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INTRODUCTION

The black sea bass, Centropristis striata striata (L.), has been reported from the Gulf of Maine to Miami, Florida, with greatest numbers being found between Cape Cod, Massachusetts, and Cape Canaveral, Florida (Miller 1959). There appear to be two populations of black sea bass, one north of Cape Hatteras, North Carolina, and one south of Cape Hatteras to northeast Florida (South Atlantic Fishery Management Council 1978). Musick and Mercer (1977) discussed the seasonal distribution of juvenile and adult black sea bass in the Middle Atlantic Bight. In the fall, the fish migrate southeasterly and winter off the Virginia Capes. In the spring, they migrate inshore and northward, the adults to coastal spawning areas and the juveniles to estuarine nursery grounds. Much less is known about seasonal distribution in the South Atlantic Bight. Cupka et al. (1973) concluded from tagging studies that seasonal movements due to temperature were not likely south of Cape Hatteras. They also noted that larger specimens were found in deeper waters and suggested that there may be a gradual offshore movement with age.

Lavenda (1949), Dias (1971), Cupka et al. (1973), and Mercer (1978) have discussed age and growth of black sea bass. The use of otoliths in determining the ages of C. striata has previously been validated by Cupka et al. (1973) and Mercer (1978) by meeting criteria established by Van Oosten (1929). By investigating monthly mean marginal increments on sagittae, Cupka et al. (1973) and Mercer (1978) have determined that annulus formation occurs from March through June, which corresponds with the peak of reproductive activity. Mercer (1978) reported 9 age groups in the Middle Atlantic and 8 in the South Atlantic. Cupka et al. (1973) reported 7 age groups off the coast of South Carolina. However, Mercer (1978) and Cupka et al. (1973) report that bias may exist in their data due to sampling design.

Lavenda (1949) examined the reproductive biology of C. striata and identified it as a normal protogynous hermaphrodite. Mercer (1978) defined this condition as hermaphroditism that exists at some time during the ontogeny of all or many members of a species where an individual functions first as a female and later as a male. She observed black sea bass undergoing sexual transition in age groups 1 through 5. Most females mature by age 3 and though males dominate the older age groups, she found sexually active males at all ages. Spawning occurs from June to October off Virginia at depths of 18 to 45 m and from March to May off the Carolinas (Cupka et al. 1973; Mercer 1978). Mercer (1978) suggested that C. striata is a multiple spawner. Estimates of fecundity range from 127,000 to 333,000 eggs for sea bass in the Middle Atlantic Bight and 29,770 to 121,500 eggs for fish off South Carolina (Cupka et al. 1973; Mercer 1978).

Accounts of egg and larval distribution are limited. Wilson (1891) observed that eggs are pelagic. Kendall (1973) reported that the larvae are pelagic until they are approximately 13 mm, whereupon they assume demersal or estuarine habitats.

The black sea bass is an important commercial and recreational resource in the South Atlantic Bight (Rivers 1966; Huntsman 1976). Reported commercial landings increased rapidly in the late 1960's, peaking at 1000 metric tons (MT) in 1967 (National Marine Fisheries Service 1960-1975). Since then, annual commercial catches have fluctuated about a downward trend. Most of this decline has been attributed to reduced fishing effort in response to low dock prices. The headboat catch also appears to have decreased in recent years (South Atlantic Fishery Management Council (1978).

As part of a long term monitoring project, the Marine Resources Monitoring, Assessment, and Prediction (MARMAP) group of the Marine Resources Research Institute has been collecting life history data on black sea bass in the South Atlantic Bight. In this paper, we present information on their distribution, age and size structure, and sexuality that will contribute to effective management of this important marine resource.

MATERIALS and METHODS

A total of 2215 black sea bass were collected from Georgetown, South Carolina to Jacksonville, Florida (Table 1) on the R/V Dolphin from 20 June to 16 July 1978. Suitable "live bottom" areas (Powles and Barans 1979) were located through the combined use of SIMRAD echo sounder and drift transects of a suspended, horizontal underwater television system (Hydroproducts TC-125 SDA). Four designated areas of "live bottom" habitat (Figure 1) were sampled day and night using six gear types. These included six commercial blackfish traps (Rivers 1966), six Antillean S-traps (Powles and Barans 1979), four fine mesh blackfish traps (60 x 60 x 52 cm, 6 mm sq. mesh), covered and uncovered commercial minnow traps (42 cm long, 22.5 cm at largest diameter, 6 mm sq. mesh), and a 3/4 Yankee

Table 1. Areas and depths from which *Centropristis striata* were sampled during June and July, 1978

		Location (midpoint of area sampled) Latitude	Longitude	Depth (fm)
AREA 1		32°50.1'N	78°35.1'W	20.0-21.0
AREA 2	Depth *a*	32°29.3'N	79°41.4'W	10.0-10.5
	Depth *b*	32°14.5'N	79°41.5'W	15.5
	Depth *c*	32°20.1'N	79°12.1'W	23.0-25.0
AREA 4		31°40.7'N	80°19.0'W	14.0-17.0
AREA 3		30°44.0'N	80°13.6'W	23.0

