Age, growth and fecundity of the cobia, *Rachycentron canadum*, from Chesapeake Bay and adjacent Mid-Atlantic waters

Richards 1967

SEDAR28-RD18

24 January 2012

Transactions of the American Fisheries Society

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/utaf20

Age, Growth and Fecundity of the Cobia, Rachycentron canadum, from Chesapeake Bay and Adjacent Mid-Atlantic Waters

C. E. Richards [a]

[a] Virginia Institute of Marine Science Gloucester Point, Virginia, USA

Available online: 09 Jan 2011

To cite this article: C. E. Richards (1967): Age, Growth and Fecundity of the Cobia, Rachycentron canadum, from Chesapeake Bay and Adjacent Mid-Atlantic Waters, Transactions of the American Fisheries Society, 96:3, 343-350

To link to this article: http://dx.doi.org/10.1577/1548-8659(1967)96[343:AGAFOT]2.0.CO;2

Age, Growth and Fecundity of the Cobia, *Rachycentron canadum*, from Chesapeake Bay and Adjacent Mid-Atlantic Waters[1]

C. E. RICHARDS
Virginia Institute of Marine Science Gloucester Point, Virginia

ABSTRACT

Age, growth, fecundity, and distribution of cobia, *Rachycentron canadum*, were studied. Data were collected primarily from lower Chesapeake Bay and adjacent mid-Atlantic waters. Age analysis by scale methods, growth estimates by use of Bertalannfy's equation, and observations of juvenile cobia indicate rapid growth. Ten age groups were represented in scale collections from 284 fish, 4.2–56.4 inches in fork length. Males and females can mature at two and three years, respectively. Growth equations are: males, $L_t = 49(1 - e^{-0.21(t+0.67)})$, $W_t = 59 \times (1 - e^{-0.13(t-0.62)})$; females, $L_t = 59(1 - e^{-0.20(t+0.65)})$, $W_t = 120(1 - e^{-0.10(t-0.80)})$. Fecundity in hundreds of thousands of eggs was evaluated as a function of body weight where fecundity was equal to 0.98 times the weight in pounds minus 6.39. The spawning season, late June through mid-August, was defined through observation of gonadal tissue. A disproportionate sex ratio for areas within Chesapeake Bay was noted, 74:26 and 28:72 males to females, for eastern and western shore areas respectively. A possible relation between spawning and a high ratio of males to females was noted for eastern shore areas.

INTRODUCTION

The life history of the cobia, *Rachycentron canadum* (Linnaeus), has been virtually unexplored. The cobia is a circumtropical species (Briggs, 1960) ranging in the Atlantic from Massachusetts and Bermuda to Argentina (35° S) and it is widespread in the Gulf of Mexico (Briggs, 1958). Smith (1907) states that, "In summer . . . (cobia is) found on the middle and South Atlantic coast of the United States being especially common in the Chesapeake Bay, in winter it withdraws to the West Indies." Briggs (1958) indicates that it is primarily a shore species. Ryder (1887) describes initial development of cobia eggs. Joseph, Norcross and Massmann (1964) have given a description of eggs and juveniles collected from Chesapeake Bay and the nearby Atlantic. Knapp (1951) has analyzed stomach contents of Texas cobia.

Cadenat (1950) reported a length of nearly 2 meters for cobia in Senegal waters. This is the maximum reported size (literature) for the species. Confirmed maximum weight for Chesapeake Bay fish is 102 lbs (I.G.F.A. record), but the maximum weight may approach 150 lbs. One unconfirmed but reliable report indicated that a 120 lb cobia was caught near Kiptopeke, Virginia (Figure 1) in a pound net during late summer, 1964.

A specimen from the harbor of Diego Suarez, Madagascar, collected by J. Sterling, Virginia Institute of Marine Science on 27 October 1964 was a 6.8 lb female 26.5 inches fork length with ova as in stage 2 below. Its scales indicate a growth pattern similar to that of Chesapeake Bay stocks, although the condition of its ovaries suggests an approximate 6 month shift in spawning time. Fin ray counts from this specimen were: A I, 26 and D VIII – I, 34 compared to the count from a single Chesapeake specimen: A I, 23 and D VIII – I, 30 as given by Hildebrand and Schroeder (1928).

