Direct validation of ages determined for adult black drum, *Pogonias cromis*, in east-central Florida, with notes on black drum migration

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Findings from indirect age validation studies, in which marginal increments in black drum, *Pogonias cromis*, otolith sections were examined, indicate that the number of opaque bands observed in otoliths is a measure of the true age in years of black drum (Murphy and Taylor, 1989; Beckman et al., 1990; Beckman et al.[1]). However, validation studies of scale-determined ages have indicated that more than one mark is deposited on black drum scales each year after they reach about age four (Richards, 1973; Cornelius, 1984). In addition, evidence from an analysis of the marginal increments for a related sciaenid, the croaker *Micropogonias opercularis*, has indicated that more than one opaque band was deposited on its otoliths each year (Haimovici, 1977).

Unlike indirect validation studies which provide estimates of the periodicity of annulus formation for a sample of fish, mark-recapture studies provide proof of the accuracy of an age determination technique for an individual fish during the period of time between marking and recapture (Beamish and McFarlane, 1983). This direct technique has been used to validate ages for a variety of species, including red drum, *Sciaenops ocellatus* (Murphy and Taylor, 1991; Ross et al., 1995); snapper, *Pagrus auratus* (Francis et al., 1992); sablefish, *Anoplopoma fimbria* (McFarlane and Beamish, 1995); and the tropical parrotfish *Scarus schlegeli* (Lou, 1992). Because mark-recapture studies provide information on the validity of age marks formed since the mark was applied, they cannot be extrapolated to imply the validity of younger ages (Francis, 1995).

In assessing the status of black drum stocks, accurate age determination is especially critical. These fish are suspected to live to about 60 years old, and the large fisheries that they have supported apparently exploited infrequent, large year classes (Jones et al., in press; Beckman et al.[1]). The purpose of this study was to validate directly the ages of adult black drum by using mark-recapture methods. The sample of recaptured fish also provided insight into the population dynamics of black drum in east-central Florida.

Materials and methods

We used a 549-m nylon trammel net (124- and 356-mm mesh, inside and outside stretch, respectively) to capture adult black drum in the southern Mosquito Lagoon and northern Banana River areas of the Indian River Lagoon system along Florida's Atlantic coast (Fig. 1). Black drum were captured for tagging in February, June, and September 1992, and in February, June, and August 1993. Each fish was measured for total length (mm), tagged with a 100-mm Hallprint plastic dart tag, injected intramuscularly with approximately 25 mg of oxytetracycline (OTC) per kilogram of body weight, and released to the capture area. The dart tag was placed in the side of the fish about 25 mm ventral to the anterior insertion of the second dorsal fin. This placement allowed the barb to lodge behind a pterygiophore while leaving the external message (streamer) visible. This external streamer bore an identification number and a message in-

[1] Beckman, D. W., C. A. Wilson, D. L. Nieland, and A. L. Stanley. 1990. Age structure, growth rates, and reproductive biology of black drum in the northern Gulf of Mexico. Final report, U.S. Dep. Commerce Cooperative Agreement NA89WC-H-MF017, Marine Fisheries Initiative (MARFIN) Program, 77 p.

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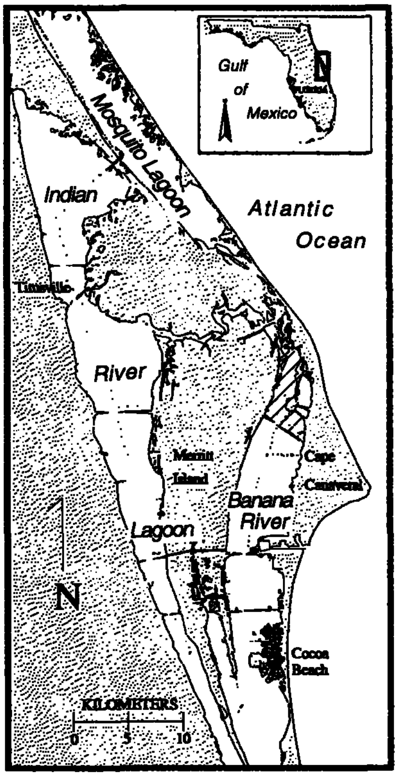

Figure 1
Sampling area for black drum along the Atlantic coast of Florida. Most sampling was done in the area shown by diagonal lines just west of Cape Canaveral. Some sampling was also done in the southern portion of Mosquito Lagoon.