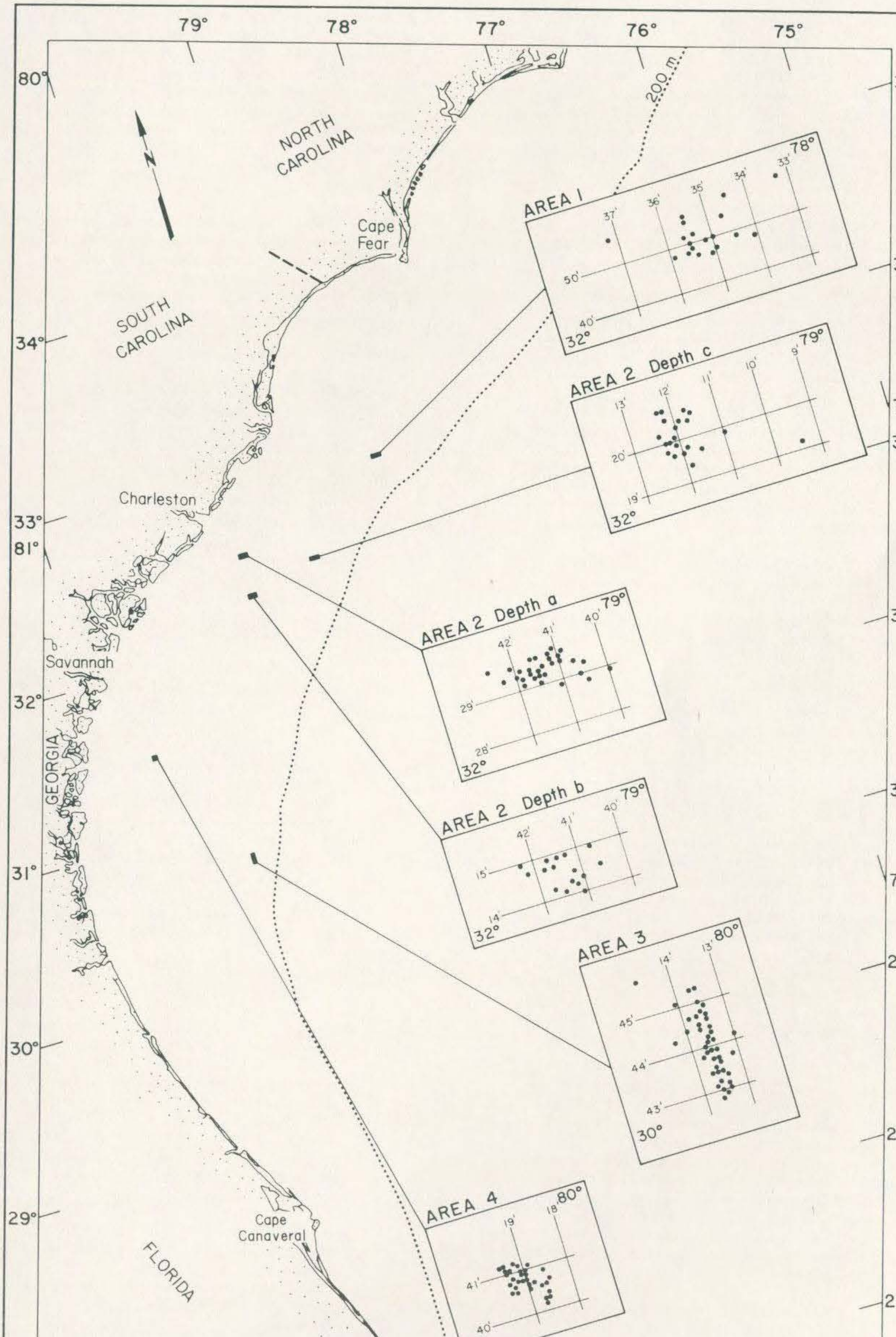

Figure 1. Areas from which *Centropristis striata* were sampled during June and July, 1978.

36 trawl net (Wilk and Silverman 1976).

Trap types were randomly selected and deployed, generally in 3 rows (4-6 traps per row). Traps were allowed to soak for approximately six hours. The 3/4 Yankee 36 trawl was towed 8-14 times in each area for a duration of 10 minutes per tow.

Total weights and total lengths were taken for all black sea bass collected. Subsamples of these individuals were weighed to the nearest gram and measured to the nearest mm (SL and TL).

The sagittae were removed and stored dry in envelopes for subsequent age determination. A total of 1952 pairs of otoliths were examined, 115 pairs of which were excluded from analysis due to damage or discrepancies between two independent readings. The otoliths were placed with their concave side up in water over a dark field and examined under a binocular microscope in reflected light at a magnification of 12X. Alternating translucent and opaque zones were observed. Based on previous work, the opaque zones were interpreted as annuli (Cupka et al. 1973; Mercer 1978). Annuli counts and measurements were taken on a line from the center of the kernel to the outermost margin of the otolith's dorsal surface with an ocular micrometer (1 oµ = 0.8 mm). Measurements were taken on the left otolith. If damaged, the right otolith was used.

From these measurements, back-calculations were derived using the equation formulated by Poole (1961):

$$L_1 = C + \frac{S_1 \ (L-C)}{S}$$

in which L_1 = length of fish at time of annulus formation, L = length of fish at capture, S_1 = measurement from the center of the otolith to the annulus, S = radial measurement from the center to the edge of the otolith, and C = y-intercept of the straight line formed by the regression of standard length on otolith radius. All regressions presented in this study are the functional regressions of Ricker (1973), unless otherwise noted.

Two-thirds of the fish subsampled in the field were frozen whole, with biological data derived one month after freezing. Seventeen hundred gonads were surgically removed, grossly inspected for sex, and fixed in a formol-alcohol solution (Humason 1972). The samples were run through an Auto-Technicon tissue processor, embedded in paraffin, sectioned at approximately 7 µm on a rotary microtome, stained with Harris Hematoxylin, and counter-stained with Eosin-Y.