Cobia are caught within Chesapeake Bay from May to mid-October. Initial sport catches for a season have occurred concurrently with the recording of a 67–69 F surface water temperature at Chesapeake Lightship. The records of fish weighing 45 lbs or more and entered in the Virginia Saltwater Sport Fishing Tournament 1958–1964 (Table 1) indicate timing and location of catches within the Bay. Commercial landings from Chesapeake Bay pound nets, 1958–1963, averaged 21.5 thousand pounds with a value to the fisherman of $2,300.00 (U. S. Fish and Wildlife Service, 1958–1963). Records from the Virginia Saltwater Sport Fishing Tournament indicate that the sport fishing catch probably exceeds the commercial catch of this species in Chesapeake Bay. The total weight of citation size fish, weighing 45 lbs or more each, was 16.8 thousand pounds during 1962 and 1963. Total

[1] Contribution No. 252, Virginia Institute of Marine Science, Gloucester Point, Virginia.

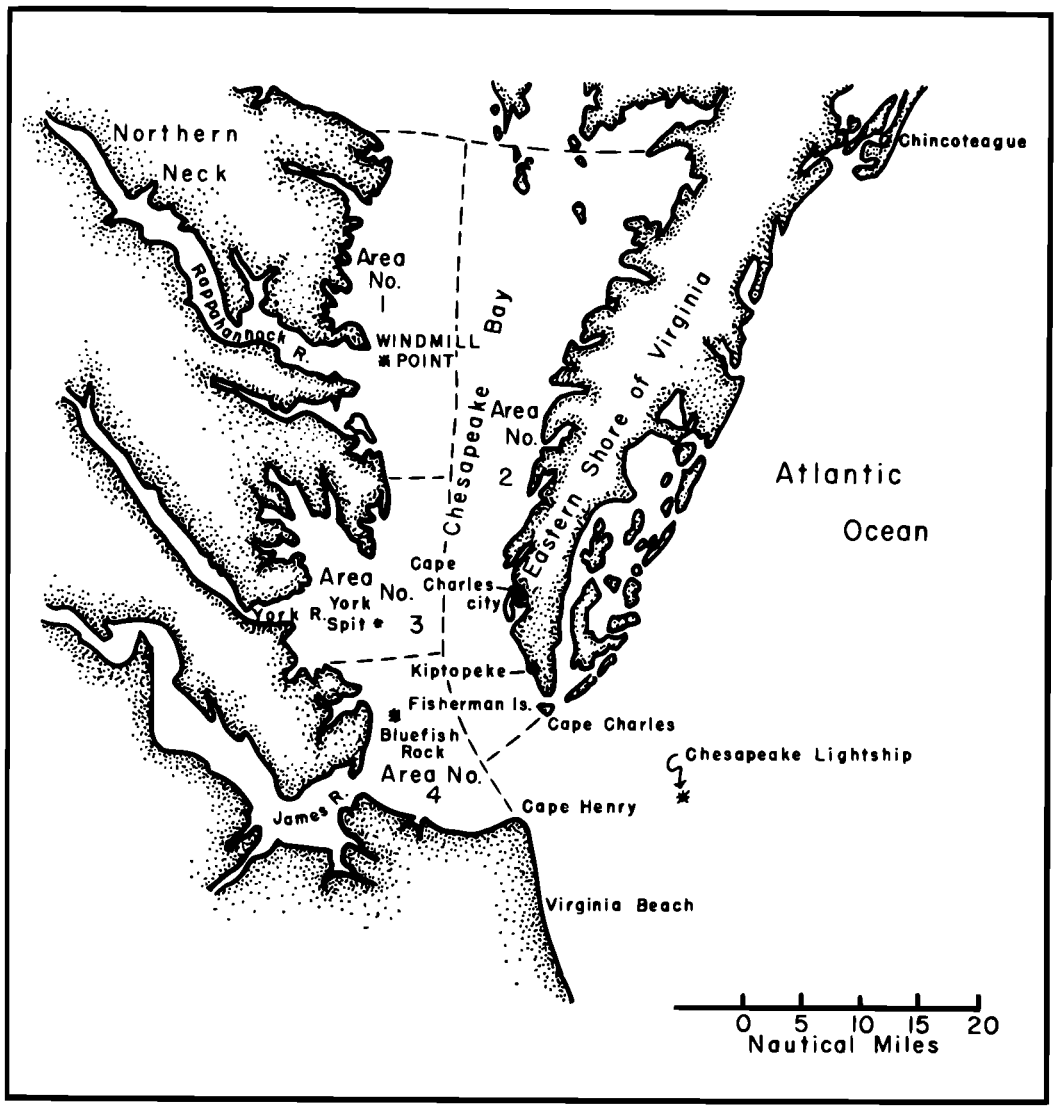

FIGURE 1.—Location of Cobia sampling areas in the Virginia portion of Chesapeake Bay and the Atlantic Ocean.

sport catches, including fish below the 45 lb minimum citation size would thus probably exceed the commercial catch. Virginia's annual total combined sport and commercial catch is probably less than 2,000 fish.

METHODS

Data for many fish less than 450 mm (17.7 in) standard length were obtained from the U. S. National Museum. Other measurements and material were obtained from pound net catches and sport catches in Chesapeake Bay and adjacent nearshore Atlantic Ocean waters from May to October 1960–1963 when periodic visits were made to landing areas and market distribution centers. Limited data were collected during 1956, 1964, and 1965.

Measurements and observations included: fork length, weight, sex, maturity, date, and location of catch. Scales for age determinations were collected beneath the extended, compressed tip of the pectoral fin.

TABLE 1.—*Location and timing of citation cobia catches entered in the Virginia Saltwater Sportfishing Tournament, 1958–1964. All fish weighed a minimum of 45 lbs. (Courtesy of the Virginia Saltwater Sportfishing Association)*

Area	May		June		July		August		September		October	Total
	1–15	16–31	1–15	16–30	1–15	16–31	1–15	16–31	1–15	16–30	1–15	
