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Reproductive biology and recreational fishery for spotted seatrout, Cynoscion nebulosus, in the Chesapeake Bay area

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REPRODUCTIVE BIOLOGY AND RECREATIONAL FISHERY FOR SPOTTED SEATROUT, *CYNOSCION NEBULOSUS*, IN THE CHESAPEAKE BAY AREA

A Thesis

Presented to

The Faculty of the School of Marine Science

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In partial fulfillment

Of the Requirements for the Degree of

Master of Arts

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by

Nancy J. Brown

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APPROVAL SHEET

This thesis is submitted in partial fulfillment of
the requirements for the degree of

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Nancy J. Brown

Approved, December 1981

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DEDICATION

This thesis is dedicated to my parents,

who introduced me to the Sea and encouraged my love for it.

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ACKNOWLEDGEMENTS

I would like to thank Dr. John Merriner for suggesting this research topic and for reviewing the manuscript. I would also like to thank Drs. Jack Musick, Herb Austin, John Ruzecki and Dave Engle for reviewing the manuscript and offering useful criticism. The following people at the Virginia Institute of Marine Science offered invaluable help and advice: Patrice Mason on histology work, Frank Wojcik, Brenda Norcross, Robert Harris, Hugh Brooks and Marion Hedgepeth for unending patience with my innumerable computer questions and problems, Dr. Gene Burreson on photomicroscopy, Ken Thornberry for everything connected with photography, Mary Ann Foell for help with drafting the figures, all the people in the SAV project for helping me collect data, Dick Cook for drawing the frontispiece, to the late Clarence Richards for his help with coding and analyzing citation data, and to my fellow graduate students and friends for providing the moral support necessary for getting through this project. A special thanks to Jess Hawkins and Sheryan Epperly of the North Carolina Division of Marine Fisheries for sharing their data with me. To all the speckled trout fishermen who took the time to fill out a fishing form or talk with me, the third section of this thesis is for you. An extra thanks to John, my family, and Dr. Jay Wright; this never would have been finished without you. This study was funded by a grant from the Sport Fishing Institute.

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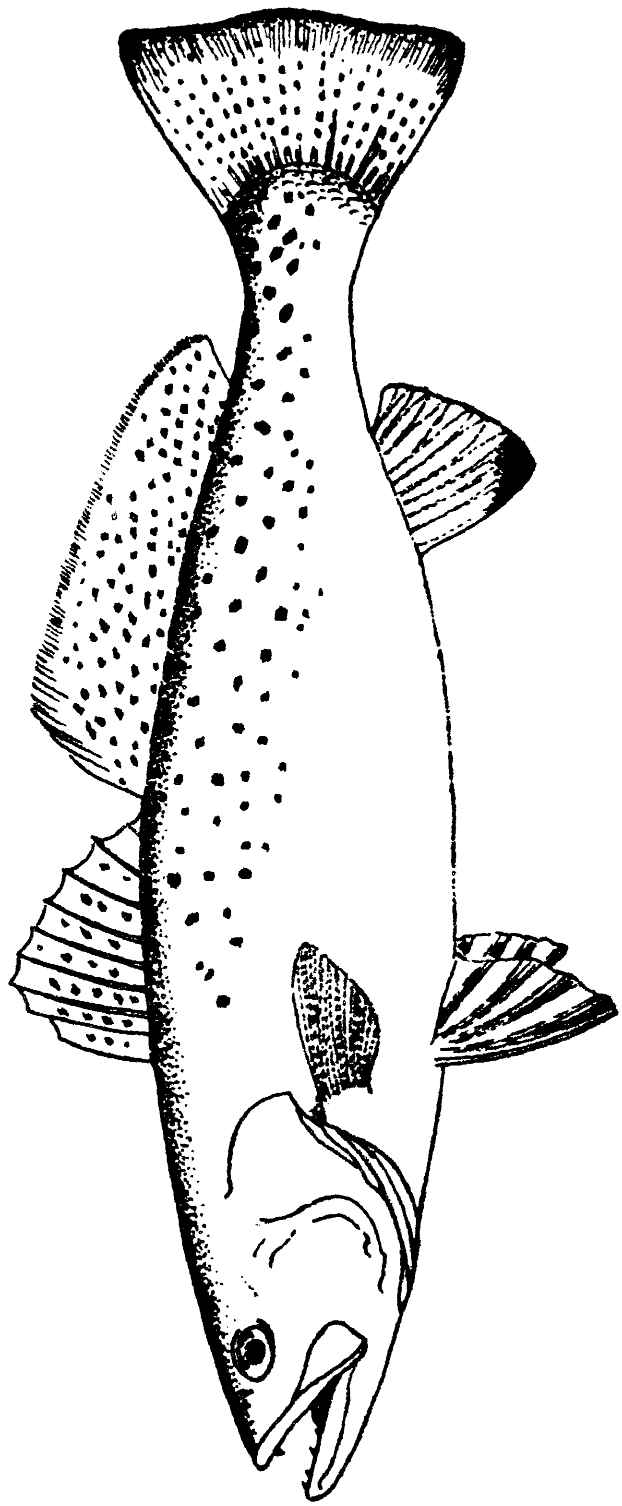
ABSTRACT

Three hundred sixty six spotted seatrout from the Chesapeake Bay area, Virginia and Pamlico Sound, North Carolina were collected during May through November, 1979-1980 with commercial and recreational fishing gear. Scales from two hundred fifty-two spotted seatrout were used to determine age. Ages ranged from 0 to 15 years; males achieved a maximum age of eight years. Seatrout grew rapidly during their first three years. Female fish grew faster and attained a greater mean length at any age than males. Estimates of ultimate attainable lengths for all fish was 935 mm TL; maximum lengths for males and females were 760 mm and 854 mm TL, respectively.

Gonads from 153 fish were utilized in calculation of Gonadosomatic Indices (GSI) and histological preparation. The GSI's indicated that female fish had two spawning peaks (May 18 to June 14 and July 13 to July 26), while males had only one peak (May 18 to June 28). Histological inspection indicated females were ripe May 17 to June 5 and July 2 to July 24. Males appeared ripe June 23 through September 5. All females were spent by August 26. All males were spent by September 5. Rapid, 6^{o} C increases in water temperature appeared to be a primary spawning cue for spotted seatrout. Histological inspection revealed all males were sexually mature in their second year; however, a ripe one-year-old was found on September 5, 1980. Only 20% of two-year-old females had maturing gonads; by age III 86% female gonads were sexually active. Condition factors (K) for female fish showed two significant peaks, corresponding to the two peaks in GSI values. No correlation between K and GSI existed in males. Data indicate spawning near grass beds of *Zostera* and *Ruppia* in the Chesapeake Bay area.

Analysis of 1958-1980 citation data from the Virginia Saltwater Fishing Tournament and a two year survey of spotted seatrout fishermen revealed that areas with beds of submerged aquatic vegetation (Ware, North and Piankatank Rivers, Nassawadox Creek, Masons Beach and Parkers Island) were the best locations to catch large spotted seatrout in the Bay during the spring and summer. Spotted seatrout leaving the Bay during their fall migration were most often caught at the Chesapeake Bay Bridge Tunnel. The most popular baits during the spring and summer were soft and peeler crabs; lures, such as stingray grubs, mirrolures and bucktails were popular during the summer and fall. North Carolina Saltwater Fishing Tournament citation data indicated similar trends. Spotted seatrout were not fully recruited into the citation fishery until age VIII. Fishing forms indicated seatrout were fully recruited into the recreational fishery by age IV. An approach to management and research needs are suggested for the East Coast spotted seatrout population.