The first three hundred fifty slides of sectioned gonads were read by two different individuals. When agreement was reached on sex and maturity, the remaining slides were read by one observer. Maturity and sex codes were formed by modifying Moe (1969), Mercer (1978), and applying the four part index of Hilge (1977). They appear to be suitable for application to gonochoristic species as well as those species showing any of the various types of hermaphroditism. The sex codes include hermaphrodites, and when used with maturity stages give a very accurate and objective estimation of each fish's reproductive state.

Sex Codes:

0 - Undifferentiated. Gonads very small and clear, histologically have not yet begun testicular or ovarian development.

1 - Male. Gonad entirely testicular.

2 - Female. Gonad entirely ovarian.

3 - Hermaphrodite (simultaneous). Both testicular and ovarian tissue present. Each tissue type in same maturity stage.

4 - Hermaphroditic male. Gonad primarily testicular with some traces of ovarian tissue present.

5 - Hermaphroditic female. Gonad primarily ovarian with some traces of testicular tissue present.

Maturity Codes:

1 - Immature. Grossly, gonad very small, clear; histologically, only primary spermatocytes in males, basophilic oocytes in females.

2 - Ripening. Grossly, gonad rotund, showing turgidity.
<u>Males</u>: grossly, gonad thickening, creamy white; histologically, secondary spermatocytes through development of tailed spermatozoa.
<u>Females</u>: grossly, rotund and showing turgidity; histologically, small acidophilic oocytes to many large yolk-filled oocytes.

3 - Ripe (running).
<u>Males</u>: grossly, milt flow with slight pressure to gonad, hard and large; histologically, few primary or secondary spermatocytes, lumens filled with tailed spermatozoa.
<u>Females</u>: grossly, large soft ovaries with many large, free flowing (with slight pressure) hydrated oocytes; histologically very large yolk filled oocytes predominate, with holes in place of hard to cut hydrated oocytes.

4 - Spent.
<u>Males</u>: grossly, flaccid and bloodshot; histologically, little structure in wall of seminiferous tubules, only residual sperm remaining.
<u>Females</u>: grossly, small gonads, hard and bloodshot, few hydrated oocytes if any; histologically, many to few atretic oocytes, relatively many small acidophilic and basophilic oocytes.

5 - Resting.
Males: grossly, small and flaccid, white to clear; histologically, few residual spermatozoa, possibly beginning development of primary spermatocytes.
Females: grossly, very small and flaccid, no visible oocytes, clear; histologically, few atretic oocytes, many small acidophilic and basophilic oocytes.

6 - Transitional. Grossly, gonad small, flaccid, clear; histologically either testicular development occurring in resting ovary (protogynous) or ovarian development occurring in resting testes (protandrous).

Presented below are the combinations of sex and maturity codes used for the black sea bass in this study.

0/1 - Grossly, small gonad; histologically, undifferentiated.

1/1 - Grossly, small gonad, opaque; histologically, no development past primary spermatocyte.

1/4 - Grossly, flaccid, white, bloodshot; histologically, little structure in seminiferous tubules, only residual spermatozoa present.

1/5 - Grossly, flaccid; histologically, little or no residual spermatozoa, some primary or secondary spermatocyte development.

2/1 - Grossly, small clear gonad; histologically, small basophilic oocytes.

2/4 - Grossly, flaccid, bloodshot, few oocytes visible; histologically, few large atretic follicles, relatively many small acidophilic and basophilic oocytes.

2/5 - Grossly, flaccid, clear gonad, few oocytes visible, granular; histologically, few to no atretic oocytes, many small basophilic oocytes regularly arranged.

5/6 - Grossly, gonad resting; histologically, spent or resting female with precocious testicular development (less than 10% of section not yet beyond spermatid formation).

4/4 - Grossly, flaccid, white, bloodshot; histologically, little structure in testes, residual spermatozoa present, oocytes also present in varying degrees of atrophy.

In the following text and tables, male black sea bass include fish with gonads entirely testicular and fish primarily or functionally testicular with some traces of ovarian tissue present. Female black sea bass include fish with gonads entirely ovarian. Transitionals include fish with gonads primarily ovarian with traces of testicular tissue present. Undifferentiated include fish with gonads very small and clear that have not begun testicular or ovarian development.

Mean weights of black sea bass caught with blackfish, Antillean S, and fine mesh traps and with 3/4 Yankee trawl were examined with a one-way ANOVA and Student-Newman-Keuls test. Area and depth distributions were compared by pooling data for fish caught by all gears combined. We examined differences in mean age, mean weight, and sex ratios for the four areas shown in Figure 1. We also evaluated the extent of differences in these factors for the three depth ranges (D_a = 10-14 fm, D_b = 15-19 fm, D_c = 20-25 fm) indicated for Area 2. Using pooled data from blackfish, Antillean S, and fine mesh traps, we examined differences in mean weight between these depth intervals with a one-way ANOVA and Student-Newman-Keuls test. All variances were homogeneous.

All data are stored on computer tapes at the Marine Resources Research Institute Computer Center.

RESULTS and DISCUSSION

Gear Selectivity

Number and average size of black sea bass caught by each of 6 gears are listed in Table 2a. Three trap types (blackfish, Antillean S and fine mesh) accounted for 79.6% of the total catch by number. The 3/4 Yankee trawl accounted for 20.0% and the covered and uncovered minnow traps caught less than 1% by number. A one-way ANOVA analysis revealed no significant difference in the average size of black sea bass caught by the 3 larger trap types, however these 3 trap types caught significantly larger fish than did the 3/4 Yankee trawl (Table 2b).

