Stomach Content Analysis Of Cobia, Rachycentron Canadum, From Lower Chesapeake Bay

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Seasonal occurrence and site-utilization patterns of adult tautog, Tautoga onitis (Labridae), at manmade and natural structures in lower Chesapeake Bay*

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The labrid Tautoga onitis (tautog) is a highly prized game fish targeted by anglers fishing at natural and manmade structure (Briggs, 1977; Lucy and Barr, 1994). Tautog are distributed between Georgia (Parker, 1990) and Nova Scotia (Bigelow and Schroeder, 1953); peak abundance is found between Massachusetts and the Delaware Capes. Slow growth rate, late age at maturity, predictable distribution, and localized population structure suggest high vulnerability to overexploitation (Hostetter and Munroe, 1993). Extended residence at accessible fishing sites may increase the potential for overexploitation; thus, residence and site-utilization patterns of tautog throughout this species' distribution range must be well understood for effective management of this resource.

Tag-recapture studies in New York, Rhode Island, and Massachusetts suggest that adult tautog spend spring and fall months inshore, may move offshore during the warmest summer months (Cooper, 1966; Briggs, 1969), and overwinter offshore (Cooper, 1966; Briggs, 1977). Tautog leave inshore waters at varying rates between July and October (Cooper, 1966) and are recaptured in coastal waters in fall (Cooper, 1966; Briggs, 1977), consistent with indirect observations on seasonal abundance (Stolgitis, 1970; Olla et al., 1974). In contrast, tag-recapture studies report limited evidence of a seasonal inshore-offshore migration for tautog in the Chesapeake Bay and coastal Virginia waters. Seasonal abundance data also suggest that tautog remain inshore in Chesapeake Bay (Hostetter and Munroe, 1993) and in Delaware Bay (Eklund and Targett, 1991) during winter.

Abstract—Ultrasonic transmitters were surgically implanted into adult tautog (n=27, 400–514 mm TL) to document seasonal occurrence and site utilization at four sites situated within known tautog habitat near Cape Charles, Virginia, in lower Chesapeake Bay. Tagged tautog were released at the same sites where originally caught within 2 h of capture. Sites were continuously monitored with automated acoustic receivers between 9 November 1998 and 13 October 1999. Two sites consisted of natural bedform materials and two sites consisted of manmade materials. Ninety-four percent of tautog (n=15) released in fall 1998 remained inshore during winter at sustained water temperatures of 5–8°C, rather than moved offshore during winter as documented for tautog off New York, Rhode Island, and Massachusetts. Ninety-one percent (n=10) of tautog released in spring 1999 remained inshore during summer when water temperature was 27°C and in the absence of an important food item, blue mussels (Mytilus edulis). These findings conflict with assertions that tautog move to cooler water in summer when water temperatures reach 20°C. Tautog released at natural bedform sites were detected only at these sites throughout the study. Tautog released at manmade structures also displayed high site-utilization patterns, but several tautog periodically moved 2–10.2 km away from these sites over featureless bottom, a known deterrent to emigration for large these sites over featureless bottom, a known deterrent to emigration for large...
The tag-recapture method is not a suitable method for evaluating site-utilization patterns because this technique does not provide information on the location of tagged animals between times of release and recapture. Furthermore, the tag-recapture method requires that tagged animals be recaptured, and be reported as recaptured, before any information is available. Ultrasonic telemetry, however, enables continuous observations on all tagged animals, in their natural environment, without requiring that tagged animals be recaptured (Winter, 1996). Previously, only in one other study (Olla et al., 1974) was ultrasonic telemetry used to monitor adult tautog. Olla et al. (1974) tagged and “tracked” 10 adult tautog ultrasonically in Great South Bay, NY, for up to 80 h after their release. Although an important study, their sample size was small and total observations too limited (<400 h, single season) to document seasonal occurrence and site-utilization patterns for this species.

Ultrasonic telemetry was selected to address seasonal occurrence and site-utilization patterns of adult tautog in lower Chesapeake Bay, given that tag-recapture methods can be applied only within limitations and given that the poor visibility and strong currents preclude direct underwater observations of this species in this turbid estuary. Rather than collect detailed positional data over short periods of time (days) for a few tautog, we chose to collect seasonal occurrence and site-utilization data for two large groups of tautog (n=16 and 11) at four specific sites located within known tautog habitat. Sites were monitored by using a fixed, submerged hydrophone array between November 1998 and September 1999. The first objective of our study was to determine if tautog remained inshore at natural and manmade structures in lower Chesapeake Bay during winter and summer. The second objective was to document and describe site-utilization patterns within inshore study sites. Data for daily activity patterns are presented elsewhere (Arendt et al., in press).

