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

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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 temperate labrids in other waters. Benthic communities were similar at manmade sites and natural bedform sites, and movement away from manmade sites may have been influenced by habitat size as well as habitat structure. Understanding temporal and spatial utilization of habitats is an important first step to identifying essential fish habitat and to evaluating and protecting fishery resources within Chesapeake Bay and elsewhere.

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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.[1] 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.[2] 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.

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[1] Atlantic States Marine Fisheries Commission (ASMFC). 1996. Fishery management plan for tautog, rep. 25, 56 p. [Available from ASMFC, 1444 Eye Street NW, Washington, DC 20005.]

[2] Virginia Game Fish Tagging Program. 1995–1999. Marine Resources Commission, 968 Oriole Dr. South, Suite 102, Virginia Beach, VA 23451.

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).

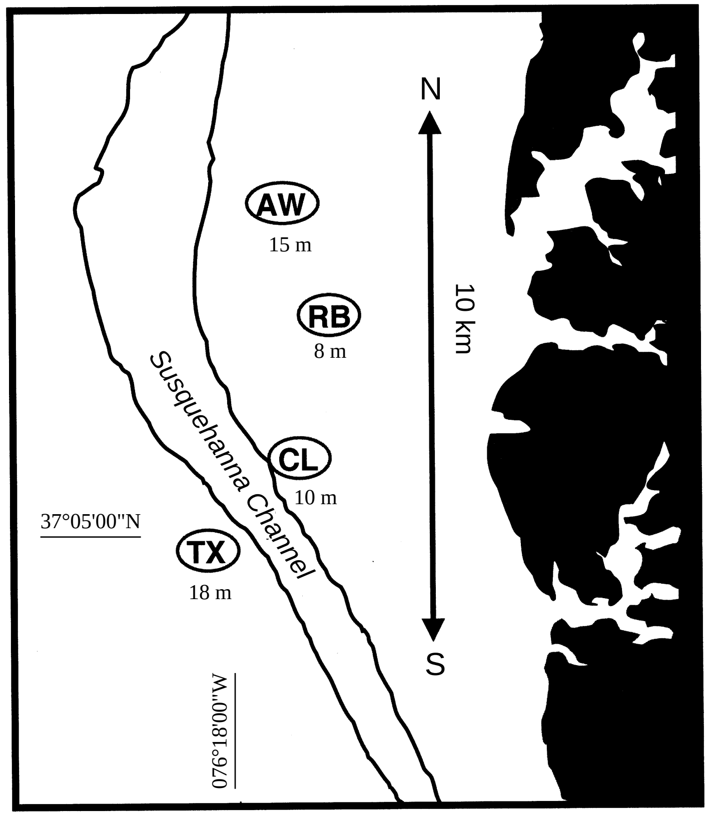

Figure 1

Location of study sites for telemetric study of tautog released in lower Chesapeake Bay near Cape Charles, VA. Texeco 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.

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 Texeco 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

(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 was 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 primarily detected with a submerged array of automated acoustic receivers (VR1, Vemco, Ltd.); however, transmitters were also detected from a research vessel with acoustic hydrophones (V10, VH65, Vemco, Ltd.) and an electronic receiver (VR60, Vemco, Ltd.).

Omnidirectional 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 Szedlymayer (1997) had observed that internal reward notices persisted longer than external reward notices for red snapper (*Lutjanus campechanus*) in the Gulf of Mexcio, 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 Texeco 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 bedform (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 Texeco Wreck. One female tautog was released at the Texeco 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 = Texeco Wreck; RB = Ridged Bottom; AW = Airplane Wreck.

					Fish days			
ID	Sex	TL	Site	Date released	At site	Not detected	At alternate site	Total
1	M	432	CL	9 Nov 1998	174	8	0	182
18	M	406	CL	9 Nov 1998	155	19	0	174
19	F	495	TX	10 Nov 1998	58	105	2	165
20*	M	470	TX	10 Nov 1998	0	167	1	168
21	M	406	RB	10 Nov 1998	88	10	0	98
22	M	400	RB	10 Nov 1998	178	0	0	178
23	M	483	AW	13 Nov 1998	152	13	0	165
24	M	432	AW	13 Nov 1998	112	45	0	157
25	M	432	CL	3 Dec 1998	183	3	0	186
26	M	400	CL	3 Dec 1998	177	4	0	181
27	M	514	TX	4 Dec 1998	177	0	0	177
28	F	413	TX	4 Dec 1998	42	130	13	185
29*	M	400	AW	7 Dec 1998	147	14	1	162
30	M	419	AW	7 Dec 1998	46	21	0	67
31	M	445	RB	8 Dec 1998	144	24	0	168
32	M	419	RB	8 Dec 1998	88	39	0	127
33	M	406	TX	21 Apr 1999	0	136	6	141
34*	M	432	CL	28 May 1999	69	0	0	69
35	M	445	TX	28 May 1999	97	7	0	104
36	M	—	TX	28 May 1999	103	1	0	104
37*	F	445	TX	28 May 1999	99	5	0	104
38*	M	483	CL	7 Jun 1999	59	0	0	59
39*	F	483	CL	7 Jun 1999	59	0	0	59
40*	F	432	CL	7 Jun 1999	59	0	0	59
41	M	445	AW	7 Jun 1999	10	2	2	14
42*	M	406	RB	9 Jun 1999	58	0	0	58
43	M	406	RB	9 Jun 1999	56	2	0	58

