=0.86) and indicated scale radius increased 0.36 unit for each unit of TL increase (Table 2).

Distance of each of the first two annuli from scale focus at release was not significantly different from that at recapture (first annulus: F=2.437; df=1,37; P=0.14; second annulus: F=0.179; df=1,33, P=0.63). However, the mean distance from scale focus to the third annulus was significantly (F=11.078; df=1,14; P=0.005) greater on scales from fish at recapture

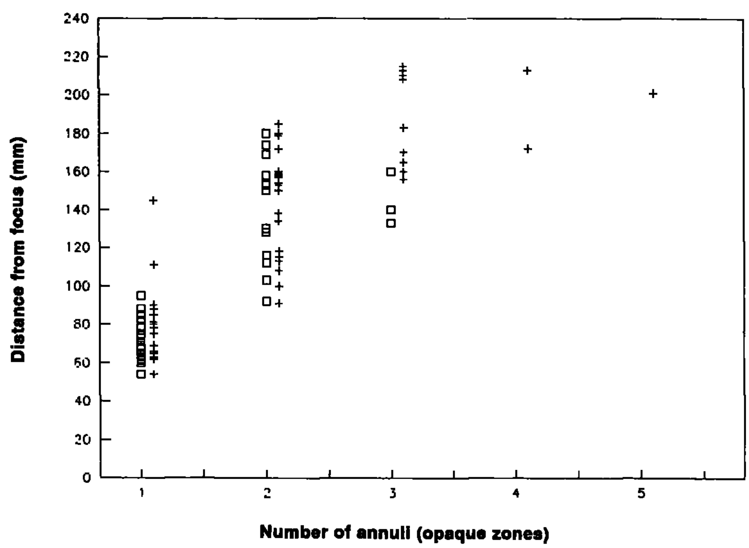

Figure 2

Scale radius distance (32× magnification) to each successive annulus on tagged black drum at release (squares) and at recapture (+).

(187 ± 7 mm) than on those from fish at release (147 ± 4 mm). The difference was due largely to small sample size; a third annulus occurred at 133 mm on one fish (B71764) at release but at 183 mm at recapture (Table 1). The same tagging procedures we used for black drum were used for red drum without affecting scale growth or annulus formation (Matlock et al., 1987). Annuli on black drum scales were formed at mean distances from scale focus (± 1 SE) of 73 ± 3 mm, 143 ± 5 mm, 179 ± 8 mm, 192 ± 20 mm, and 201 mm (Table 3).

The assumption that fishermen reported TL accurately appears valid, but they apparently reported TL less precisely than did TPWD personnel. Evidence for this is that the 95% confidence interval associated with the scale radius-TL relationship was wider for recapture data than for release data (Table 2), but the regressions were not significantly different from each other. Ferguson et al. (1984) demonstrated that anglers in Texas generally report accurate length of recaptured tagged fish, although length measurement reported by anglers were less precise than TPWD measurements for the same fish.

The life history of black drum and annulus formation in related sciaenids further support that black drum scale annulus formation is completed during April and May. Adult black drum spawn during January through April; peak spawning is in March or April (Murphy and Taylor, 1989). Growth in TL is continuous until water temperature cools in winter (December through February) when growth slows substantially (Doerzbacher et al., 1988). Growth increases in spring. If scale growth follows a similar pattern, circuli are closer to each other as growth increases after winter (i.e., annulus formation is completed in spring). Red drum (>1-year-old) growth pattern is similar to black drum and circuli deposition on red drum scales (annulus formation) occurs as expected (Colura et al., 1984; Matlock et al., 1987; Doerzbacher et al., 1988; Green et al., 1990; Bumgaurdner, 1991). If annulus formation in all black drum bony structures (e.g., scales and otoliths) occurs at the same time, then indirect evidence of annulus formation in black drum otoliths also supports the formation of annuli between April and June (Bechman et al., 1990). Additional research is needed to validate annulus formation on scales with four or more annuli.

Acknowledgments

We thank the staff of the Texas Parks and Wildlife Department, Coastal Fisheries Branch, who removed scales from black drum at tagging and David Pina for preparing the final drawing of a black drum scale. We also appreciate two anonymous reviewers and Ronald Hardy who provided constructive comments and suggestions that improved the clarity of the manuscript.