REPRODUCTIVE BIOLOGY AND RECREATIONAL FISHERY FOR SPOTTED SEATROUT,

CYNOSCION NEBULOSUS, IN THE CHESAPEAKE BAY AREA

GENERAL INTRODUCTION

The spotted seatrout (*Cynoscion nebulosus* Cuvier) is one of the most important commercial and recreational fishes in the southeastern United States. They range from Cape Cod to Mexico (Tabb, 1966) but are extremely rare north of Delaware Bay (Welsh and Breder, 1923). Although much is known about spotted seatrout biology from the Gulf of Mexico, little has been published for the population(s) north of Beaufort, North Carolina. *C. nebulosus* is not as abundant in Virginia as it is in Florida and along the Gulf Coast; nonetheless it is an important teleost component of seagrass ecosystems in Chesapeake Bay and supports a specialized, active recreational fishery.

C. nebulosus is primarily an estuarine species and is most abundant in semi-landlocked lagoons and quiet estuaries (Tabb, 1958). They seem to prefer shallow waters along tidal creeks, rivers, sounds and beaches (Mahood, 1975) and are frequently associated with extensive beds of submerged aquatic vegetation (Tabb, 1958; Miles, 1950; Moody, 1950). In Louisiana spotted seatrout prefer sandy bottoms, submerged or emergent islands and shell reefs (Lorio and Perret, 1980).

Spotted seatrout are euryhaline and found at times in fresh water (Perret, 1971 *In* Lorio and Perret, 1980) to 75 ppt (Simmons, 1957). Tabb (1966) reported that normal salinity ranges are between 5 and 30 ppt. *C. nebulosus* is essentially a warmwater species (Moody, 1950). Tabb (1958) reported optimal temperatures of 15 to 27° C for this species in Florida. In Georgia spotted seatrout inhabit shallow waters between 16 and 25° C. At lower or higher temperatures, they moved into deeper water in the estuaries (Mahood, 1975). Temperatures below 10° C induced Florida fish to move from estuaries to ocean inlets or off beaches for brief periods (Tabb, 1966). A rapid drop in temperature results in "trout numbs" and stunned seatrout float on the water surface or are washed onto beaches (Storey and Gudger, 1936).

The spotted seatrout is a non-selective carnivore. Tabb (1966) reported that fish along the Gulf Coast fed most frequently on striped mullet (*Mugil cephalus*), anchovies (*Anchoa* sp.), pinfish (*Lagodon rhomboides*), mojarras (*Eucinostomus* sp.), sheepshead minnows (*Cyprinodon variegatus*) and penaeid shrimp (*Peneaus* sp.). Mahood (1975) found spotted seatrout in Georgia fed most often on menhaden (*Brevoortia* sp.), mullet (*Mugil* sp.), croaker (*Micropogonias undulatus*), mummichog (*Fundulus heteroclitus*) and penaeid shrimp (*Penaeus* sp). Tabb (1958) stated that in many estuaries *C. nebulosus* is the top carnivore, having successfully invaded the rich feeding grounds of the euryhaline herbivores.

Spotted seatrout reside in the Chesapeake Bay area during the warmer months (May through October) and migrate south as water temperatures fall in October and November. The southern limit of fish resident in Chesapeake Bay remains to be defined.

In the Bay, *C. nebulosus* tend to stay in shallow creeks and rivers adjacent to beds of eelgrass (*Zostera marina*) and widgeon grass (*Ruppia maritima*) although they will move into deep holes during midsummer. While they have never been plentiful in the Bay, there has always been a population of relatively large fish that supports a small, though avid, recreational fishery. In the last three to four years, numbers of spotted seatrout have diminished. This is a matter of some concern to local sportsfishermen.

The purpose of this thesis is to describe the age and growth, reproductive biology and recreational fishery of spotted seatrout in the Chesapeake Bay area of Virginia. Each topic is addressed in a separate section.

SECTION I

AGE AND GROWTH

INTRODUCTION

The age and growth of the spotted seatrout, *Cynoscion nebulosus*, in Florida and the Gulf Coast area are well documented in the literature. Pearson (1929) reported one of the first thorough aging studies of spotted seatrout. Klima and Tabb (1959), Stewart (1961), Tabb (1961) and Moffett (1961) discussed the age structure of spotted seatrout in Florida. More recently, Wade (in press) described the age and growth of spotted seatrout populations in Alabama.

Age and growth information for spotted seatrout from Atlantic coast waters is very limited. Mahood (1975) presented length frequencies of spotted seatrout in Georgia and some brief comments on the aging of this species. Staff of the Georgia Department of Natural Resources are presently investigating age and growth of spotted seatrout (J. Music, pers. comm.). Age and growth of adult *C. nebulosus* in North and South Carolina are undocumented. Hildebrand (1941) discussed the growth of juvenile spotted seatrout in North Carolina. Hildebrand and Schroeder (1928) gave no age or growth estimates for spotted seatrout in the Chesapeake Bay, but did provide size ranges for young-of-the-year.

My objectives were to describe the age and growth of *Cynoscion nebulosus* from Virginia waters. Results will be used to determine age at sexual maturity (Section II) and the age composition of the recreational catch (Section III). Data from other areas will be compared with that from Virginia.

MATERIALS AND METHODS

Three hundred sixty-six spotted seatrout caught from May through November of 1979 and 1980 with commercial fishing gear (haul seines, pound nets, gillnets and otter trawls) and hook and line fishing were examined. Spotted seatrout were caught at Ware Neck Point, Hungars Creek, York River, Lynnhaven River and the Pamlico Sound near Rodanthe, North Carolina. Total lengths to the nearest millimeter and total weight to the nearest 10 grams were measured for each fish. Gonads were removed from 153 fish; an additional 39 fish were sexed, although gonads were not removed. A scale sample was removed from underneath the tip of the pectoral fin on the left side of each fish. In the few cases when the fish were damaged in this area, scales were removed from the same location on the right side of the body.

Scales were cleaned in warm water and six scales per fish were mounted on acetate strips. The scales were pressed at 175^{o} C, 2100 psi for 1.5 minutes on a Carver Laboratory press. Scale images were projected on an Eberbach scale reader at a magnification of 48X. Annuli were measured in millimeters from the origin diagonally to the edge of the scale. Each annulus was counted as one year. The scale edge was not counted as an additional year. Scales were read twice; if the two counts did not agree, a third reading attempt was made. Disagreement after three readings precluded use of that fish in age and growth analysis. Two hundred fifty-two fish were used in the age calculations.

Regression analysis of scale length on total length was performed on sexes combined and males and females separately. Back-calculations of total length at age were computed for all fish, and for males and females separately using the Lee method (Ricker, 1975).

The von Bertalanffy growth curve was fitted to spotted seatrout data following Ricker (1975). Mean backcalculated lengths were used to compute the growth parameters. Walford graphs were drawn to determine Ford's growth coefficient, k ($=e^{-K}$), and L_{∞}. Plots were made following Beverton's (1954, *In* Ricker, 1975) procedure to determine the best value for L_{∞} and to compute t_0. Growth equations were calculated for all fish combined as well as males and females separately. The length-weight and length-age regressions were calculated for all fish, and for male and female fish separately. Multiple regression analysis, with length and weight as dependent variables and small sample paired difference tests (Mendenhall *et al*, 1974) were performed. Calculations were performed on an IBM 370-115 and a Prime 350 computer, using the Statistical Package for the Social Sciences (SPSS) and programs from the computer library at the Virginia Institute of Marine Science. Where conversions of fish lengths were necessary for comparisons among various age and growth studies I used Moffett's (1961) conversion factor (TL=1.22 SL).