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 Texeco Wreck was low (34–71% of fish-days) in all seasons (Fig. 2). One tautog (ID20) released at the Texeco Wreck was only detected at the Texeco 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 Texeco Wreck in fall, winter, and spring, and a fourth tautog (ID33) spent 100% of fish-days away from the Texeco 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 Texeco 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 Texeco 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

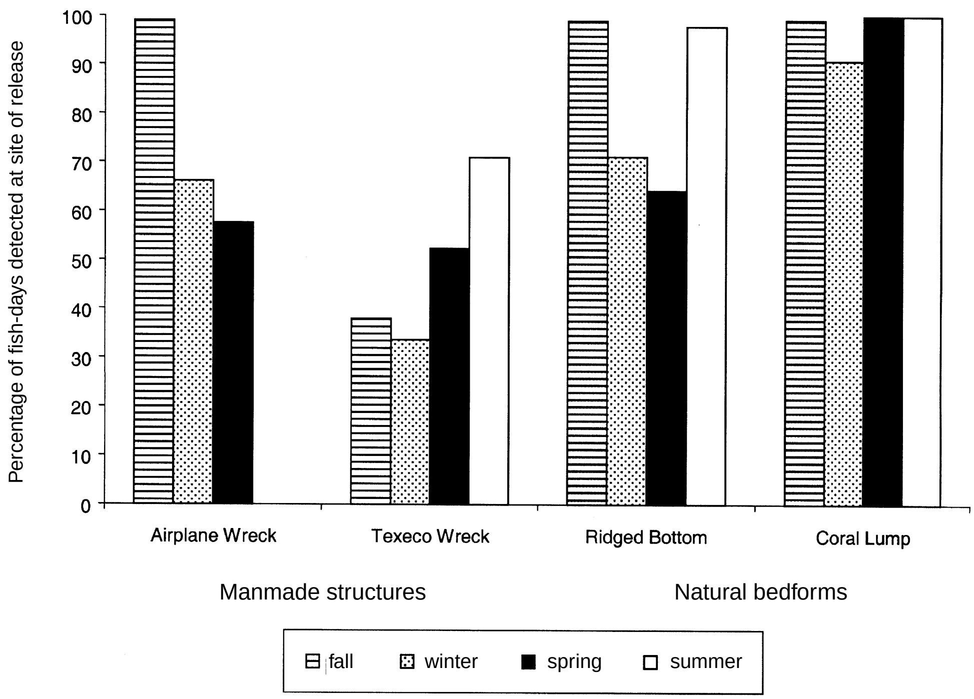

Figure 2

Seasonal site-utilization patterns of tautog released at manmade (Airplane Wreck and Texeco Wreck) and natural bedform (Ridged Bottom and Coral Lump) sites near Cape Charles, Virginia, in fall (9 Nov 98 to 20 Dec 98), winter (21 Dec 98 to 20 Mar 99), spring (21 Mar 99 to 20 Jun 99), and summer (21 Jun 99 to 9 Sep 99). Site-utilization patterns were greatest for tautog released at natural bedform sites.

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 Texeco 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 Texeco 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.[3] 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,[4] Delaware Bay (Eklund and Targett, 1991), and lower Chesa-

[3] Lucy, J. A., and M. D. Arendt. 1999. Exploratory field evaluation of hook-release mortality in tautog (*Tautoga onitis*) in Lower Chesapeake Bay, Virginia. Rep. VMRC-99-10, 11 p. [Available from Marine Advisory Program, Virginia Institute of Marine Science, Gloucester Point, VA 23062.]

[4] Auster, P. J. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (North and Mid-Atlantic)—tautog and cunner. U.S. Fish and Wildlife Service Biological Report 82 (11.105). U.S. Army Corps of Engineers Rep. TR EL-82-4, 13 p. NOAA's National Undersea Research Program, Univ. Connecticut at Avery Point, Groton, CT 06430.

peake Bay (Hostetter and Munroe, 1993). When water temperatures remains above 9–10°C,[5] 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.[6] Infrequent recreational catches of tautog in lower Chesapeake Bay during summer have also been reported.[2] 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.[7] 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 *Alcyinidium verilli*. At an artificial fishing reef near Cape Charles, VA, tautog consumed a variety of crustaceans, shellfish, bryozoans, and hydroids.[8] Similar temporal distributions of blue mussels have been reported in Delaware Bay, where diets of tautog subsequently shift towards alternative, less nutritious food items at times when blue mussels are unavailable.[9]