Table 2

Regression statistics for scale radius (Y in mm × 32× magnification)—total body length (X in mm) relationships ($Y = a + bX$) for scales taken from tagged black drum released and recaptured in Texas bays during April 1985 through December 1991. See Table 1 for which fish were used in each analysis.

Time measurements recorded	No. fish measured	a	b	95% CI around b	r	F
Release	17	15.85	0.34	0.26–0.42	0.905**	58.38**
Recapture	21	17.17	0.35	0.24–0.50	0.807**	35.20**
Combined	38	11.44	0.36	0.29–0.45	0.860**	105.33**

**P<0.01.

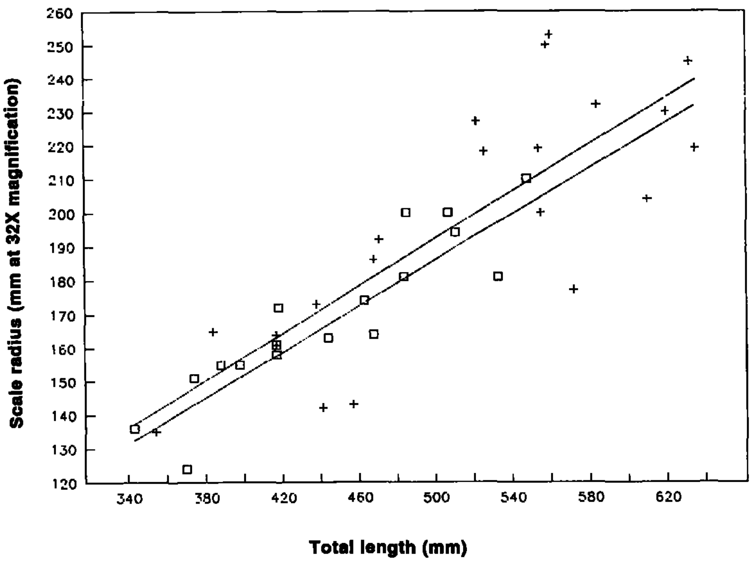

Figure 3

Relationship between fish TL and scale radius (32× magnification) for tagged black drum at release (squares, and bottom line) and at recapture (+, and top line).

Literature cited

Beckman, D. W., A. L. Stanley, J. H. Render, and C. A. Wilson.

1990. Age and growth of black drum in Louisiana waters of the Gulf of Mexico. Trans. Am. Fish. Soc. 119:537–544.

Bumgaurdner, B. W.

1991. Marking subadult red drums with oxytetracycline. Trans. Am. Fish. Soc. 120:537–540.

Colura, R. L., C. W. Porter, and A. F. Maciorowski.

1984. Preliminary evaluation of the scale method for describing age and growth of spotted seatrout (*Cynoscion nebulosus*) in the Matagorda Bay system, Texas. Tex. Parks Wildl. Dep., Coast. Fish. Branch, Manage. Data Ser. 57, Austin, TX, 17 p.

Cornelius, S. A.

1984. Contribution to the life history of black drum and analysis of the commercial fishery of Baffin Bay. Volume II. Tech. Bull. 6, Caesar Kleberg Wildl. Res. Inst., Kingsville, TX, 53 p.

Table 3

Mean (±1SE) distance (mm at 32× magnification) from focus to annulus (*Y*) for each annulus on scales taken from black drum tagged and recaptured in Texas bays during April 1985 through December 1991.

Time measurements recorded	No. scales measured	Mean distance to annulus (number of annuli measured)				
		1	2	3	4	5
Release	17	[1]69±2 (17)	[2]140±7 (14)	[3]147±4 (4)		
Recapture	22	[4]77±4 (22)	[5]144±6 (21)	[6]187±7 (12)	192±20 (2)	[8]201 (1)
Combined	39	[1,4]73±3 (39)	[2,5]143±5 (35)	[3,6]179±8 (16)	[7]192±20 (2)	[8]201 (1)