RESULTS

Length-Weight relationships

Specimens measured 122 to 776 mm TL and weighed 21 to 5443 grams. Equations describing the length-weight relationship for spotted seatrout (Figure 1), sexes combined are:

$$\log W = 3.043 \log L - 5.072, \ (r^2=.97)$$

$$W = .000085\, L^{(3.043)}$$

The total length-weight relationships for 74 male spotted seatrout and for 102 female spotted seatrout (Figure 2) are:

male: $\log W = 3.244 \log L - 5.598, \ (r^2=.97)$

$$W = .0000025\, L^{(3.244)} \text{ and}$$

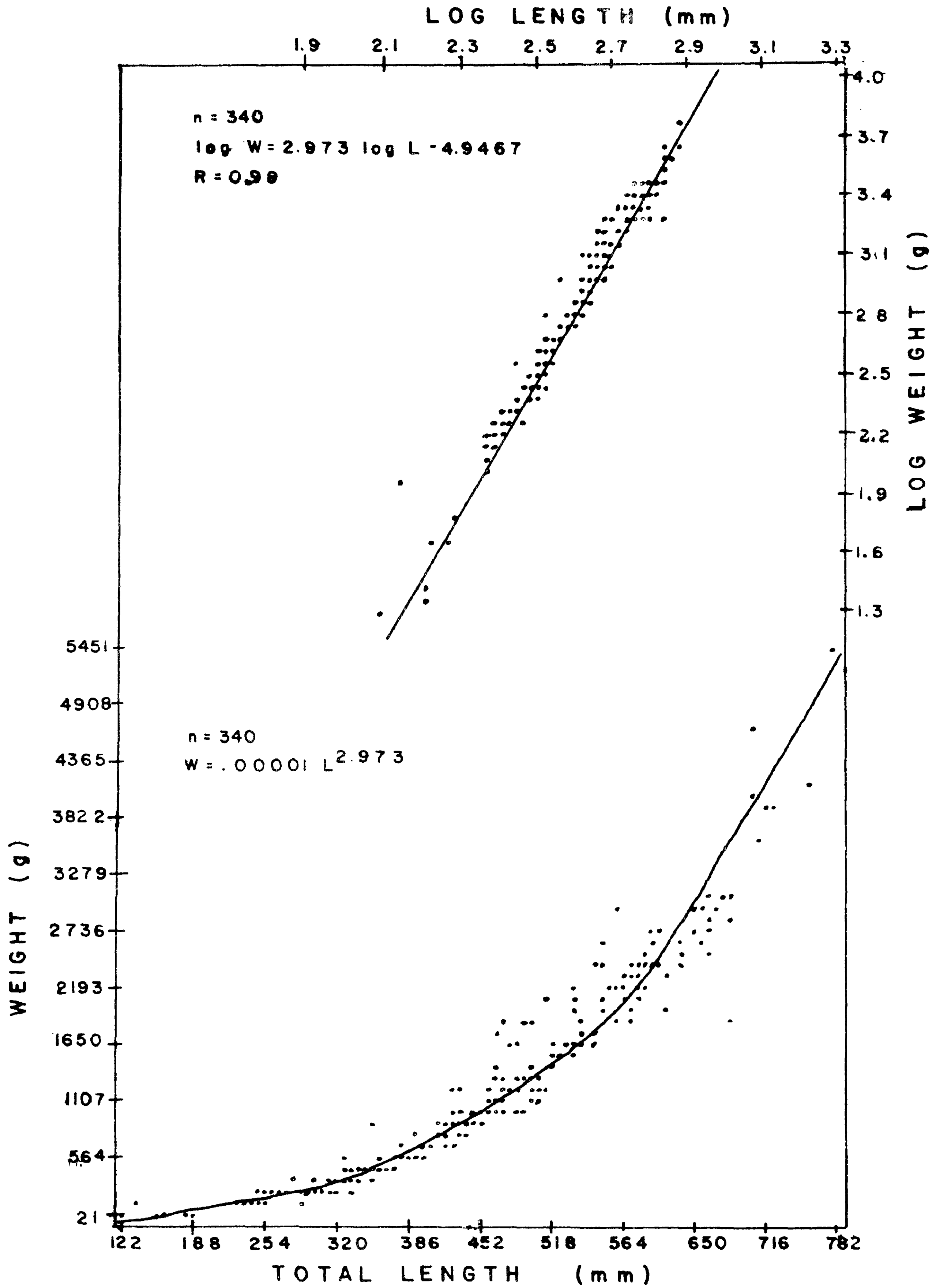
female: $\log W = 2.986 \log L - 4.924, \ (r^2=.94)$

$$W = .0000119\, L^{(2.986)}.$$

Age Analysis

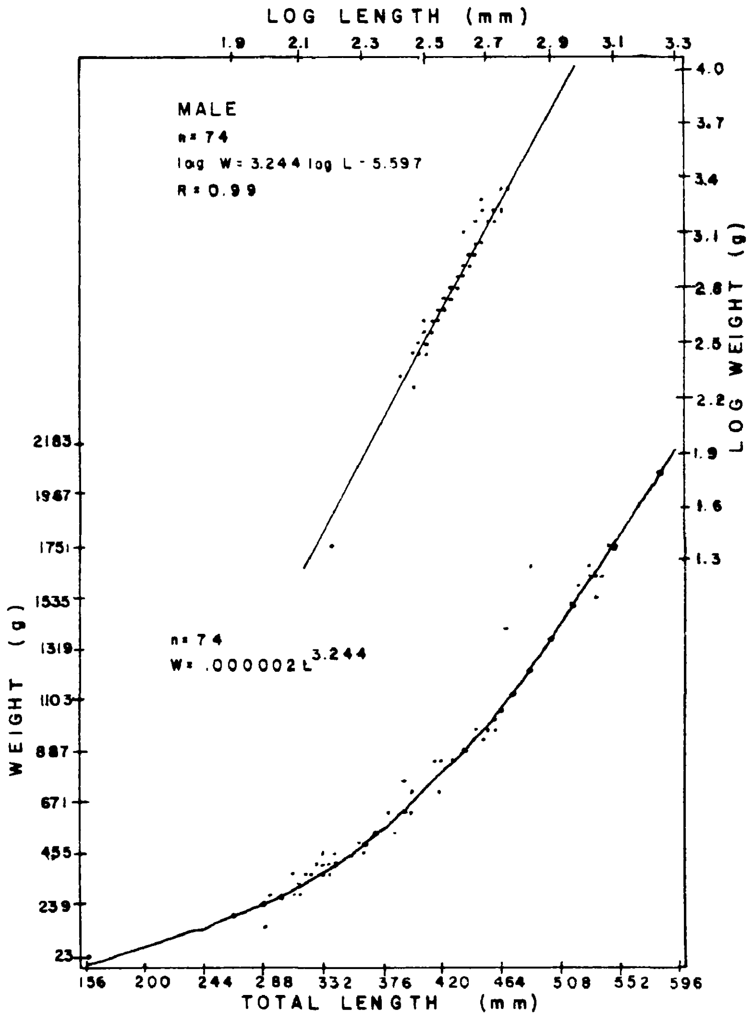
Spotted seatrout lay down one annular mark each year, corresponding to periods of slow growth during the winter. The first mark is often difficult to distinguish and occasionally no mark is laid down. Scales from young-of-the-year *C. nebulosus* captured in the fall after completion of a summer's growth aided in determining the approximate distance of the first annulus from the origin. A scale from a typical young-of-the-year fish (Age 0) is shown in Figure 3A. The distance to the outer edge respresents one year of growth.