Length-Length and Length-Weight Relationships

The functional regression of SL on TL (sexes combined) is:

$$SL = 8.179 + 0.7387\,(TL) \quad r = .97,\ n = 1903$$

where SL is standard length in mm and TL is total length in mm.

The functional regressions for length and weight are:

All fish: $\log w = -4.48326 + 2.98699 \log (SL)$ $r = .99,\ n = 1771$

$\log w = -4.6016 + 2.8973 \log (TL)$ $r = .98,\ n = 1773$

Females: $\log w = -4.39716 + 2.95103 \log (SL)$ $r = .98,\ n = 693$

$\log w = -4.54842 + 2.87788 \log (TL)$ $r = .97,\ n = 683$

Males: $\log w = -4.35943 + 2.93354 \log (SL)$ $r = .97,\ n = 568$

Table 2a. Numbers, percents, and mean weights of black sea bass caught by each gear.

Gear	Total Number	Percent	Mean Weight (kg)[1]
Antillean S-Trap	566	25.6	.383
Blackfish Trap	859	38.8	.400
Fine Mesh Trap	336	15.2	.311
Covered Minnow Trap	3	0.1	.011
Uncovered Minnow Trap	8	0.4	.007
3/4 Yankee 36 Trawl	443	20.0	.144
Total	2215		

[1] $\text{Mean Weight (kg)} = \dfrac{\text{Total weight (kg)}}{\text{Total number}}$

Table 2b. One-way ANOVA, Student-Newman-Keuls test, and Bartlett's test for the mean weight of black sea bass caught by blackfish traps, Antillean S-traps, fine mesh traps, and 3/4 Yankee 36 trawls.

Source	df	SS	MS	F
Treatment	3	.159	.053	5.961*
Error	11	.098	.009	
Total	14	.257		

Bartlett's test Chi-square = 3.704^{ns} df = 2

Student-Newman-Keuls

Gear	3/4 Yankee trawl	Fine mesh	TRAPS Antillean S	Blackfish
$\bar{x}$ weight[2]	.178	.347	.425	.464

* = P < .05

[2] $\bar{x}\text{ weight (kg)} = \dfrac{\sum_{\text{Area 1}}^{\text{Area 4}} \bar{x}\text{ wt}}{4}$

$$\log w = -4.41241 + 2.81689 \log (TL)$$
$$r = .95,\ n = 564$$

where weight is in grams and length is in millimeters.

Data used for the length-length and length-weight regressions were collected within a 1 month period. Therefore, differences due to seasonal variation were not considered here. Length-weight relationships for males and females show that males and females with the same length have similar calculated weights. This is similar to findings of Mercer (1978) for the South Atlantic Bight.

Age Structure

Our findings confirm those of Cupka et al. (1973) and Mercer (1978) concerning times of spawning and annulus formation. Measurements of marginal increments revealed that annulus formation had recently occurred.

The regression of standard length to otolith radius (OR) revealed a linear relationship for each sex. The predictive regression equations for male and female C. striata are SL = -12.785 + 6.283 OR (r = 0.90) and SL = -6.441 + 5.848 OR (r = 0.93) respectively. These are based on 610 male fish ranging from 105 to 352 mm SL and 693 female fish ranging from 72 to 330 mm SL. These regressions were transformed to functional regressions using methods described by Ricker (1973). The functional regression equations for male and female C. striata are SL = -41.273 + 6.974 OR and SL = -20.706 + 6.290 OR, respectively. Thus, the correction factors (C) used for back-calculations were -41.273 and -20.706 for males and females respectively.

According to Ricker (1973), the use of predictive regressions in the computation of length from scale radii, and supposedly otolith radii, tends to overestimate lengths less than the mean, and underestimate those greater than the mean of the sample. He strongly suggests the use of functional regressions in deriving this relationship. However, previous workers with black sea bass have used correction factors derived from predictive regressions in back-calculations; therefore, predictive correction factors of -12.785 and -6.441 for males and females were also used for comparative purposes.

Results of back-calculated lengths for ages I-X using both correction factors, are shown in Tables 3 and 4 for males and females respectively, while Table 5 lists mean observed size by age. Figure 2 illustrates the range in observed lengths for each age group. The lack of skewness in the histograms suggests that gear selectivity was not a factor. Differences in mean back-calculated lengths using functional verses predictive correction factors are more pronounced in the younger age groups. After age 3 there is closer agreement between the two back-calculated lengths. Our mean back-calculated lengths (functional) are much lower than Mercer's South Atlantic data. This is especially obvious in the younger age groups. Predictive back-calculated lengths at age are slightly lower than Mercer's data for age groups I and II, and become similar with increasing age. Our mean observed standard lengths for male (age groups I-VIII) and females (age groups I-VI) are smaller than data given by Mercer (1978), which could explain the differences observed in the back-calculated lengths. There is reasonable agreement between our back-calculated lengths and observed lengths for older age groups.

Sex Composition and Age of Maturity

Total numbers and percentages of male, female, transitional, and undifferentiated C. striata grouped in 10 mm intervals are given in Table 6 and Figure 3 respectively. Total numbers and percentages of male, female, transitional, and undifferentiated C. striata grouped by age are given in Table 7 and Figure 4 respectively. Our samples were from the month following spawning only; therefore they showed only spent, resting, and transitional fish. Undifferentiated fish comprised < 1%; females 42.7%; transitionals (females with precocious sperm crypts and those with active testicular infiltration) 18.4%; and males (including functional male hermaphrodites) 38.7% of the population sexed. These data agree somewhat with the percentages derived from Mercer (1978), which were 1% undifferentiated, 56% female, 16% transitional, and 26% male.