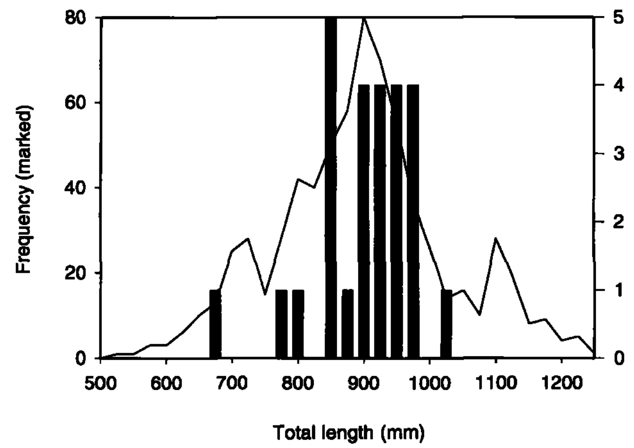

Figure 2
Total length-frequency distribution (mm) for black drum that were tagged and released (line, n=707) and for those that were recaptured (bars, n=26).

structing anglers to contact us. The OTC provided a reference mark defining the otolith margin at the time of initial capture; all recaptures of fish whose otoliths were recovered were made by biologists during sampling trips conducted in August 1993 and January, October, and December 1995.

Recaptured fish were sacrificed and returned to the laboratory, where they were measured for total, fork, and standard lengths; weighed to the nearest tenth of a kilogram; and sexed macroscopically. Sagittal otoliths were excised and stored dry. An Isomet low-speed saw was used to make transverse cuts near the core of the whole otolith. Otolith sections were about 0.5-mm thick and were mounted on glass slides with coverbond mounting media. Opaque bands and OTC marks were examined with a compound dissecting microscope (4× magnification) equipped with an ultraviolet light source. Distances from the otolith core to the proximal edge of the OTC mark and to each opaque band distal to the OTC mark were measured along the axis from the core to the ventral edge of the sulcus acousticus with the aid of an Optimus digital-image processing system.

Results and discussion

A total of 707 adult black drum, from 515 to 1,237 mm TL, were captured, injected, and tagged during this study. Twenty-six of these fish were recaptured, and their otoliths were excised. Lengths of recaptured black drum ranged from 656 to 1,011 mm TL (Fig. 2). Most of the large (>1,050 mm TL) adult black drum found in our sample came from a school of very large fish caught in southern Mosquito Lagoon; according to two tag returns (see below), this school had apparently left the area shortly after tagging and release.

Ages of recaptured black drum ranged from 3 to 13 years (Table 1); 16 were age 8 and older and were likely to have been mature adults at time of recapture (Murphy and Taylor, 1989). Time-at-large for recaptured fish was from just over a month to just less than three years, i.e. 42–1,031 days.

Observations of the number of opaque bands deposited since the fish had been marked supported our hypothesis that one band formed each year from the late winter to early spring. We observed that five fish tagged during February or June 1993 and recaptured 42–176 days later in August 1993 had not deposited an opaque band since being marked (Table 1). One fish at large for 555 days between June 1993 and January 1995 had deposited one band since release. All other fish recaptured had been at large for 805 to 1,031 days, during which two late-winter to early-

Table 1

Tag, recapture, and otolith-measurement data for OTC-marked black drum. Otolith measurements were made from the core to the proximal edge of the OTC band and all subsequent opaque bands to the otolith edge along the ventral margin of the sulcus acousticus.

Tagged		Recaptured				Distance from otolith core (mm)			
Date	Total length (mm)	Date	Total length (mm)	Days free	Age (yr)	OTC mark	Annulus	Annulus	Otolith edge
Jun 93	660	Aug 93	656	42	3	2.33			2.35
Feb 93	836	Aug 93	838	176	5	2.75			2.86
Feb 93	975	Aug 93	945	176	11	3.99			4.08
Feb 93	925	Aug 93	921	176	11	3.85			3.90
Feb 93	940	Aug 93	926	176	11	3.79			3.86
Jun 93	732	Jan 95	790	555	4	2.39	2.65		2.81
Aug 93	832	Oct 95	887	805	13	3.56	3.62	3.74	3.93
Aug 93	899	Oct 95	968	805	9	3.44	3.50	3.68	3.87
Aug 93	922	Oct 95	961	805	13	3.75	3.81	3.95	4.11
Jun 93	711	Oct 95	826	847	5	1.74	1.83	2.04	2.31
Feb 93	975	Oct 95	1,011	991	13	3.61	3.75	3.94	4.13
Aug 93	821	Oct 95	859	805	13	3.73	3.77	3.93	4.09
Feb 93	873	Oct 95	886	981	9	3.00	3.16	3.29	3.51
Aug 93	925	Oct 95	952	805	13	4.03	4.08	4.23	4.40
Feb 93	673	Oct 95	842	981	6	2.50	2.63	2.86	3.10
Jun 93		Oct 95	903	847	5	2.44	2.55	2.81	3.03
Aug 93	832	Oct 95	843	805	13	3.77	3.80	3.96	4.11
Aug 93	941	Oct 95	943	805	13	3.95	4.00	4.17	4.33
Aug 93	852	Oct 95	886	805	13	3.98	4.02	4.15	4.29
Jun 93	620	Oct 95	771	847	5	2.37	2.55	2.83	3.06
Feb 93	880	Dec 95	965	1,031	9	3.30	3.45	3.67	3.92
Feb 93	892	Dec 95	936	1,031	13	3.78	3.90	4.03	4.20
Aug 93	782	Dec 95	899	855	6	2.99	3.08	3.40	3.67
Feb 93	790	Dec 95	911	1,031	7	2.79	2.96	3.18	3.44
Aug 93	789	Dec 95	917	855	8	3.24	3.28	3.53	3.76
Aug 93	690	Oct 95	830	806	5	2.55	2.64	2.91	3.24