Figure 1. Length-weight relationships of *Cynoscion nebulosus*.



LOG LENGTH (mm)
1.9 2.1 2.3 2.5 2.7 2.9 3.1 3.3
4.0 3.7 3.4 3.1 2.8 2.5 2.2 1.9 1.6 1.3
LOG WEIGHT (g)
n = 340
log W = 2.973 log L - 4.9467
R = 0.99
n = 340
W = .00001 L2.973
5451 4908 4365 3822 3279 2736 2193 1650 1107 564 21
WEIGHT (g)
122 188 254 320 386 452 518 564 650 716 782
TOTAL LENGTH (mm)

Figure 2. Length-weight relationships of male and female *Cynoscion nebulosus*.


LOG LENGTH (mm)
1.9 2.1 2.3 2.5 2.7 2.9 3.1 3.3
MALE
n = 74
log W = 3.244 log L - 5.597
R = 0.99
n = 74
W = .000002 L^3.244
WEIGHT (g)
23 239 455 671 887 1103 1319 1535 1751 1967 2183
LOG WEIGHT (g)
1.3 1.6 1.9 2.2 2.5 2.8 3.1 3.4 3.7 4.0
TOTAL LENGTH (mm)
156 200 244 288 332 376 420 464 508 552 596

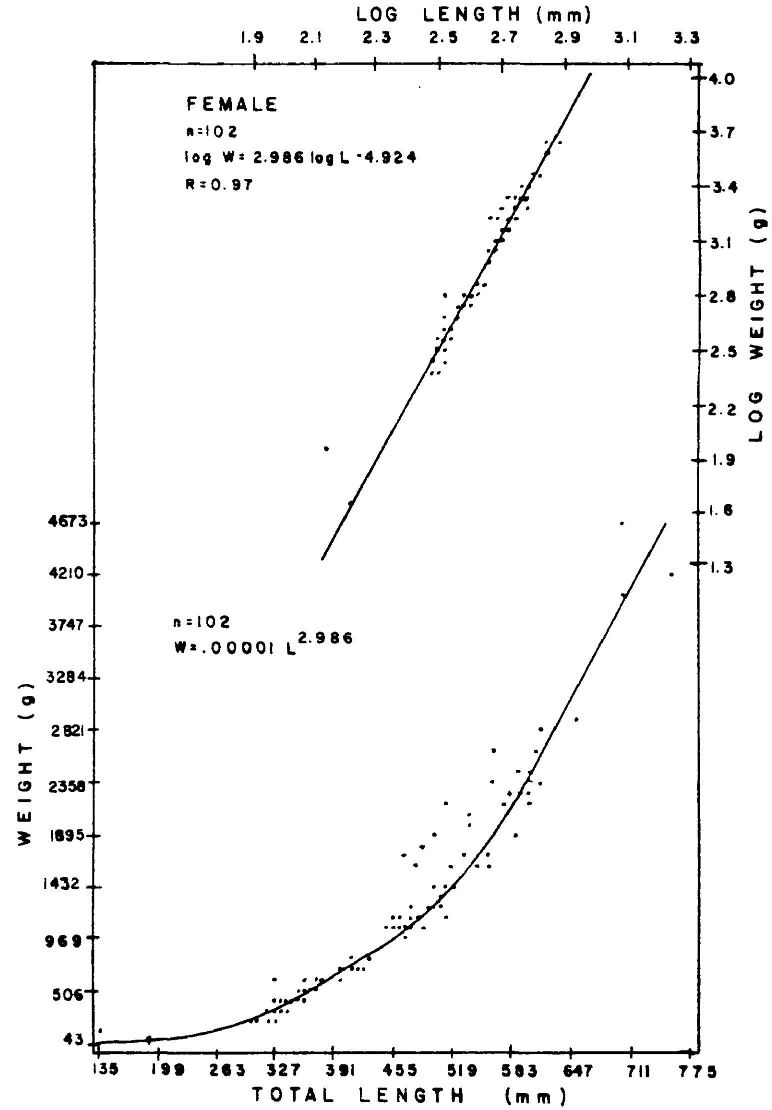

LOG LENGTH (mm)
1.9 2.1 2.3 2.5 2.7 2.9 3.1 3.3
FEMALE
n = 102
log W = 2.986 log L - 4.924
R = 0.97
n = 102
W = .00001 L^2.986
WEIGHT (g)
43 506 969 1432 1895 2358 2821 3284 3747 4210 4673
LOG WEIGHT (g)
1.3 1.6 1.9 2.2 2.5 2.8 3.1 3.4 3.7 4.0
TOTAL LENGTH (mm)
135 199 263 327 391 455 519 583 647 711 775

Figure 3. A. Scale from young-of-the-year *Cynoscion nebulosus*, November 1980, 164 mm TL, with no annular marks. 108X magnification.

B. Scale from age XV *Cynoscion nebulosus*, September 1979. 776 mm TL. 12X magnification.

Abbreviations: F, focus; FM, scale radius and line of annular measurements; M, scale margin.


A
XV
XIV
XIII
XII
XI
X
IX
VIII
VII
VI
V
IV
III
II
I
M
F
B

The oldest spotted seatrout collected in Chesapeake Bay during this study was 15 (Figure 3B). Male spotted seatrout through age VIII and females through age XII were collected. The age XV spotted seatrout was not sexed; I have presumed that it was a female.

Annual growth was clearly shown by modal progression in the length-frequency histograms for ages I through VIII (Figure 4). The small sample size in older groups tends to obscure this progression. Significant overlap was evident between ages II and III and ages VI and VII. Mean lengths, with 95% confidence intervals and ranges are shown in Figure 4. Females were longer than males at all ages.