The size-sex distribution indicates that females are more abundant than males between 70-219 mm SL (< 4 years). Above 220 mm SL (> 4 years), males predominate. Thus, mature males dominate the older age groups while females dominate the younger. This agrees with findings by Cupka et al. (1973) and Mercer (1978). Our data agree with Mercer (1978) in that we find mature males and females at age 1. Transitional black sea bass ranged in size from 118-327 mm SL, and occurred in age groups I-VIII.

Distribution

Cupka et al. (1973) found no seasonal movement of C. striata in South Carolina waters, although they did note that larger specimens were found in deeper waters. They suggested that this reflected gradual offshore movement with increasing age. The data collected at various depths in Area 2 support this theory (Table 9a). A one-way analysis of variance showed that black sea bass caught between 20-25 fm were significantly larger than those collected at shallower depths (Table 9b). The average age increased with depth from 2.4 years at 10-14 fm to 4.8 years at 20-25 fm. Cupka et al. (1973) suggested that this offshore movement of larger and older specimens, predominately males, might result in sexual segregation. Our data show that males were more abundant than mature females at 20-25 fm.

The total numbers, average weight, number of males, females, and transitionals,

Table 3. Mean Back-Calculated Lengths (mm SL) of South Atlantic Centropristis striata - Male. (Correction factor = -41.273, derived from functional regression).

Age	Number of Specimens	Mean Length at Capture	Mean Back-Calculated Lengths at Successive Annuli									
			I	II	III	IV	V	VI	VII	VIII	IX	X
1	5	114	83									
2	56	168	65	149								
3	110	210	62	130	195							
4	114	233	52	117	167	220						
5	158	269	56	124	167	212	259					
6	93	279	50	117	159	193	232	272				
7	38	292	42	103	150	184	214	248	285			
8	31	304	39	99	143	177	208	233	266	297		
9	3	298	55	112	144	166	187	210	238	266	290	
10	2	340	44	102	154	190	212	234	256	289	311	340
	Weighted Mean		55	122	169	205	240	258	275	294	298	340
	Growth Increment		55	67	47	36	35	17	18	19	4	42
	Weighted Mean*		73	134	177	210	244	260	277	295	300	340

* Correction factor (C) = -12.785, derived from predictive regression.

Table 4. Mean Back-Calculated Lengths (mm SL) of South Atlantic *Centropristis striata* - Female. (Correction factor = -20.706, derived from functional regression).

Age	Number of Specimens	Mean Length at Capture	Mean Back-Calculated Lengths at Successive Annuli									
			I	II	III	IV	V	VI	VII	VIII	IX	X
1	84	117	90									
2	181	161	71	147								
3	215	186	65	128	176							
4	119	200	53	114	155	192						
5	51	232	53	116	154	185	222					
6	25	270	60	118	159	188	220	263				
7	11	281	49	111	155	179	203	232	274			
8	6	261	53	106	144	167	189	205	227	258		
9	0											
10	1	330	25	70	109	129	148	187	213	239	278	330
	Weighted Mean		66	129	166	188	217	245	256	255	278	330
	Growth Increment		66	63	37	22	29	28	11	-1	23	52
	Weighted Mean*		74	133	168	190	218	247	257	256	280	330

* Correction factor (C) = -6.441, derived from predictive regression.

Table 5. Mean observed SL, TL, and weight for each age group of *Centropristis striata*.

FEMALES				MALES			
Age	$\bar{x}$SL	$\bar{x}$TL	$\bar{x}$ wt	Age	$\bar{x}$SL	$\bar{x}$TL	$\bar{x}$ wt
1	117.08	150.68	53.46	1	113.60	145.80	46.40
2	161.44	207.71	137.12	2	168.23	216.05	152.98
3	186.41	242.92	208.00	3	210.45	276.22	305.38
4	200.13	259.81	255.29	4	233.35	307.92	393.58
5	231.65	297.10	390.02	5	268.91	353.93	581.21
6	270.28	347.00	604.06	6	279.41	367.40	629.94
7	280.73	359.36	645.00	7	291.76	385.89	757.00
8	261.00	336.00	513.50	8	303.81	392.47	841.38
9	------	------	------	9	297.67	404.67	624.00
10	330.00	425.00		10	340.00	447.50	954.00