Materials and methods

Tautog were caught, tagged, and released at four sites situated within a 1.5 km × 6 km area near Cape Charles, Virginia (Fig. 1). Side-scan sonar (Sea Scan Technology, Ltd., White Marsh, VA) was used to measure dimensions of the four study sites and to map the surrounding seafloor. The Texaco Wreck, a 30 m × 100 m shipwreck, was located in 18 m of water west of the Susquehanna Channel (30-40 m deep) in an area characterized by flat, relatively featureless bottom topography (Wright et al., 1987). The three remaining sites (Airplane Wreck, Coral Lump, and Ridged Bottom) were located in 8-15 m of water east of the Susquehanna Channel in an area characterized by sand flats and deep, mud-bottomed channels (Wright et al., 1987). The Airplane Wreck (40 m × 20 m) consisted of concrete rubble. The Ridged Bottom (30 m × 100 m) and Coral Lump (100 m × 300 m) sites consisted of natural bedforms. Otter trawl, oyster dredge, and underwater video surveys indicated that all sites were densely populated by several species of sponges, colonial bryozoans, mollusks, and crustaceans.

Tautog were caught with standard two-hook bottom rigs baited with pieces of blue crab or clam and were brought aboard with a nylon landing net. Tautog were observed in an aerated live well up to 2 h before transmitters were implanted. Total length (mm) and sex (White, 1996) were recorded. Only tautog >400 mm TL were tagged ultrasonically. This minimum size increased the odds of transmitters weighing less than 1.25% of fish body weight in water (Winter, 1996), based on size-weight relationships for tautog in Virginia (Hostetter and Munroe, 1993; White, 1996). Tautog >400 mm were also reproductively mature (Hostetter and Munroe, 1993; White, 1996).

Surgical procedures were similar to those used in Nemetz and Macmillan (1988), Mortensen (1990), Holland et al. (1993), Szedlmayer (1997), and Thoreau and Baras (1997). In preparation for surgical implantation of transmitters, level-four anesthesia (Mattson and Ripple, 1989; Prince et al., 1995) was induced by immersing tautog in a 325-mg/L solution of MS-222. Once anesthetized, a small

Figure 1
Location of study sites for telemetric study of tautog released in lower Chesapeake Bay near Cape Charles, VA. Texaco Wreck (TX) is located in 18 m of water on a plain west of Susquehanna Channel (30–40 m deep). Coral Lump (CL), Ridged Bottom (RB), and Airplane Wreck (AW) are located in 8–15 m of water on a flat east of the Susquehanna Channel.
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(25-mm) incision was made on each fish immediately dorsal to the ventral midline between pelvic fins and anus with a sterilized, disposable razor blade. The transmitters were coated in sterile mineral oil and placed into the visceral cavities of tautog with the transducer end of the transmitter facing forward. Braided, polyglycolic acid sutures (Dexon®, I-III), surgical staples (Proximate Plus MD 35W®), and acrylic adhesive (Krazy glue®) were used to close the incision. Betadine was used periodically throughout the surgical procedure and antibiotics (Nu-Flor®) were injected intramuscularly to increase postsurgical survival (Schramm and Black, 1984; Bart and Dunham, 1990; Poppe et al., 1996). Tautog were revived in the aerated live well and released within 0.5 h after surgery. Preliminary evaluation of surgical procedures with “dummy” transmitters indicated 100% transmitter retention, 86% survival, and normal swimming, feeding, reproductive behavior, and physiology for tautog >400 mm TL held up to 418 days in captivity (Arendt, 1999). Tautog were fully recovered from surgery <1 to 6 days after release (Arendt, 1999) according to detection patterns recorded by automated acoustic receivers (Arendt and Lucy, 2000).