Year-round occurrence of adult tautog in Chesapeake Bay differs from seasonal (spring and fall) inshore occurrence of adult tautog in Great South Bay, NY (Olla et al., 1974; Briggs, 1977), Narragansett Bay, RI (Cooper, 1966), and the Weweantic River Estuary, MA (Stolgitis, 1970). Year-round occurrence of ultrasonically tagged tautog was consistent with large-scale patterns of occurrence of tautog from conventionally tagged tautog (127–584 mm TL) in the Virginia Game Fish Tagging Program between 1995 and 1999.[2,5] Of 563 recaptured tautog that were originally tagged in lower Chesapeake Bay, excluding Cape Charles, and adjacent coastal waters, 85% (n=476) were recaptured at the same sites where released 0–1214 d earlier, including 20 multiple recaptures of individuals at the same sites where originally released. High incidence of recaptures of tautog at the same sites where they were released occurred during all seasons. Only 5% of all recapture events involved movement (8–97 km) of tautog between Chesapeake Bay and adjacent coastal waters.

Daily detection patterns were almost always similar for both VR1 receivers at sites, indicating that tautog remained within the central signal reception area of both VR1 receivers and in the general vicinity of sites throughout the entire day. Tautog were generally not detected by VR1 receivers at night; however, tautog likely remained at sites throughout the night (Arendt et al., in press). Tautog were likely detected less often (or not at all) at night because of nocturnal quiescence in or near structure (Olla et al., 1974) and therefore were effectively out of range of VR1 receivers because of the presence of an acoustic 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, Pictilabrus laticlavius, Pseudolabrus psittaculus)* 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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5 White, G. G., J. E. Kirkley, and J. A. Lucy. 1997. Quantitative assessment of fishing mortality for tautog (*Tautoga onitis*) in Virginia. Preliminary report, 54 p. Department of Fisheries Science and Marine Advisory Program, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA 23062.

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, 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.

8 Feigenbaum, D., C. Blair, and A. J. Provenzano. 1985. Artificial reef study—year II report. Virginia Marine Resources Commission rep. VMRC-83-1185-616, 57 p. VA Institute of Marine Science, Gloucester Point, VA 23062.

9 Steimle, F., K. Foster, W. Muir, and B. Conlin. 1999. The diet of tautog collected on an artificial reef in Delaware Bay and interannual effects of prey availability (and notes on other tautog diet studies in the middle Atlantic Bight). First Biennial Conference on the biology of tautog and cunner, Mystic, CT, 30 November–1 December 1999. National Marine Fisheries Service, Highlands, NJ 07732.

predator that may have preyed upon tagged tautog, even though these three tautog were never recaptured nor visually observed after release. Adult tautog are very infrequently preyed upon by sharks in Virginia (Gelsleichter et al., 1999); however, sharks are not likely present in Chesapeake Bay when water temperatures are 5–8°C. At these water temperatures, large striped bass (*Morone saxatilis*) pose the only possible predatory threat to tautog. A recent study on feeding habits of adult striped bass in Chesapeake Bay found no tautog in the stomachs of more than 2000 striped bass, many of which were collected from the Chesapeake Bay Bridge-Tunnel complex, a well-known fishing area for adult tautog (Walters, 1999).

All tautog detected or recaptured away from release sites were released at manmade sites, which also happened to be the smallest sites. No information was available regarding the origin of these manmade sites, but both have been in place for at least 20 years.[10,11] Stone et al. (1979) concluded that artificial reefs reach a stable state after five years. Benthic macrofauna collected at manmade sites during our study were similar to benthic macrofauna collected at natural sites, suggesting that food may have been similar between manmade and natural sites. Given these observations, habitat size may be an important factor for adult tautog in determining the scale of local movements between adjacent habitats. Understanding the relationship between habitat size and site utilization warrants further investigation, especially with recent increased interest in the construction of artificial habitats for purposes of stock enhancement and enhanced fishing opportunities for tautog.

Sex ratio of female to male tautog in our study was heavily skewed (1:3.5) towards male tautog due to opportunistic sampling, and the preponderance of male tautog likely contributed to the high levels of site utilization observed in our study. In laboratory settings, adult male tautog aggressively defend territories throughout most of the year (Olla et al., 1978, 1980) and only during the spawning season are female tautog permitted to enter territories (Olla and Samet, 1977; Olla et al., 1981). Overall activity, including male agonistic behavior, also decreases as water temperatures approach annual minimum and maximum values (Olla et al., 1978, 1980). Although sample size in our study was too small to distinguish site-utilization patterns by sex, it is worth noting that both tautog that left the Texeco Wreck in Nov–Dec and that periodically returned to this site throughout the winter and spring were females. In contrast, during the spring spawning season, three females (one at Texeco Wreck, two at Coral Lump) remained at release sites throughout the spring–summer monitoring period and all three were subsequently recaptured by recreational fishermen at these same sites in the fall. More sex-specific data are needed to fully comprehend 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 Ridged 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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