Northern Neck	1	0	0	14	143	190	174	71	24	0	0	617
Eastern Shore	0	0	26	83	56	24	18	8	4	0	0	219
York Spit and mid-Bay channels	0	0	3	8	32	37	51	39	24	6	1	201
Bluefish Rock, lower Bay	0	3	26	16	24	17	16	21	20	2	0	145
Total	1	3	55	121	355	268	259	139	72	8	1	1,182

Sex determinations were based on observation of milt or ova collected in a 6 to 8-inch glass tube with a rubber squeeze bulb. The ¼-inch diameter tube with a slightly jagged distal end was inserted into the genital pore. Suction was applied with the squeeze bulb as the glass tube was rotated and slowly withdrawn. If sex was not obvious, the collected tissue was preserved and examined microscopically.

RESULTS

Length-weight relation.—Length-weight data were collected from 155 females, 98 males, and 17 cobia of undetermined sex. Plots of these data indicate a curvilinear relationship between length and weight with no apparent difference between sexes. Standard logarithmic least squares technique was used to obtain a formula which best expressed the relation between fork length and weight. That formula is: $\log W = (3.088 \log L) - 3.506$, where W is weight in pounds and L is fork length in inches (Figure 2).

Maximum size recorded for measured males was 47.0 inches fork length and 41.8 lbs. The largest female measured 54.2 inches fork length and weighed 74.8 lbs. Seventy-one cobia over 42 lbs were females. The following sex distribution was noted by two-inch increments (a 1.9 inch class interval) for 152 cobia that exceeded 40 inches fork length: 40 inches (16 female, 14 male); 42 (19, 9); 44 (22, 0); 46 (26, 1); 48 (25, 0); 50 (13, 0); 52 (5, 0); 54 (2, 0). The largest cobia sampled, presumed to be female, weighed 96 lbs and measured 61.2 inches.

Scale length – fork length.—Magnified (45×) radial scale lengths, measured from the focus to the anterior margin, were plotted against fork lengths. These data are apparently linear in relation and through standard least squares technique the following formula emerged: Scale length = 2.399 (fork length) – 10.08 where scale lengths were measured in ocular units (1 unit = 0.033 mm) and fork lengths in inches. Solution of the equation for fork length when scale length equals zero yields a "K" intercept value of 4.2 inches for "back calculation" purposes.