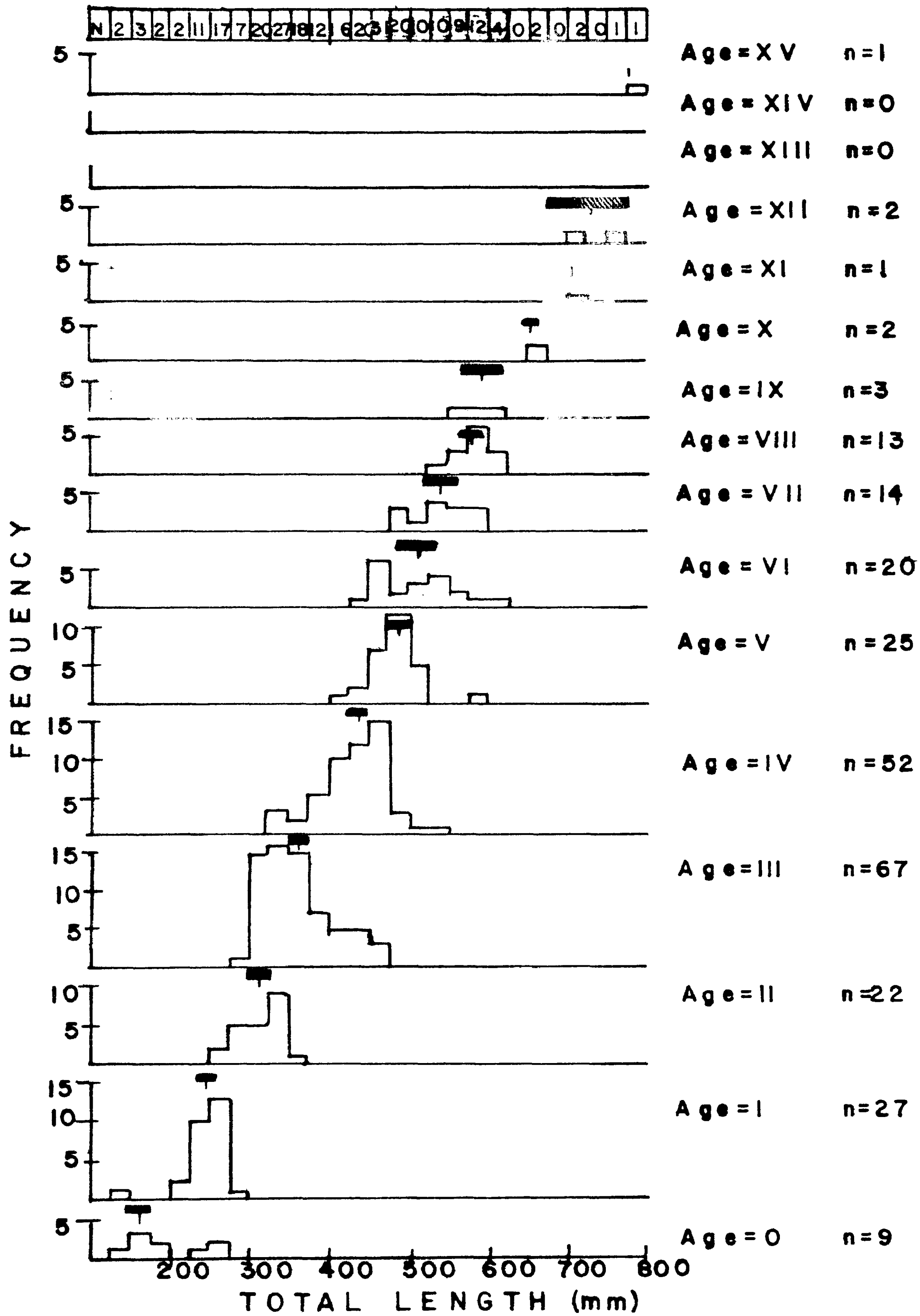
Growth

Back calculated lengths for *Cynoscion nebulosus* males, females and sexes combined are shown in Tables 1 and 2. The absence of age XIII and XIV fish, and presence of only one age XV fish resulted in unrealistically high values in the predicted growth equation. Growth calculations for sexes combined included only fish through age XII. Calculations for female fish excluded the age XI and XII fish.

Spotted seatrout grew rapidly during their first year (170 mm, sexes combined). Growth was rapid during the first three years of life and then slowed in older fish. Some inconsistencies in the expected annual growth rate trend are evident in Table 1 but are attributable to small sample size. Females grow faster and attain a greater mean length than males at any given age (Table 2).

The simple linear regression equations were calculated for the age-total length relationship of spotted seatrout. The

Figure 4. Length frequency histograms of *Cynoscion nebulosus* for ages 0 through XV (sexes combined) with mean lengths and 95% confidence intervals (solid bar).



FREQUENCY
TOTAL LENGTH (mm)
200 300 400 500 600 700 800
Age = XV n = 1
Age = XIV n = 0
Age = XIII n = 0
Age = XII n = 2
Age = XI n = 1
Age = X n = 2
Age = IX n = 3
Age = VIII n = 13
Age = VII n = 14
Age = VI n = 20
Age = V n = 25
Age = IV n = 52
Age = III n = 67
Age = II n = 22
Age = I n = 27
Age = 0 n = 9

Table 1

Mean Back Calculated Total Lengths for 247 *Cynoscion nebulosus*

Age	Number	Mean Length at Capture	Mean Back Calculated Lengths of Successive Annuli 1	2	3	4	5	6	7	8	9	10	11	12
1	26	246	165											
2	22	315	169	262										
3	67	361	169	253	383									
4	52	435	174	264	340	446								
5	25	486	176	271	349	400	445							
6	20	512	173	262	335	399	448	466						
7	14	543	162	250	327	389	439	481	518					
8	13	583	169	262	325	377	428	478	521	557				
9	3	592	164	251	317	371	424	459	502	544	579			
10	2	658	187	276	355	408	449	494	541	579	612	642		
11	1	704	171	272	343	397	451	498	552	586	630	660	684	
12	2	731	154	237	310	376	441	487	533	585	616	648	688	721
	Weighted Means		170	260	353	414	441	475	521	561	603	648	687	721
	Growth Increments		170	90	93	61	27	34	46	40	42	45	39	34

Table 2

Observed and Calculated Total Lengths of 68 Male and 92 Female *Cynoscion nebulosus*

	Age									
	1	2	3	4	5	6	7	8	9	10
Males										
Number	2	8	32	6	5	8	5	2		
Mean Length at Capture	278	312	341	391	449	505	527	599		
Weighted Mean of Back Calculated Length	152	243	313	378	432	472	501	554		
Growth Increment	152	91	70	65	54	40	29	53		
Females										
Number	1	11	23	22	11	8	4	8	3	1
Mean Length at Capture	135	329	356	438	503	531	535	585	592	655
Weighted Mean of Back Calculated Length	191	279	347	404	449	493	523	560	588	644
Growth Increment	191	88	68	57	45	44	30	37	28	56

equation for sexes combined was

$$\text{Age} = 0.018\ \text{TL} - 3.61 \text{ with an } r^2=.86;$$

the regression equation for the age-total length relationship of males was

$$\text{Age} = 0.017\ \text{TL} - 2.70 \text{ with an } r^2=.85;$$

and for females was

$$\text{Age} = 0.019\ \text{TL} -3.92 \text{ with an } r^2=.84.$$

I used the Walford values (Ricker, 1975, Figure 5) for spotted seatrout to plot log(e)$[L_\infty - L_t]$ against age and obtain L_∞, K and t_0 values for the following von Bertalanffy growth equation for sexes combined:

$$L_t = 935[1-e^{(-0.059(t + 5.6091)}]$$

Theoretical lengths at age, derived from the von Bertalanffy growth curve, empirical lengths at age and back calculated lengths at age compared favorably (Table 3 and Figure 6).