V-16-1H-R256 coded transmitters (16 mm × 48 mm, 9 g in water; Vemco, Ltd., Shad Bay, Nova Scotia, Canada) were used in our study. Signal repeat intervals for coded transmitters (69 kHz) varied randomly between 45 and 75 s, which extended battery life to 111 d. Transmitters were designed to create three distinct reception zones: a central reception zone common to both receivers and two peripheral reception zones unique to either receiver. VR1 receivers were deployed 100–150 m to the west and east of the perimeter of each of the four sites. Detection radius for each receiver was approximately 400 m. Detection areas for both receivers were overlapped to create three distinct reception zones: a central reception zone common to both receivers and two peripheral reception zones unique to either receiver. VR1 receivers were moored 1.5–3.0 m above the seafloor to provide an unobstructed line-of-sight for transmitter signal reception (i.e. positioned above the “structure” associated with each site) and to reduce acoustic interference from suspended material associated with strong bottom currents. Mooring units consisted of a railroad wheel (227 kg), stainless steel aircraft cable (0.64 cm, 7 × 19 strand), and subsurface and surface floats. Receivers were retrieved every three to six weeks and detection data (transmitter ID, date and time of detection) were downloaded directly to a shipboard computer by means of a VR1-PC cable interface (Vemco, Ltd.).

Data for tautog released in fall 1998 were collected for the duration of the transmitter battery life. Data for tautog released in spring 1999 were collected until all VR1 receivers were permanently removed from each site. VR1 detections for each tautog were sorted into hourly bins and examined graphically. Because tautog are diurnally active and nocturnally quiescent (Olla et al., 1974; Arendt et al., in press), only daytime detection was used to determine site-utilization patterns. Tautog were considered resident at a particular site each day if they were detected at the same site throughout the day (morning, mid-day, evening). Total fish-days (sum of all days between date of first and last detection for all fish) for each calendar season were classified as 1) days when tautog were resident at the site of initial release, 2) days when tautog were detected at an alternative site, or 3) days when they were not detected at all. Site-utilization patterns of tautog were examined for each site in fall (from 9 Nov 98 to 20 Dec 98), winter (from 21 Dec 98 to 20 Mar 99), spring (from 21 Mar 99 to 20 Jun 99), and summer (from 21 Jun 99 to 9 Sep 99).

To increase the probability that tautog would be reported as recaptured should recapture occur, transmitters were labeled with the specimen’s ID number, a $50 “reward” notice, and a phone number. Tautog were tagged externally with a small, orange t-bar anchor tag (TBA2; Hallprint, Holden Hill, South Australia) used by the Virginia Game Fish Tagging Program and with a larger, green t-bar tag (SHD-95; Floy Mfg., Seattle, WA) containing the specimen’s ID number, a $50 reward notice, and a phone number. Internal and external reward notices were included because Szedlmayer (1997) had observed that internal reward notices persisted longer than external reward notices for red snapper (Lutjanus campechanus) in the Gulf of Mexico, and that internal reward notices were noticed accidentally. In addition to distinct marking of each tautog, colorful reward posters were posted at over 40 marinas, boat ramps, and tackle shops in lower Chesapeake Bay and literature describing the project was mailed to over 5000 homes and businesses.

Results

Twenty-seven adult tautog (400–514 mm TL) were tagged with ultrasonic transmitters and released (16 in fall 1998, 11 in spring 1999) near Cape Charles, VA (Table 1). Four tautog were released at each of the four sites in fall 1998 and at the Coral Lump and Texaco Wreck in spring 1999. Two tautog were released at the Ridged Bottom and one tautog was released at the Airplane Wreck in spring 1999. Similar numbers of tautog were tagged and released at manmade (n=13) and natural (n=14) sites.

Eighty-one percent (n=22) of all tautog released were males; 19% were females. Thirteen percent (n=2) of tautog released in fall 1998 were female; 27% (n=3) of all tautog released in spring 1999 were female. Both female tautog released in fall 1998 (ID19, ID28) were released at the Texaco Wreck. One female tautog was released at the Texaco Wreck (ID37) and two female tautog were released at the Coral Lump (ID39, ID40) in spring 1999.

Ninety-four percent (n=15 of 16) of tautog released in fall 1998 remained inshore within lower Chesapeake Bay during winter. Ninety-one percent (n=10 of 11) of tautog released in spring 1999 remained inshore within the Bay during summer.

All tautog (n=14) released at natural sites remained inshore and were detected only at their respective release sites. Tautog released at the Ridged Bottom and Coral Lump sites were detected 99% of fish-days in fall, 71–91% of fish-days in winter, 64–100% of days in spring, and
### Table 1
Summary of fish-days for data from 27 adult tautog (400–514 mm TL) tagged and released with ultrasonic transmitters at four sites in lower Chesapeake Bay near Cape Charles, Virginia. Recaptured tautog are noted with an asterisk (*). Abbreviations for sites: CL = Coral Lump; TX = Texaco Wreck; RB = Rridged Bottom; AW = Airplane Wreck.