Age analysis.—Age determinations were

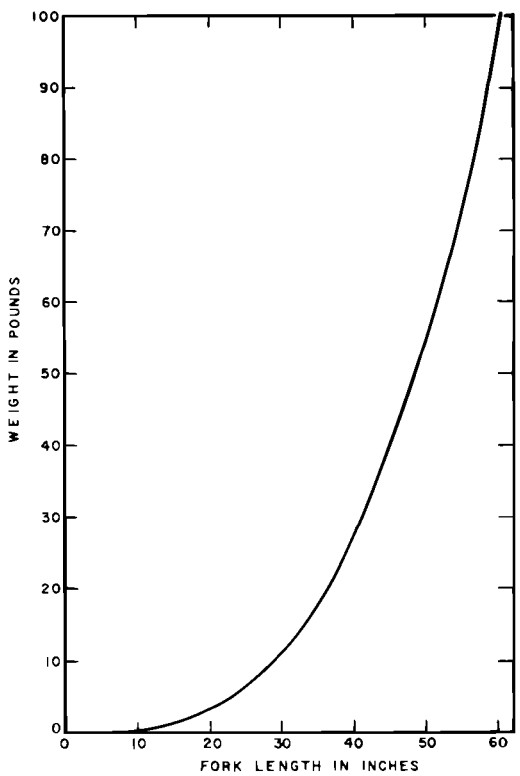

FIGURE 2.—Length-weight relation for Cobia collected in Virginia.

TABLE 2.—*Mean marginal scale increments in ocular units for cobia May through November. One ocular unit equals 0.033 mm*

Period		Mean increment	No. of fish
May	16–31	15.0	4
June	1–15	10.0	8
	16–30	9.8	20
July	1–15	6.5	46
	16–31	5.5	40
August	1–15	6.8	57
	16–31	7.7	65
September	1–15	7.9	12
	16–30	7.4	21
October	1–15	6.4	11
	16–31	–	0
November	1–15	10.0	1

made from scale impressions in soft, clear, plastic cards 0.02 inches thick. Full impressions were obtained in 5 minutes with a Carver hydraulic, electrically heated press set for 165 F, and a pressure of 10 tons per square inch.

Impressions, magnified 45 times by a dissecting microscope were measured with an ocular micrometer. Measurements were made from the focus of the scale to each annulus and to the anterior margin of the eliptical, cycloid scale (Figure 3).

Scale samples were collected from 288 cobia, 4.2 to 61.2 inches fork length. The smallest fish were held alive in an aquarium for several weeks with measurements and scale samples taken after their death, thus the effect of captivity on their scale growth is an unknown factor. Scales show their largest average terminal increment during late May (15.0 ocular units) and smallest terminal increment in the latter half of July (5.5 ocular units) (Table 2). Minimum terminal scale increments for the first five age groups (I–V) occurred for three of the age groups (I, II, V) during the latter half of July. Minimum increments for the other two age groups occurred for one (IV) during the first half of July and the other (III) during the first half of August, implying an annulus is formed during the summer probably during late July. It was not feasible to follow age group 0 through to annulus formation.

Annuli (Figure 3) are characterized by: a pattern of cutting over of circuli on the posterior field of the scale, some lateral grouping of circuli into a tight band, and a broadening area of proliferating circuli in the anterior

FIGURE 3.—Scale impression showing two annuli marked with arrows, from a female cobia 34.2 in. FL collected 21 June 1962.

region, where minimal cutting over of circuli occurs. Changes in intensity and direction of illumination is an aid in identification of annuli. Annuli formed after the fifth year are difficult to recognize although readings were obtained for 99% of the scale samples. Two annuli are exceptionally clear in the scale shown (Figure 3). The scale was collected on 21 June 1962 from a female 34.2 inches in fork length. Most probably, this fish was caught just prior to formation of the third annulus.