[1] Tagged fish used in analysis were B71575, B71764, F24845, F27341, F27765, F28988, F29119, F29583, F29867, F31261, F31642, F31801, F34101, F37668, F37671, F42134, and F42489.
[2] Tagged fish used in analysis were the same as in footnote 1 except B71575, F29583, and F34101.
[3] Tagged fish used in analysis were B71764, F24845, F29119, and F42134.
[4] Tagged fish used in analysis were B71575, B71764, F21080, F24845, F24355, F27341, F27765, F28057, F28641, F28988, F29119, F29583, F29867, F31261, F31642, F31801, F34101, F37668, F37671, F42134, F42489, and F71439.
[5] Tagged fish used in analysis were the same as in footnote 4 except F34101.
[6] Tagged fish used in analysis were B71764, F21080, F24845, F24355, F27341, F27765, F28057, F28988, F29119, F29867, F42134, and F71439.
[7] Tagged fish used in analysis were B71764 and F24355.
[8] Tagged fish used in analysis was F24355.

Dailey, J. A., J. C. Kana, and L. W. McEachron.
1991. Trends in relative abundance and size of selected finfishes and shellfishes along the Texas coast: November 1975–December 1989. Tex. Parks Wildl. Dep., Fish. Wildl. Div., Manage. Data Ser. 53, Austin, TX, 241 p.

Doerzbacher, J. F., A. W. Green, and G. C. Matlock.
1988. A temperature compensated von Bertalanffy growth model for tagged red drum and black drum in Texas bays. Fish. Res. 6:135–152.

Ferguson, M. O., A. W. Green, and G. C. Matlock.
1984. Evaluation of the accuracy and precision of volunteered size data from tagged red drum returns. N. Am. J. Fish. Manage. 4:181–186.

Green, A. W., L. W. McEachron, G. C. Matlock, and H. E. Hegen.
1990. Use of abdominal streamer tags and maximum-likelihood techniques to estimate spotted seatrout survival and growth. Am. Fish. Soc. Sym. 7:286–292.

Klima, E., and D. C. Tabb.
1959. A contribution to the biology of the spotted weakfish, *Cynoscion nebulosus* (Cuvier), from northwest Florida with a description of the fishery. Fla. State. Bd. Conser. Tech. Ser. 30, St. Petersburg, FL, 38 p.

Matlock, G. C., R. L. Colura, A. F. Maciorowski, and L. W. McEachron.
1987. Use of on-going tagging programs to validate scale readings. *In* R.C. Summerfelt and G.E. Hall (eds), The age and growth of fish, p. 279–285. Iowa State Univ. Press, Ames.

Murphy, M. D., and R. G. Taylor.
1989. Reproduction and growth of black drum, *Pogonias cromis*, in northeast Florida. N.E. Gulf Sci. 10:127–137.

Music, J. F., and J. M. Pafford.
1984. Population dynamics and life history aspects of major marine sportfishes in Georgia's coastal waters. Ga. Dep. Nat. Resour. Coast. Div. Contrib. Ser. 38:1–382.

Osburn, H. R., G. C. Matlock, and H. E. Hegen.
1980. Description of multiple census tagging program for marine fisheries management. Ann. Proc. Tex. Chapter Am. Fish. Soc. 2:9–25.

Pearson, J. C.
1929. Natural history and conservation of redfish and other commercial sciaenids on the Texas coast. Bull. U.S. Bur. Fish. 44:129–214.

Peters, K. M., and R. H. McMichael Jr.
1990. Early life history of the black drum *Pogonias cromis* (Pisces: Sciaenidae) in Tampa Bay, Florida. N.E. Gulf Sci. 11:39–58.

Richards, C. E.
1973. Age, growth, and distribution of the black drum (*Pogonias cromis*) in Virginia. Trans. Am. Fish. Soc. 102:584–590.

Simmons, E. G., and J. P. Breuer.
1962. A study of redfish, *Scianeops ocellatus*, and black drum, *Pogonias cromis*. Publ. Inst. Mar. Sci. Univ. Tex. 8:184–211.

Smith, S. H.
1954. Method for producing plastic impressions of fish scales without using heat. Prog. Fish-Cult. 16:75–78.

Sokal, R. R., and F. J. Rohlf.
1981. Biometry. W.H. Freeman, NY, 859 p.