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98–100% of fish-days in summer (Fig. 2). Reduced detection in winter and spring was partially attributed to two tautog (ID21, ID32) that were detected 46 d and 75 d less than the mean (175 d) for other tautog (n=12) released at the same time. To provide a more conservative estimate of site utilization, these tautog were listed as “not detected” at these sites for these days.

Eighty-five percent (n=11) of tautog released at man-made structures remained inshore and all but three of these were detected only at their respective release sites. Site utilization by tautog at the Texaco Wreck was low (34–71% of fish-days) in all seasons (Fig. 2). One tautog (ID20) released at the Texaco Wreck was only detected at the Texaco Wreck for three hours after being tagged and released in fall 1998. Two additional tautog (ID19, ID28) spent 64–70% of fish-days away from the Texaco Wreck in fall, winter, and spring, and a fourth tautog (ID33) spent 100% of fish-days away from the Texaco Wreck in spring and summer. One of these tautog (ID28) was detected at the Coral Lump for 6 days in January 1999 (VR1 receivers) and all three tautog were regularly detected with the VR60 receiver at a site 2 km south of the Texaco Wreck. Tautog released at the Airplane Wreck were resident 99% of fish-days in fall, 66% of fish-days in winter, and 58% of fish-days in spring (Fig. 2). Reduced detection in winter resulted partially from one tautog (ID30) being detected 108 days less than the mean (175 days) for other tautog (n=12) released at the same time. To provide a more conservative estimate of site utilization, this tautog was listed as “not detected” at the Airplane Wreck for these days. No summer data were available for tautog at the Airplane Wreck because the single tautog (ID41) released there in spring 1999 was detected at this site for two days following release, was later detected at the Texaco Wreck, and then was never detected again at any site. Tautog 41 was listed as “not detected” at the Airplane Wreck from the time of
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Leaving this site until VR1 receivers were removed from this site, 112 d later.

Eight tautog (27%) released in our study were subsequently recaptured (Table 1). Two tautog (ID20, ID29) released in fall 1998 were recaptured (13%) away from release sites by commercial fishermen in spring 1999. Tautog 20 was released at the Texaco Wreck on 10 November 1998 and either left this site the same day or its transmitter failed to transmit data. This tautog was subsequently recaptured 10.2 km northeast of the Texaco Wreck in a crab pot on 27 April 1999, 169 days later. Tautog 29 was first caught at the Airplane Wreck on 13 November 1998 and held in a wire cage with several other tautog at the Airplane Wreck for five days as part of a catch-release mortality study on tautog. After being released at the Airplane Wreck on 18 November 1998, this tautog was recaptured at the Airplane Wreck on 7 December 1998 (19 d later) and ultrasonically tagged and released. Tautog 29 remained at the Airplane Wreck until 12 May 1999, then was recaptured in a gill net 2 km east of the Airplane Wreck on 19 May 1999. Recreational fishermen recaptured six tautog released in spring 1999 (55%) at the same sites where these fish were released 114–211 d earlier and 8–13 weeks after VR1 receivers were removed from sites.

**Discussion**

Tautog remained inshore within lower Chesapeake Bay during winter, at sustained water temperatures of 5–8°C (Arendt et al., in press). Although detected at these water temperatures, tautog overall were detected less than during other times of the year, most likely because tautog remained inactive and within structures for several days at a time (Arendt et al., in press). Inshore occurrence of tautog in winter has been observed in eastern Long Island Sound, Delaware Bay (Eklund and Targett, 1991), and lower Chesa-

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peake Bay (Hostetter and Munroe, 1993). When water temperatures remains above 9–10°C, a viable winter inshore fishery exists for tautog within lower Chesapeake Bay. Within the winter fishery, inshore catches occur predominantly in December and March, whereas offshore catches occur predominantly in January and February. Occurrence of an inshore winter fishery for tautog in Virginia is unique within this species’ geographic distribution.

Tautog remained inshore during the summer at a maximum sustained water temperature of 27°C (Arendt et al., in press). Summer residence data have been supported by direct underwater observations. In frequent recreational catches of tautog in lower Chesapeake Bay during summer have also been reported. Inshore, summer residence of tautog has been documented for Great South Bay, NY, when water temperatures were 19–24°C (Olla et al., 1974) and Narragansett Bay, RI, at maximum sustained water temperatures of 22°C. These findings contradict reports from Virginia (Adams, 1993), New York (Briggs, 1969), and Rhode Island (Cooper, 1966) that adult tautog may move offshore to cooler water during summer.