Validity of age analysis is based on the apparent formation of an annual ring during mid-summer and the length-weight frequency distribution which separates young-of-the-year, yearlings, and fish 2 years and older with no apparent over-lap of either lengths or weights for these three groups.

The formulae for growth in fork length of male and female cobia (Table 3) were computed from average size estimates back calculated from scale measurements. Equations that best represent growth in length are: males, $L_t = 49\ (1-e^{-0.21(t+0.67)})$; females, $L_t = 59\ (1-e^{-0.20(t+0.65)})$. Length (L) is fork

TABLE 3.—*Calculated fork lengths in inches and average capture length-weight date for cobia sampled from catches within Chesapeake Bay, 1960–1964*

Sex	Age	Sample size	Mean capture weight (lbs.)	No. of fish	Mean capture length (in.)	Calculated lengths at successive annuli									
						1	2	3	4	5	6	7	8	9	10
Males	I	3	3.3	4	21.4	15.1									
	II	32	8.3	37	28.1	14.1	24.6								
	III	16	16.7	18	33.2	13.9	22.9	30.1							
	IV	9	21.2	10	37.1	13.9	23.6	30.2	34.8						
	V	12	26.3	13	39.7	13.9	23.7	30.1	34.7	38.0					
	VI	9	30.3	12	40.9	13.4	20.2	27.0	32.3	36.3	39.3				
	VII	4	32.0	4	41.4	12.8	19.1	25.4	29.8	33.4	36.8	39.7			
	VIII	0	–	0	–										
	IX	2	39.1	2	43.0	10.6	16.2	20.5	24.0	29.6	34.0	36.4	39.2	41.6	
	X	1	41.8	1	47.0	11.8	20.2	23.7	27.1	32.5	38.2	40.5	42.4	44.3	45.9
	Total	88		101	Grand Average	13.8	23.1	28.8	32.9	36.2	38.3	39.1	40.3	42.5	45.9
Females	I	6	4.0	6	22.9	15.3									
	II	11	10.2	15	30.7	14.3	25.0								
	III	25	24.5	30	37.5	14.0	24.5	34.4							
	IV	17	29.2	20	41.0	13.9	23.3	31.6	38.1						
	V	34	43.5	39	45.6	14.3	24.2	32.7	38.5	42.8					
	VI	19	48.1	22	47.1	14.0	23.0	30.3	35.7	40.8	44.7				
	VII	13	55.4	14	49.5	14.7	23.5	30.7	36.2	40.6	44.2	47.4			
	VIII	7	62.7	7	51.3	14.2	22.3	28.6	33.5	38.4	42.8	45.8	49.2		
	IX	3	67.3	3	52.5	13.3	22.8	31.0	34.5	39.2	42.2	44.6	47.7	50.3	
	Total	135		156	Grand Average	14.2	23.8	32.0	37.0	41.4	44.1	46.6	48.7	50.3	

length in inches and t is time in years. Constant values were obtained by plotting $\text{Log}_e (L_\infty - L_t)$ against "t" (Ricker, 1958).

Formulae representing growth in weight were computed from average capture weights of each age group. The equations are: males $W_t = 59\ (1-e^{-0.13(t-0.62)})$; females $W_t = 120\ (1-e^{-0.10(t-0.8)})$. W_t represents weight in pounds.

Records of cobia less than 450 mm (17.7 in) standard length, give a further indication of growth rate. Lengths of 27 fish from the northwestern Atlantic coast (Table 4) show a pattern of growth that supports the age analysis given. There is progression of increasing lengths from June through October. Five lengths in mm (Table 4) not defined as being standard lengths were converted by the formula, standard length (SL) = 0.903 (TL) total length – 10.5. This formula was derived by standard least squares technique from seven juveniles 44 to 235 mm standard length. The formula is limited in scope, but is adequate for the purposes here.

One fish, 360 mm collected in May, is assumed to be nearly one year old. Two other fish of less than 450 mm standard length are in the National Museum collection from the Atlantic coast of the United States. One specimen (26434) dated 18 July–1 September 1800 from Maryland was 189 mm and the other undated (19508) 216 mm from North Carolina 1871–72.