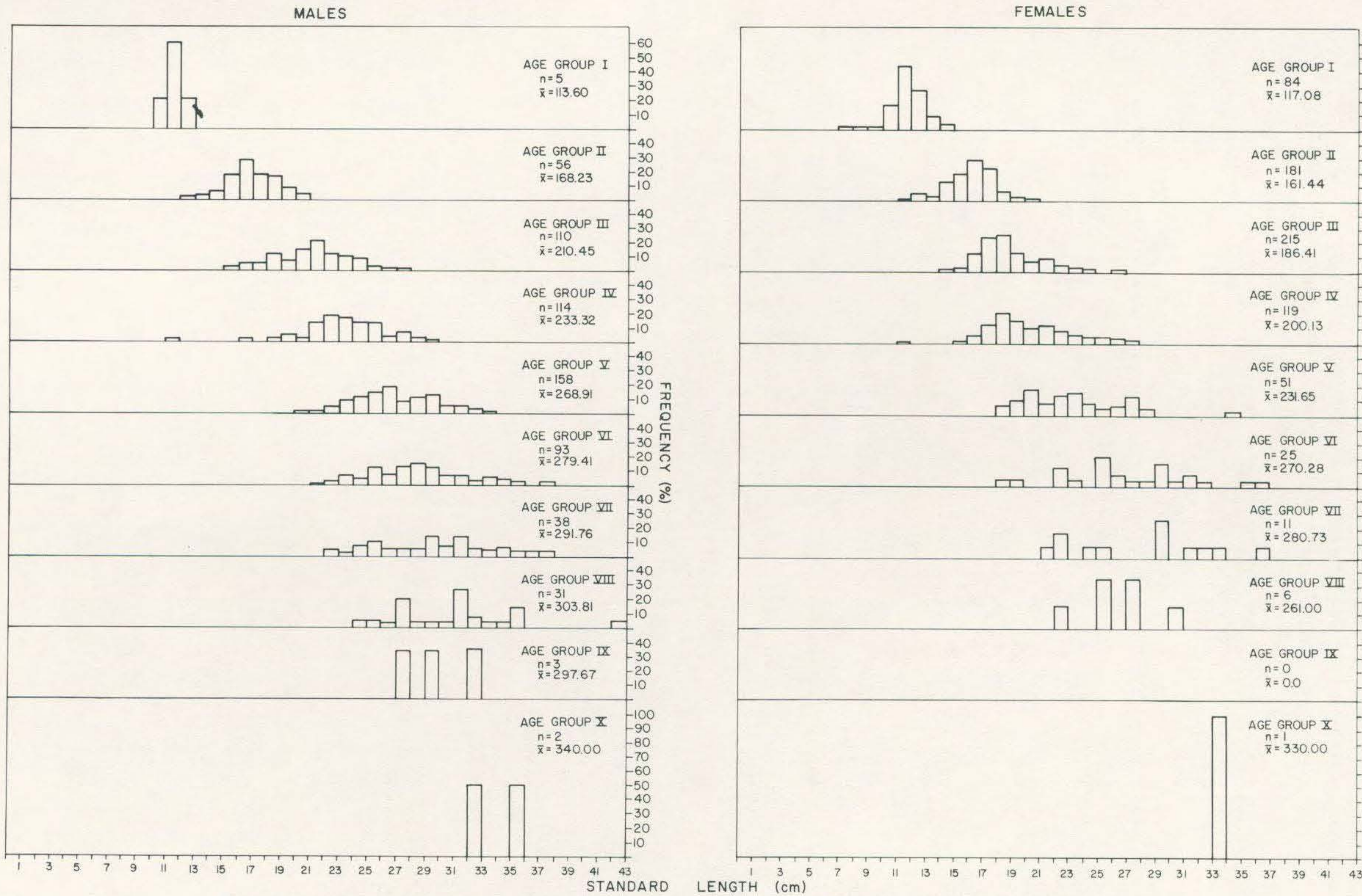

Figure 2. Length frequency histograms of *Centropristis striata* for age groups I–X (sexes separate) in the South Atlantic.

Table 6. Total numbers of male, female, transitional, and undifferentiated *Centropristis striata* grouped in 10 mm intervals (all gears combined).

SL	MALE	FEMALE	TRANSITIONAL	UNDIFFERENTIATED	TOTAL
70-79	0	1	0		1
80-89	0	1	0		1
90-99	0	1	0		1
100-109	1	13	0		14
110-119	4	38	1	1	44
120-129	2	33	0	1	36
130-139	3	15	1	1	20
140-149	3	28	5		36
150-159	14	47	5		66
160-169	21	86	9		110
170-179	16	106	24		146
180-189	26	97	31		154
190-199	18	59	35		112
200-209	22	39	54		115
210-219	41	44	35		120
220-229	49	31	28		108
230-239	55	19	20		84
240-249	58	11	20		89
250-259	61	14	15		90
260-269	48	9	15		72
270-279	44	11	4		59
280-289	38	3	6		47
290-299	44	6	1		51
300-309	22	3	1		26
310-319	30	3	2		35
320-329	12	2	1		15
330-339	7	2	0		9
340-349	7	1	0		8
350-359	8	1	0		9
360-369	1	2	0		3
370-379	2	0	0		2
380-389	0	0	0		0
390-399	0	0	0		0
400-409	0	0	0		0
410-419	0	0	0		0
420-429	1	0	0		1
Total	658	726	313	3	1700
Percent	38.7%	42.7%	18.4%	0.2%	