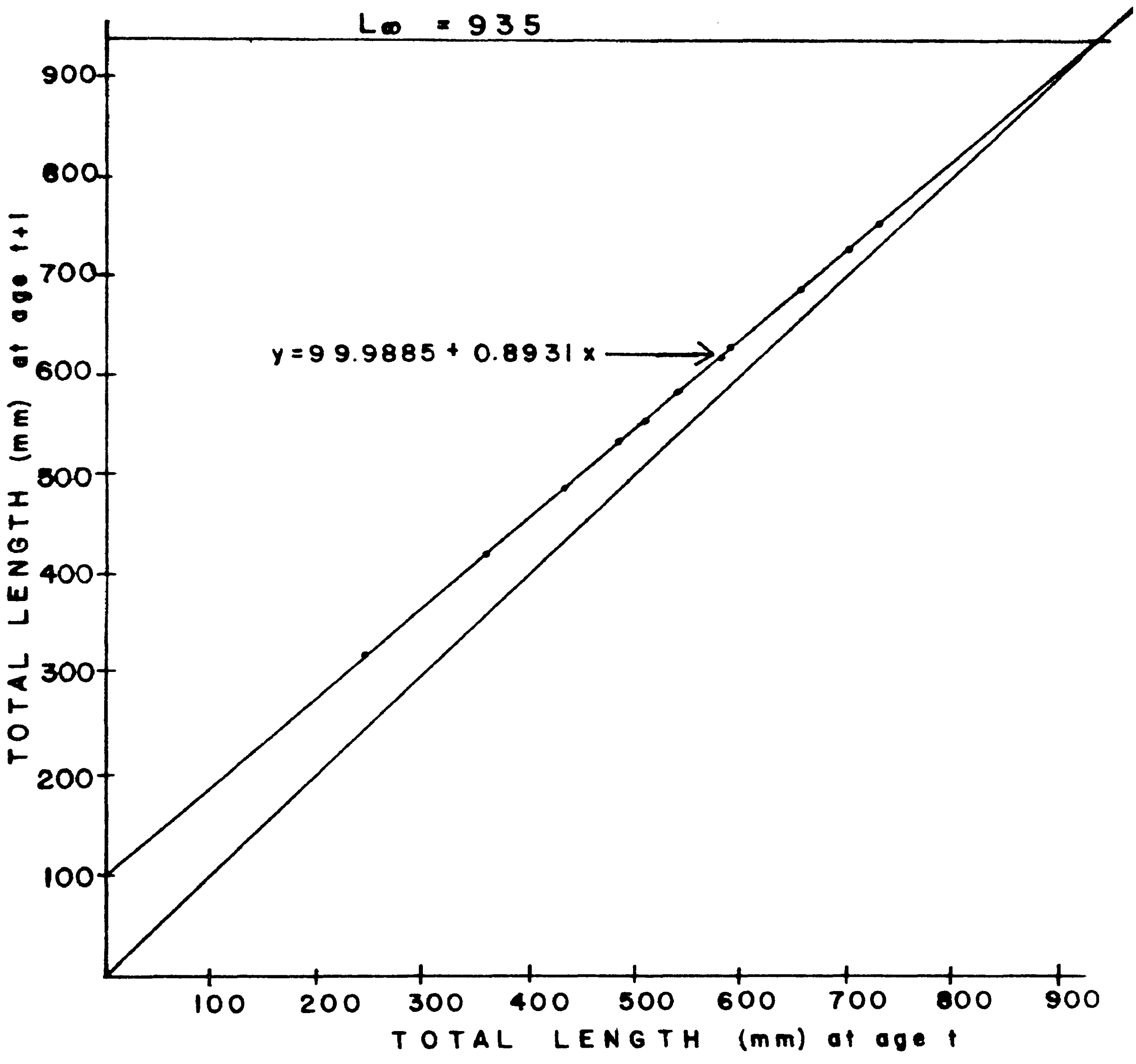
Walford lines (Figure 7) were used to develop the following von Bertalanffy growth equations describing growth in length:

for males $L_t = 760[1-e^{(-0.052(t + 7.5933)}]$ and

for females $L_t = 854[1-e^{(-0.052(t + 7.9278)}]$, respectively.

Theoretical lengths at age, derived from the von Bertalanffy growth curve, empirical lengths at age and back calculated lengths at age for male and female *Cynoscion nebulosus* compared favorably (Table 4 and Figure 8). Sampling methods and sample sizes precluded calculation of annual and instantaneous mortality, catch curves and the Beverton-Holt yield equation.

Figure 5. Walford line for *Cynoscion nebulosus* (sexes combined) age data with estimate of asymptotic length.



L∞ = 935
y = 99.9885 + 0.8931 x
TOTAL LENGTH (mm) at age t+1
TOTAL LENGTH (mm) at age t
100
200
300
400
500
600
700
800
900

Table 3

Comparison of Mean Empirical, Back Calculated and von Bertalanffy

Total Length/Age for all *Cynoscion nebulosus*

Age	Number	Mean Empirical Length	Mean Back Calculated Length	von Bertalanffy Length
1	26	246	170	302
2	22	315	260	338
3	67	361	353	373
4	52	435	414	405
5	25	486	441	435
6	20	512	475	464
7	14	543	521	491
8	13	583	561	516
9	3	592	603	540
10	2	658	648	563
11	1	704	687	584
12	2	731	721	604

Figure 6. Empirical lengths at age, back calculated lengths at age and von Bertalanffy lengths at age for *Cynoscion nebulosus* (sexes combined).