Maturity, distribution by sex and spawning.—A specimen was considered mature if free ova or milt could be observed in gonadal samples. Males were mature at a smaller size and earlier age than females. The smallest mature cobia observed were: a male weighing 2.5 lbs, 20.4 inches in fork length, and a female weighing 7.2 lbs, 27.4 inches in fork length. These fish were in their second and third year of life, respectively.

It was noted during the study that disproportionate numbers of males (86) and females (126) were being caught in western shore (male 44, female 111) and eastern shore (male 42, female 15) areas of Chesapeake Bay. A four-fold chi-square contingency test of the data shows that a highly significant statistical difference does exist in the distribution of males and females. Chi-square equals 33.6 with one degree of freedom. Twenty-six percent of the cobia from the Eastern Shore were females; whereas along the western shore 72% were females. Sixty percent of all specimens were female.

Spawning of cobia most probably occurs along or near Virginia's Eastern Shore in Chesapeake Bay or the Atlantic Ocean. Those

TABLE 4.—*Known, dated collection of juvenile cobia less than 450 mm standard length from the western North Atlantic Coast*

May	June	July	August	September	October	Day if known	Year	Location	Reference
360						18	1877	Ft. Macon, N. C.	USNM 19717
	55.0					11	1963	We Creek, S. C.	Bears Bluff Laboratory
	5.5					15	1928	Beaufort, N. C.	USNM 111820
	74.0					–	1876	Sing Sing, N. Y.	USNM 43952
		41				12	1960	Wachapreague, Va.	VIMS
			96			15	1962	Gloucester Point, Va.	VIMS-USNM 257755-F5
			82			15	1962	Gloucester Point, Va.	VIMS-USNM 257755-F5
			66*			21	1911	Sea Isle City, Cape May, N. J.	Fowler (1945)
			135			21	1961	Wadmalaw River, Bears Bluff, S. C.	Bears Bluff Laboratory
			74			2	1887	Somers Point, N. J.	USNM 45144
			75			23	1887	Great Egg Harbor Bay, New Jersey	USNM 45145
			204			14	1953	St. Helena Sound, S. C.	Bears Bluff Laboratory
			234*			20	1927	Cove Inlet, S. C.	Fowler (1945)
			66			–	1951	Gloucester Point, Va.	VIMS
				62*		–	1925	Hempstead Bay, Long Island, N. Y.	Breder (1926)
				220		15–30	1890	Cape Charles, Va.	USNM 43145
				256		15–30	1890	Cape Charles, Va.	USNM 43145
				238		15–30	1890	Cape Charles, Va.	USNM 43145
				229		15–30	1890	Cape Charles, Va.	USNM 43145
				268		15–30	1890	Cape Charles, Va.	USNM 43145
				242		15–30	1890	Cape Charles, Va.	USNM 43145
				244		15–30	1890	Cape Charles, Va.	USNM 43145
				244		15–30	1890	Cape Charles, Va.	USNM 43145
				243		15–30	1960	Perrin, Va.	VIMS
				150		20	1934	Sandy Hook Bay, N. J.	Breder & Nigrelli (1934)
					324*	13	1931	South Carolina	Fowler (1945)
					200*	16	1933	Folly River, S. C.	Fowler (1945)

* Computed standard length.

females that appeared to be nearest to spawning condition were trapped by pound nets set along the Eastern Shore. Joseph *et al.* (1964) collected cobia eggs at the entrance and south of Chesapeake Bay. Ryder (1887) stripped, fertilized, and hatched cobia eggs in Eastern Shore waters. The ratio, 2.9 males to 1 female, suggests that a spawning population exists here. Also, sport catches of cobia in the area decrease sharply during mid-July (Richards, 1965) and remain low during the remainder of that summer while commercial landings reported for the lower Eastern Shore (Kelly, 1960–63)[2] indicate continuous catches through August. Perhaps cobia cease feeding while they spawn. Schools of cobia also have been sighted near the surface during the June–September period close offshore from Chincoteague, and within Chesapeake Bay off Fisherman Island and Kiptopeke.

Multiple spawning may occur. Partially spent females have been captured in western shore areas. Perhaps western shore areas are used as feeding grounds before and, to a lesser degree, after spawning occurs.