spring periods of opaque band formation had occurred. All of the latter had deposited two bands on their otoliths (Fig. 3).

Our direct validation for most ages from 3 years to 13 years indicates that for young adult black drum, at least, age can be determined accurately by counting saggital otolith annuli. Our results extend the findings of an indirect validation study that had used the periodicity of marginal increments as evidence for validation of ages for black drum up to age four in northeast Florida (Murphy and Taylor, 1989). In addition, the seasonal appearance of opaque margins on the otolith sections in older black drum between 20 and 37 years old in the northern Gulf of Mexico (Beckman et al., 1990) is evidence for the validity of this aging technique in older fish. In contrast, the formation of two growth increments or marks per year on scales appears to begin at the time of maturity; formation of the second mark has been attributed to spawning (Richards, 1973). All black drum larger than 700 mm FL (717 mm TL) and more than four years old that were sampled in the northern Gulf of Mexico (Nieland and Wilson, 1993), and all black drum larger than 650 mm TL and more than 5 years old sampled off northeast Florida (Murphy and Taylor, 1989) were mature. Because our samples included adult fish of these sizes and ages, they were likely mature. Therefore black drum in our sample had clearly deposited only one opaque band on the sagittae each year for a number of years after they first matured. It seems likely then that, unless black drum begin to deposit multiple annuli each year after they attain some age older than that found in our samples, their maximum age would be at least equal to the highest reported opaque band count, about 60 for black drum in U.S. Atlantic coastal waters (Murphy and Taylor, 1989; Jones et al., in press).

Our relatively small sample of validated ages for black drum lends support to previous findings of highly variable year-class strength for this species, and for the generally rapid growth of some fishes inhabiting the Indian River and Mosquito Lagoons. Eleven of the 26 black drum we recaptured were members of the 1982 year class, the oldest year class in our sample. Beckman et al.[1] also noted the persistence of several large year classes (the 1979, 1974, 1970, and 1966 year classes) in the purse-seine fishery catch in the northern Gulf of Mexico, during 1986–89, and Jones et al. (in press) noted that the exceptionally large 1942 and 1934 year classes were still prominent in 1990–92 samples collected from Chesapeake Bay fisheries. Observed sizes at age of black drum in our sample, when released, were 620–732 mm TL for 3 year olds, 782–836 mm for 4 year olds, and 789–880 mm for 6 year olds. These sizes at age were much larger than those predicted for northeast Florida black drum: 477, 555, 625, and 687 mm TL for ages 3–6 (Murphy and Taylor, 1989). Young red drum, *Sciaenops ocellatus,* and spotted seatrout, *Cynoscion nebulosus*, are also larger at age in the Indian River Lagoon than in other areas of Florida (Murphy and Taylor, 1990, 1994).

Limited tag-recapture information gathered during this study indicates that some larger black drum make extensive migrations from the Indian River Lagoon system. Seven of the 9 angler-recaptured, tagged black drum (none of whose otoliths were recovered) were caught in the northern Indian River Lagoon within 10 km of their release site. Two fish (1,025 and 1,163 mm TL), however, tagged and released in February 1992 travelled about 1,370 km north to Chesapeake Bay, where they were captured by anglers in late May and early June. Although the reproductive states of these two tagged fish were not recorded at release, many of the males tagged along with them were running ripe. The fact that these fish moved to Chesapeake Bay during the time period when peak spawning progresses up the Atlantic coast may imply that black drum continue spawning as they move northward during the spring. This migration would enable them to broadcast their average annual fecundity of 32–45 million eggs (Fitzhugh et al., 1993; Nieland and Wilson, 1993) over a wide range of suitable egg and larval habitats.