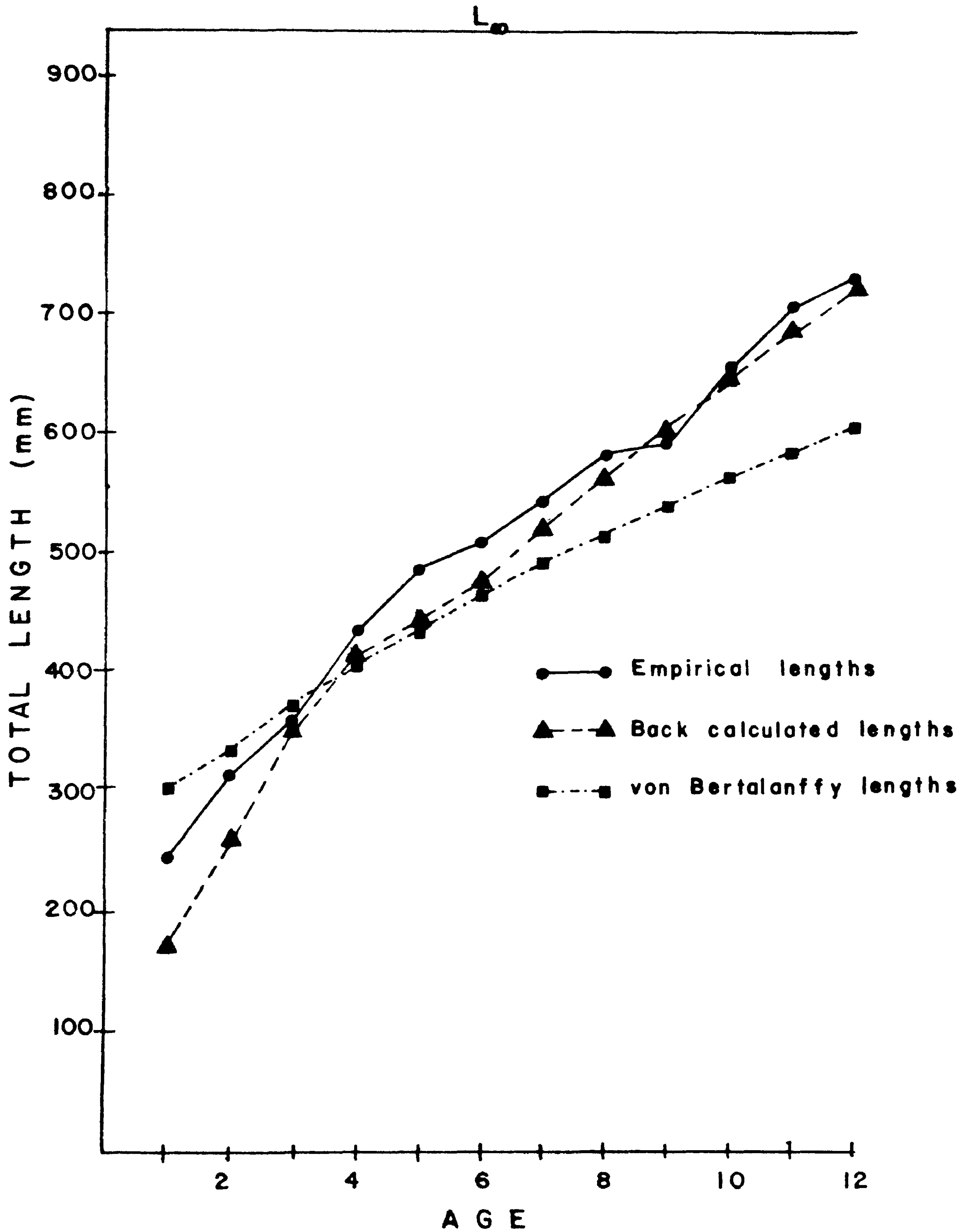

L∞
TOTAL LENGTH (mm)
900
800
700
600
500
400
300
200
100
2
4
6
8
10
12
AGE
Empirical lengths
Back calculated lengths
von Bertalanffy lengths

Figure 7. Walford lines for male and female *Cynoscion nebulosus* age data with estimates of asymptotic lengths.

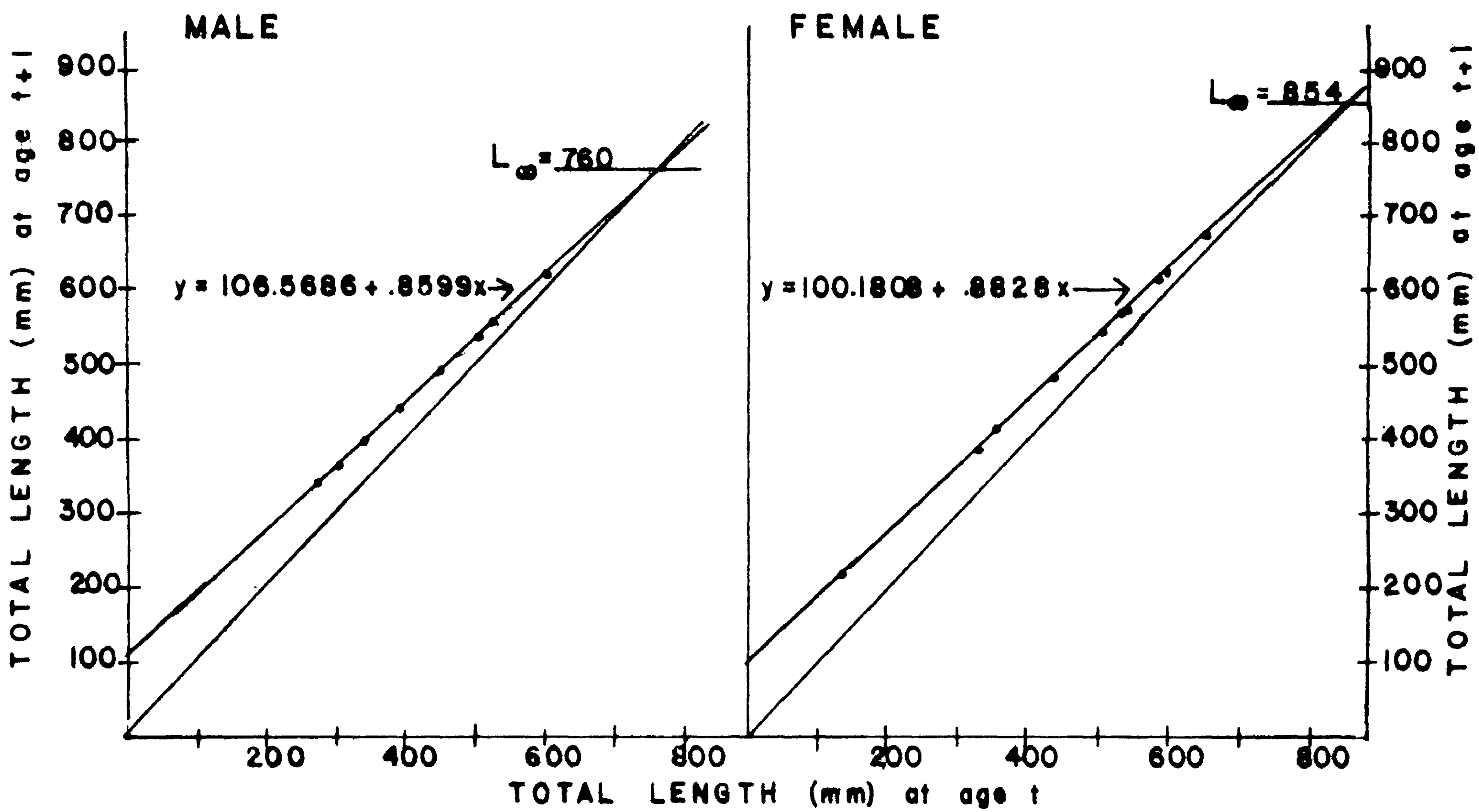

MALE
FEMALE
y = 106.5686 + .8599x
y = 100.1808 + .8828 x
L∞ = 760
L∞ = 854
TOTAL LENGTH (mm) at age t+1
TOTAL LENGTH (mm) at age t
100
200
300
400
500
600
700
800
900