Ova description and fecundity.—Two gravid females caught off Kiptopeke in pound nets (16 August 1960 and 28 June 1962) contained eggs (measurements by microscope) in three stages of development: 1. Immature: 0.10–0.30 mm diam, clear, nucleated egg cells, 2. Maturing: 0.36–0.66 mm diam, oil globule vaguely discernible, egg with a clouded appearance, and 3. Mature: 1.09–1.31 mm diam, average 1.20 mm. Oil globule 0.29–0.44 mm diam average 0.37 mm egg clear or transparent. Eggs were examined after preservation in a solution of 10–15% formalin. Eggs in stage 3 above are only slightly smaller, 0.05 mm, than cobia eggs described by Ryder (1887). Ryder states that fertilized cobia eggs are about 1.25 mm in diameter and implies that hatching occurred during the first week of August, 1881. The indication is clear that cobia spawn at least from late June through mid-August.

Fecundity estimates, (Table 5) were derived from five fish caught off Windmill Point at the mouth of the Rappahannock River and one caught near York Spit Light off the mouth of the York River (Figure 1). Four of these fish had distended ovaries (Figure 4) and two fish had partially spent ovaries. None contained eggs as in stage three above, but it is

[2] Kelly, W. N. 1960–1963. Production of fishery products in selected areas of Virginia, Maryland and North Carolina, annual summaries. U. S. Bur. Comm. Fish. Market News Service, 18 S. King Street, Hampton, Va.

TABLE 5.—*Fecundity estimates for cobia collected from Windmill Point and York Spit,* Chesapeake Bay. (Ova counted ranged from 0.50 to 0.90 mm diameter)*

Fork length inches	Wt (lbs)	Date July 1963	Ovary condition	Total ovarian tissue wt (g)	Egg count average per g	Estimated total fecundity in thousands of eggs
49.1	57.75	17	Full	2,113	2,574	5,439
48.8	54.75	17	Full	1,877	2,316	4,347
46.5*	45.50	6[1]	Partly spent	1,121	2,497	2,799
39.2	26.25	17	Full	506	3,825	1,935
47.0	45.25	17	Partly spent	769	2,866	2,204
41.8	33.00	18	Full	1,083	2,464	2,669

[1] 1962.

assumed that ova in stage two could develop to maturity within the season of collection. Eggs ranged from 0.10 to 0.90 mm in diameter There was a break in size frequency of ova at about 0.50 mm diameter. Only ova above 0.50 mm diameter were counted for fecundity estimates. The four fully gravid females obviously had not spawned, yet did not contain any ova in stage 3 development. The number of ova per gram of tissue varied from 2,300 to 3,800 with an average of 2,600. Ova were smaller in average size in the partially spent specimens and so their number per gram of tissue was higher (Table 5). Fecundity ranged from 1.9 to 5.4 million eggs for the gonads examined. The relation between fecundity in hundreds of thousands and body weight of the four fully gravid individuals is: $F = 0.98 (wt) - 6.39$.

DISCUSSION

The cobia grows rapidly, lives a moderately long life, and has a high reproductive potential. Rapid growth and occupation of areas not normally sampled may be reasons why juveniles are rarely seen. Their coloration as juveniles (Breder, 1926; Joseph *et al.*, 1964) suggests habitation of surface waters near or with floating objects and debris probably in shallow, inshore areas.

The survival rate of fertilized ova to the juvenile stage must be unusually low. The high fecundity cited above must be counterbalanced by high mortality. Joseph *et al.* (1964) collected large numbers of ctenophores and various medusae along with cobia eggs. Low survival rates could be expected at the periphery of a species range, but juvenile