Tautog remained inshore during summer in the absence of blue mussels (Mytilus edulis), a primary food item of tautog in northern areas (Bigelow and Schroeder, 1953; Olla et al., 1974). In June 1998–99, using underwater video, otter trawl, and oyster dredge, we documented large clusters of live blue mussels at study sites and noted growth of mussels on VR1 mooring units. By July 1998–99, blue mussels were not present at any of these sites. Absence of mussels in July in both years was most likely due to lethal effects of water temperatures ≥27°C (Wells and Gray, 1960).

Because blue mussels are not present in lower Chesapeake Bay year round, the diet of tautog inhabiting lower Chesapeake Bay throughout the year may be more diverse than that of tautog in northern areas. Stomach contents from an ultrasonically tagged tautog recaptured in October 1999 at the Ridged Bottom site consisted primarily of the bryozoan Alcyonidium verilli. At an artificial barrier (Matthews, 1992; Pearcy, 1992; Bradbury et al., 1995, 1997; Zeller, 1997).

Featureless bottom topography, a known deterrent to emigration for large, temperate labrids (Notolabrus tetricus, N. fucicola, Ptililabrus latilauvis, Pseudolabrus psittacus) in Tasmania (Barrett, 1995), did not act as a deterrent to emigration for tautog in lower Chesapeake Bay. Two tautog (ID20, ID28) released at the Texeco Wreck in fall 1998 traversed a wide (2-km), deep (37–40 m) mud-bottomed channel (Wright et al., 1987) on at least three occasions, and one of these tautog (ID20) was subsequently recaptured. Two tautog (ID19, ID28) traveled between the Texeco Wreck and a site 2 km south of the Texeco Wreck on at least 12 occasions. A third tautog (ID33) left the Texeco Wreck almost immediately after being released and was subsequently detected (VR60 receiver) at this site throughout the remainder of our study.

Movement by tautog was assumed to represent actual movement by tagged tautog as opposed to movement of a

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6 Hager, C. 1999 (July). Personal communication of direct underwater observation of tautog at Plantation Light (3–8 m depth), 2 km southeast of Texeco Wreck study site. School of Marine Science, College of William and Mary, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA 23062.

7 Castro, K. 1999 (October). Personal communication of water temperature observation for Narragansett Bay. East Farm Fisheries Center, Univ. Rhode Island, Kingston, RI 02881.


what role reproductive biology and social structure have on seasonal site-utilization patterns.

Site-utilization patterns exhibited by ultrasonically tagged tautog were consistent with patterns reported for tautog released at these same sites from the Virginia Game Fish Tagging Program (VGFTP). Between April 1998 and October 1999, 40 tautog, tagged and released at these sites, were recaptured, including one tautog recaptured twice at the same site. Six of eight (75%) tautog originally released at the Texeco and Airplane Wrecks were recaptured away from these sites. Of these six tautog, three moved to the Coral Lump and Ridged Bottom and three moved to sites located 26.9 to 43.2 km away in lower Chesapeake Bay. In contrast, 32 tautog tagged and released at the Coral Lump and Ridged Bottom sites were recaptured, all but two (which moved from the Ridge Bottom to the Coral Lump) were recaptured where released. One additional fish moved to the Coral Lump from an artificial reef located 4 km to the northeast and within 2 km of where both tautog were recaptured by commercial fishermen in spring 1999.

Ultrasonically and conventionally tagged tautog released near Cape Charles, VA, in lower Chesapeake Bay demonstrated high site utilization at and high site affinity (returned to release sites after short emigration) for release sites. Extended residence by tautog at familiar sites during annual environmental extremes is considered more beneficial than emigration to more optimal environmental conditions because residence at familiar sites reduces the risk of not finding suitable shelter, food, mates, or of encountering predators (Olla et al., 1978). Although directed seasonal offshore movements were not observed in our study, movements between adjacent inshore locations occurred several times, including movement to adjacent locations during the periods of seasonal thermal extremes. Understanding temporal and spatial utilization of habitats is an important first step to identifying essential fish habitat and critical to evaluating and protecting fishery resources within Chesapeake Bay and elsewhere.

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