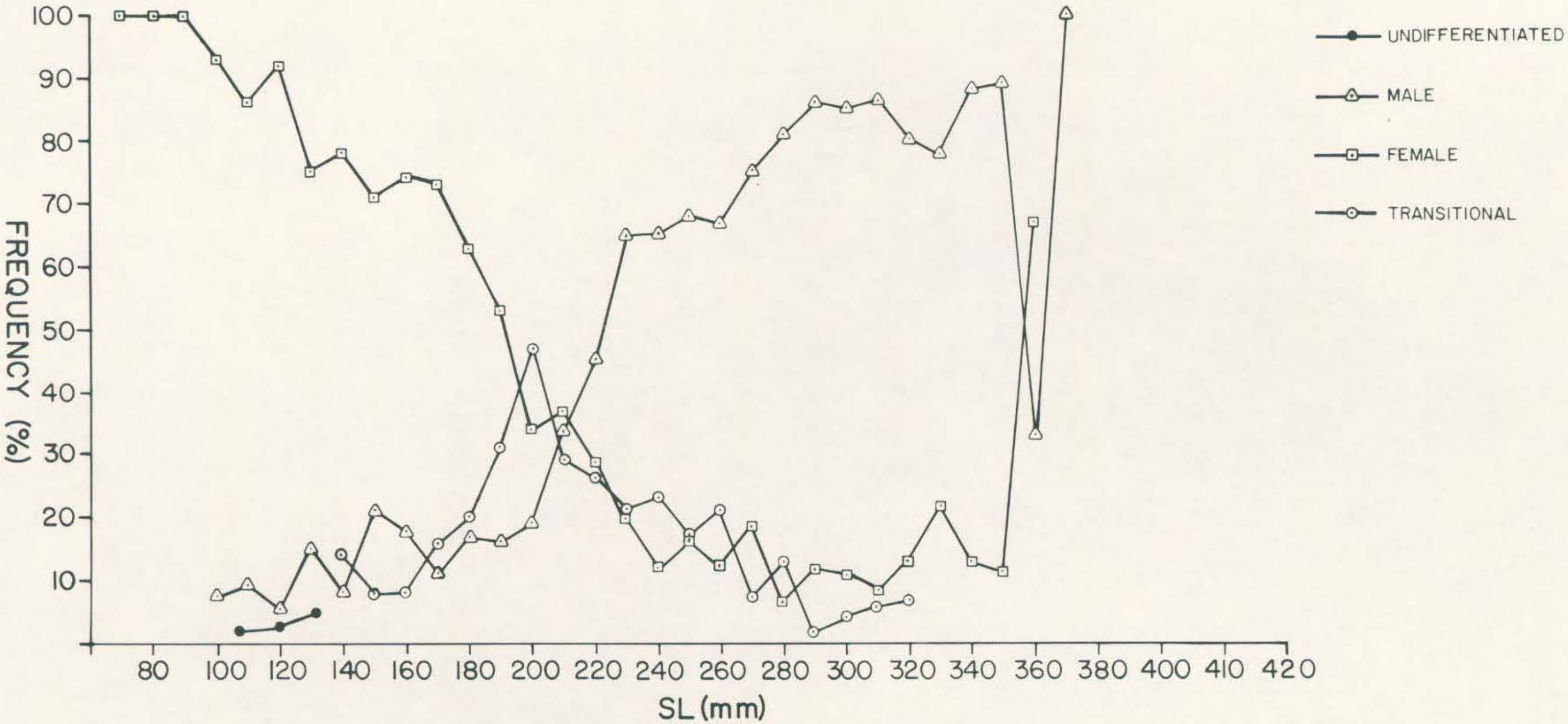

Figure 3. Percent frequency of sexual types of South Atlantic *Centropristis striata* in each 10mm size interval.

Table 7. Total number male, female, transitional, and undifferentiated C. striata by age.

Age Group	Number of Fish	Undifferentiated	Male	Female	Transitional
0	2	2	0	0	0
1	92	1	5	84	2
2	272	0	56	181	35
3	448	0	110	215	123
4	284	0	114	119	51
5	268	0	158	51	59
6	133	0	93	25	15
7	53	0	38	11	4
8	40	0	31	6	3
9	3	0	3	0	0
10	3	0	2	1	0

Table 8. Total numbers, average weight, number of males, females, transitionals, and the average age of C. striata subsampled from each area.

	Total Number	$\overline{x}$ wt. (kg)	SUBSAMPLE Males	Females	Transitional	Subtotal	Mean Age
Area 1	128	.489	31	27	7	65	5.0
Area 2	1725	.328	445	520	219	1184	3.6
Area 3	28	.512	11	12	3	26	3.9
Area 4	334	.310	123	134	63	320	2.9
Total	2215		610	693	292	1595	