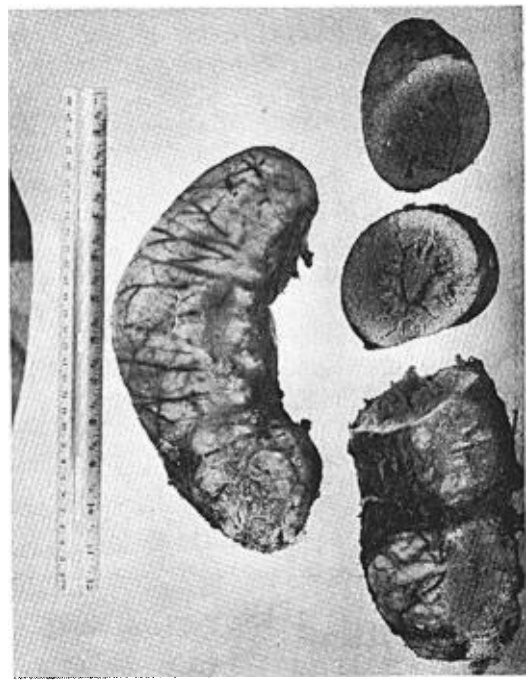

FIGURE 4.—Ovaries from a fully gravid 57.8 lb., 49.1 inch FL cobia caught 18 July 1963.

cobia have been rarely reported anywhere. The U. S. National Museum has catalogued only 45 specimens under 450 mm standard length. Of these, 19 are from the northwestern Atlantic coast of the United States, 14 are from the Gulf of Mexico and Caribbean area, 11 are from Asiatic-Pacific waters, and 1 is from Australia. A moderately long life, ten years plus, does not demand a high rate of egg to juvenile survival and recruitment to maintain a stable population.

ACKNOWLEDGMENTS

I wish to thank the personnel of the division of fishes of the U. S. National Museum and R. H. Kanazawa for data on juvenile cobia. The Bears Bluff Laboratory, South Carolina, through C. Bearden graciously provided data on three small cobia. Mr. William More, Texas Parks and Wildlife Dept., contributed a juvenile cobia that has since been deposited with the National Museum. Members of the ichthyology department at VIMS collected data, and provided advice in the writing of this report.

LITERATURE CITED

BREDER, C. M., JR. 1926. A small cobia. N. Y. Zool. Soc. Bull. 29: 179–180.

———, AND R. F. NICRELLI. 1934. Fish notes for 1933 and 1934 from Sandy Hook Bay and other New York localities. Copeia 1934(4): 193–195.

BRIGGS, J. C. 1958. A list of Florida fishes and their distribution. Bull. Fla. State Mus. Biol. Sci. 2: 1–318.

———. 1960. Fishes of world wide (circumtropical) distribution. Copeia 1960(3): 171–180.

CADENAT, J. 1950. Poissons de mer du Sénégal. Inst. Français Noire, Init. D'Africaines III. 345 p.

FOWLER, H. W. 1945. A study of the fishes of the southern Piedmont and coastal plain. Acad. Nat. Sci. Phila. Monogr. No. 7, 408 pp.

HILDEBRAND, S. F., AND W. C. SCHROEDER. 1928. Fishes of the Chesapeake Bay. Bull. U. S. Bur. Fish. 43 (pt. 1). 366 p.

JOSEPH, E. B., J. J. NORCROSS AND W. H. MASSMANN. 1964. Spawning of the cobia, *Rachycentron canadum*, in the Chesapeake Bay area, with observations of juvenile specimens. Chesapeake Sci. 5: 67–71.

KNAPP, F. T. 1951. Food habits of the sergeant fish, *Rachycentron canadus*. Copeia 1951(1): 101–102.

RICHARDS, C. E. 1965. Availability patterns of marine fishes caught by charter boats operating off Virginia's Eastern Shore, 1955–1962. Chesapeake Sci. 6: 96–108.

RICKER, W. E. 1958. Handbook of computations for biological statistics of fish populations. Fish Res. Bd. Canada, Bull. 119, 300 p.

RYDER, J. A. 1887. On the development of osseous fishes, including marine and freshwater forms. Rept. U. S. Fish. Comm. 13 (1885): 488–604.

SMITH, H. M. 1907. The fishes of North Carolina. North Carolina Econ. Geol. Surv. 2: 453 p.

UNITED STATES FISH AND WILDLIFE SERVICE. 1958–1963. Chesapeake fisheries, Annual summaries: Comm. Fish. Stat. Nos. 2203, 2444, 2685, 3043, 3353, 3616, 3967.