Extensive tagging studies in Florida during the early and mid-1960's showed that, except for some of those released on beaches, black drum hardly moved from a release site (Topp, 1963; Beaumariage, 1964, 1969; Beaumariage and Wittich, 1966); even the greatest movement of fish along the beaches was less than 145 km. The total lengths of fish tagged during these studies were generally less than 500 mm. In Texas, Osburn and Matlock (1984) found substantial intrabay movement of small immature black drum, but little movement between bays. Music and Pafford (1984) also found that most black drum tagged in Georgia did not move far from the area of release. However, in Georgia 13% of all returned fish

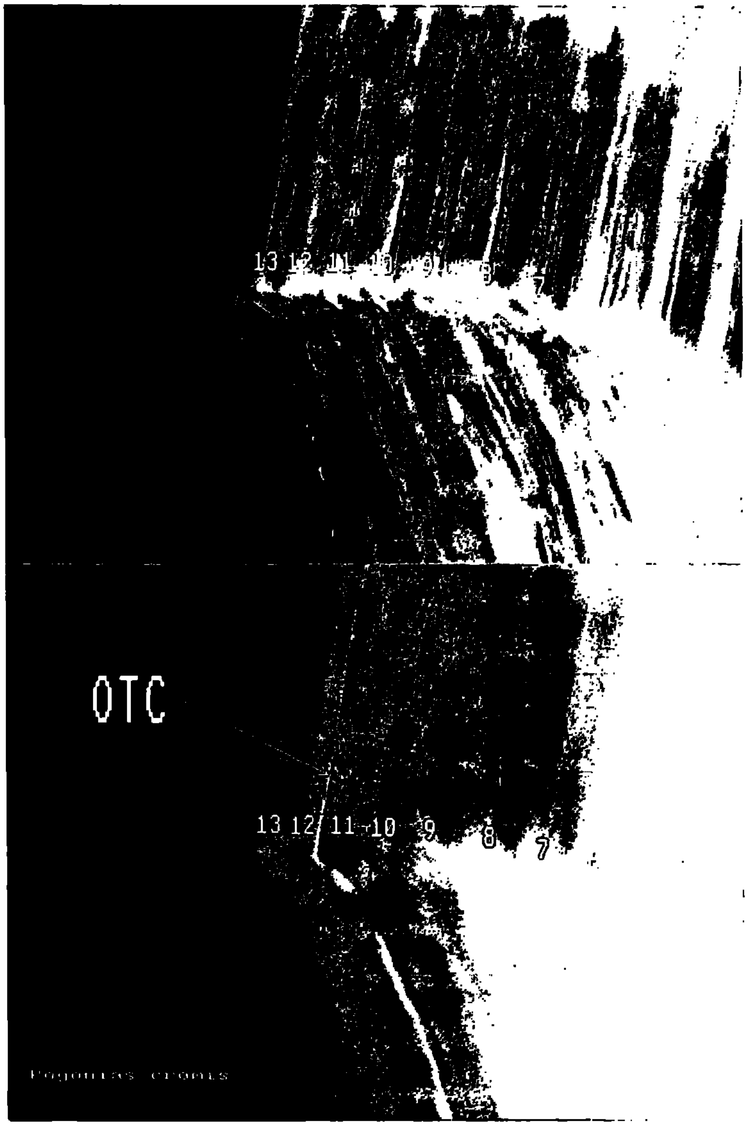

Figure 3

A black drum otolith section shown under reflected light only (top) and under reflected light and ultraviolet light (bottom). Opaque bands are numbered consecutively from the core, and the fluorescing oxytetracycline (OTC) band is indicated. This fish was tagged and injected in August 1993 and recaptured 941 days later in October 1995.

had moved more than 100 km, reaching as far south as West Palm Beach, Florida (619 km), and as far north as Murrells Inlet, North Carolina (437 km). Surprisingly, the two black drum that had travelled the farthest from their release sites in Georgia were less than 350 mm TL.

Because black drum are long-lived and capable of extensive movements, knowledge about the magnitude and frequency of their mixing during their potential 60-year life span is critical for understanding how fishing pressure within one geographic area affects fish populations in other areas. In Florida, strict regulations on the harvest of black drum were implemented in 1989 following unvalidated evidence that they were long-lived fish (Murphy and Taylor, 1989). Because many current stock assessment techniques often depend on an accurate estimate of maximum life span so that a natural mortality rate for a population can be determined, validation studies are especially critical in helping to prevent mismanagement of long-live species (Beamish and McFarlane, 1983).

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