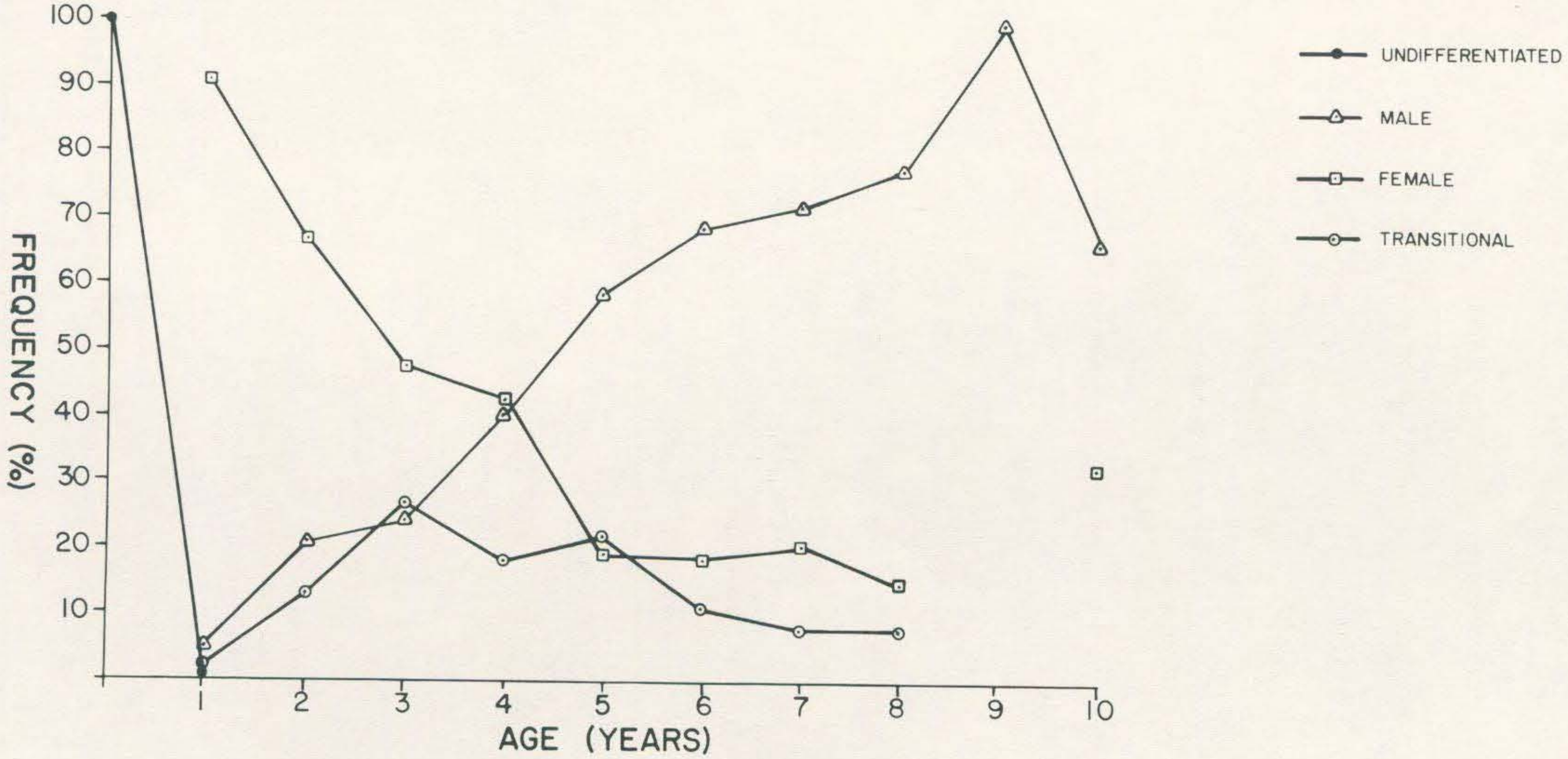

Figure 4. Percent frequency of sexual types of South Atlantic *Centropristis striata* at each age.

Table 9a. Total number, average weight, numbers of males, females, transitionals, and the average age of C. striata by depth subsampled from Area 2.

	Total Number	$\bar{x}$ wt. (kg)	SUBSAMPLE Males	Females	Transitional	Subtotal	Mean Age
10-14 fm	652	.225	135	172	86	393	2.4
15-19 fm	697	.293	172	245	84	501	4.2
20-25 fm	376	.571	138	103	49	290	4.8
Total	1725		445	520	219	1184	

Table 9b. One-way ANOVA, Bartlett's test, and Student-Newman-Keuls test for mean weight of sea bass caught in 3 depth intervals in Area 2.

Source	df	SS	MS	F
Treatment	2	.290	.145	29.436***
Error	6	.030	.005	
Total	8	.320		

Bartlett's test	Chi-square = 3.704^{ns} df = 2			
Student-Newman-Keuls	Depth	10-14	15-19	20-25
	$\bar{x}$ wt. (kg)	.267	.297	.662

*** = P < .001

and the average age of C. striata subsampled from each area are presented in Table 8. Because the depths sampled within each area varied greatly (Table 1), analysis of mean weight between areas was not done.

The ratio of males to females ranged from 0.86 to 1.15 and the average age ranged from 2.9 to 5.0 years among the 4 areas sampled.

SUMMARY and CONCLUSIONS

The length-length and length-weight regressions calculated in this report are the functional regressions of Ricker (1973). Mercer (1978) found a significant difference in the length-weight relationships between male and female black sea bass from the Middle Atlantic Bight. She noted that males were heavier than females at the same length. Although not tested statistically, our data show a close agreement between calculated weights for males and females of similar size.

This study has provided back-calculated lengths at age using correction factors derived from functional and predictive regressions. Ricker (1973) states that back-calculated lengths, using a predictive correction factor, are progressively too large at younger ages. In this study the use of functionally derived correction factors did reduce the back-calculated lengths for the younger age groups. However, back-calculated lengths for age group I are probably too low to be considered realistic. Thirty-seven C. striata ranging in size from 45 to 130 mm SL ($\bar{x}$ = 71 mm SL) sampled subsequent to this study revealed that the first annulus had not yet formed. Therefore, we have concluded that the use of a functionally derived correction factor in this study underestimated the back-calculated length in the younger age groups. Back-calculated lengths reported by Cupka et al. (1973) and Mercer (1978) are larger than those reported here, especially for ages 1 and 2. We believe the sampling design employed in this study provided a very representative picture of the black sea bass population in the South Atlantic Bight. Therefore, back-calculated lengths given here are probably a much closer approximation of the average size at age for black sea bass in this area than those of other studies.

Black sea bass are protogynous hermaphrodites, the males dominating the larger classes (> 220 mm SL) and older age groups (> 4 years). Sex reversal takes place over a large size and age range; however, transitional fish are most commonly age 3. Mature males and females were found in all age groups.

The size and age distribution of black sea bass varied greatly between the four areas sampled. These differences may be attributed in part to the different depths sampled at each area.

Distributional analysis showed that most black sea bass are larger and older in deeper waters. Females predominate in depths less than 20 fm, while males are more numerous in waters deeper than 20 fm. The reason for this is unknown, although it has been suggested that black sea bass gradually move offshore with age.

This study has provided biological data on the black sea bass population south of Cape Hatteras. It is hoped that this information will form the basis for future comparisons of the size, age and sexual composition of the black sea bass, which will contribute to the effective management of this important fisheries resource.

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