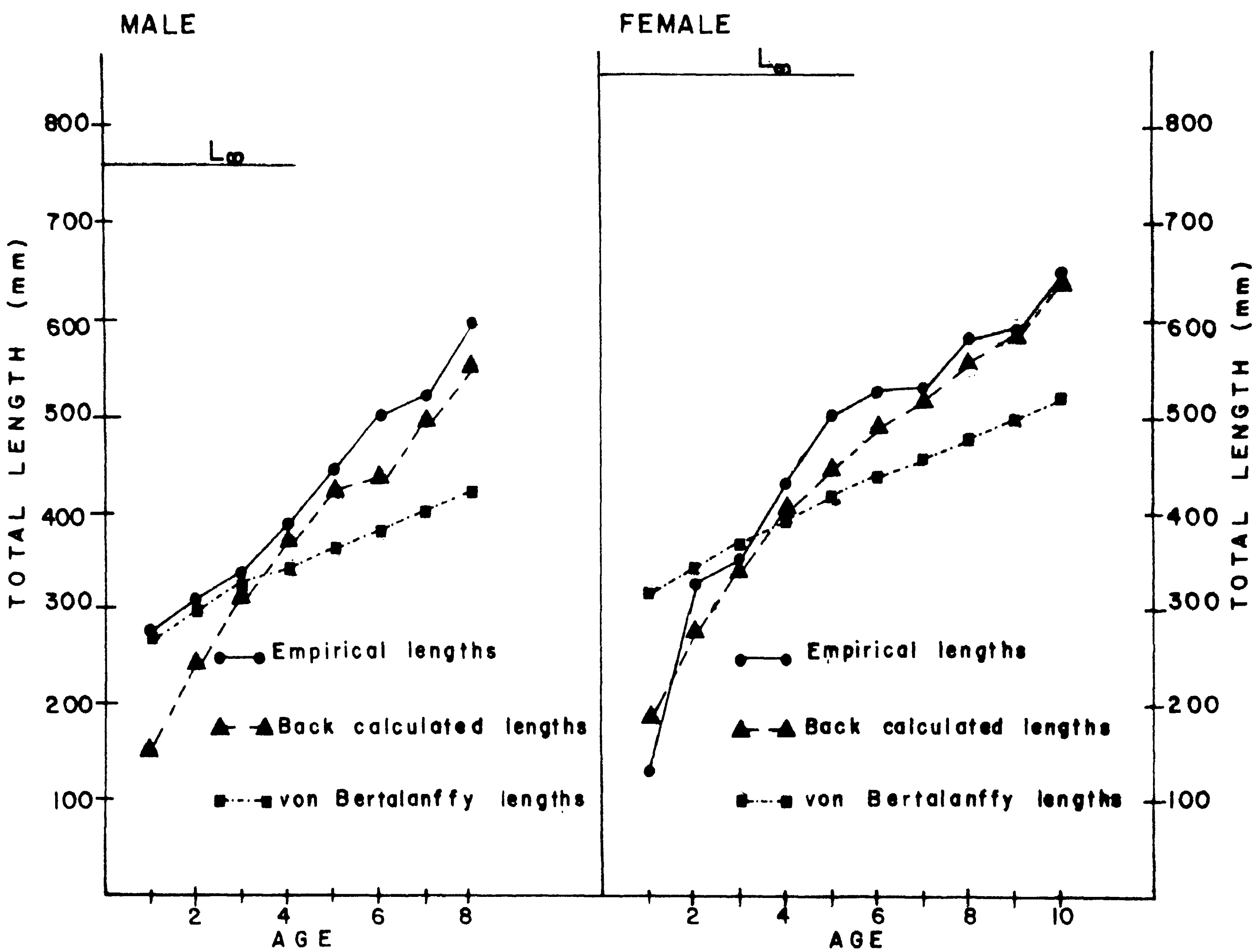
Table 4

Comparison of Mean Empirical, Back Calculated and von Bertalanffy

Total Length/Age for Male and Female *Cynoscion nebulosus*

Age	Number	Mean Empirical Length	Mean Back Calculated Length	von Bertalanffy Length
Males				
1	2	278	153	275
2	8	312	244	299
3	32	341	313	323
4	6	391	378	345
5	5	449	432	366
6	8	505	440	386
7	5	527	501	405
8	2	599	554	423
Females				
1	1	135	191	318
2	11	329	279	345
3	23	356	347	371
4	22	438	404	396
5	11	503	449	419
6	8	531	493	441
7	4	535	523	462
8	8	585	560	482
9	3	592	588	501
10	1	655	643	519

Figure 8. Empirical lengths at age, back calculated lengths at age and von Bertalanffy lengths at age for male and female *Cynoscion nebulosus*.



MALE
FEMALE
L∞
L∞
TOTAL LENGTH (mm)
800
700
600
500
400
300
200
100
Empirical lengths
Back calculated lengths
von Bertalanffy lengths
Empirical lengths
Back calculated lengths
von Bertalanffy lengths
2
4
6
8
10
AGE
AGE
TOTAL LENGTH (mm)

DISCUSSION

Scales have been validated as an aging method for spotted seatrout (Pearson, 1929; Klima and Tabb, 1959; Moffett, 1961; Stewart, 1961; Tabb, 1961; Mahood, 1975; Hein and Shepard, 1980; Tatum, 1980; Wade, in press). Annulus formation for *C. nebulosus* occurred during December in Everglades National Park (Stewart, 1961) or during the winter months in west Florida (Moffett, 1961). Annulus formation was in March along the Gulf coast (Guest and Gunter, 1958). Annulus formation is coincident with the period of fat deposition within the body cavity (Tabb, 1961). Scales from spotted seatrout in the Chesapeake Bay area show only one mark per year, although often the first year mark was indistinct or nonexistent. This suggests that many fish captured in the Bay spent their first year in more tropical waters, where annular markings are not pronounced. Scale patterns and markings of older fish parallel those of younger groups, indicating similar environmental conditions for all ages of seatrout, and the possibility of a distinct Chesapeake Bay population of spotted seatrout.

The length-weight relationship calculated for combined sexes of spotted seatrout in the Chesapeake Bay area showed isometric growth (b=3.043). Spotted seatrout from the Bay area were heavier at a given length than fish in Florida, Alabama, Louisiana and Texas (Table 5); fish in the other areas were sampled year round. Spotted seatrout were available in the

Table 5

Comparison of Length-Weight Relationships of *Cynoscion nebulosus* Populations

Author	Present Study	Moffett (1961)	Wade (In press)	Hein et al (1980)	Harrington et al (1980)
Location	Chesapeake Bay	Florida	Alabama	Louisiana	Texas
Sexes Combined	logW=3.043 logL-5.072	logW=3.113 logL-5.333	logW=3.105 logL-5.305	logW=3.154 logL-5.425	logW=3.062 logL-5.192
W of 350 mm fish	469	386	392	401	396
W of 500 mm fish	1388	1172	1188	1235	1181
Males	logW=3.244 logL-5.598		logW=3.085 logL-5.258		
W of 350 mm fish	448		397		
W of 500 mm fish	1424		1209		
Females	logW=2.986 logL-4.924		logW=3.085 logL-5.258		
W of 350 mm fish	470		389		
W of 500 mm fish	1364		1170		

Chesapeake Bay only during the period of maximum feeding and sexual activity; thus their weights would tend to average more than during winter when feeding and reproductive activities are at a minimum. Sampling time bias in my data and small sample sizes must be considered when comparing with other reported length-weight relationships.

The length-weight relationships for spotted seatrout from the Chesapeake Bay show females can be expected to be heavier than males at 350 mm, but males are expected to be heavier than females at 500 mm (Table 5). Male spotted seatrout from Alabama appear to be heavier than females at any length (Table 5) although Wade (in press) found no significant differences between sexes in length-weight relationships. Moffett (1961) found little difference between male and female spotted seatrout from Florida and did not calculate separate length-weight relationships by sex. *C. nebulosus* from Alabama waters are lighter than males and females at the same length from Chesapeake Bay. Again, this could be due to the sampling time bias in my data. These differences suggest that Chesapeake Bay spotted seatrout may come from a different population than Alabama *Cynoscion nebulosus*.

Length-frequency distributions were relatively useless for assignment of age to Chesapeake Bay spotted seatrout. This is no doubt due to the protracted spawning of this species (Section II). Pearson (1929), Moody (1950), Stewart (1961), Wade (in press) and Guest and Gunter (1958) reached similar conclusions for seatrout populations in North Carolina, Texas, Florida, Alabama and along the Gulf coast in general.

Spotted seatrout in Virginia were older than the greatest age reported from southern populations. Tabb (1961) reported spotted seatrout in east-central Florida through age X; Moffett (1961) and Mahood (1975) found spotted seatrout no older than age VIII in west Florida and Georgia, respectively. Klima and Tabb (1959) and Stewart (1961) reported age VII spotted seatrout in Florida; Pearson (1929) and Wade (in press) found fish through age VI in Texas and Alabama. Age groups II and III dominated the catch in Florida (Moffett, 1961; Stewart, 1961); Alabama (Tatum, 1980; Wade, in press) and Louisiana (Hein and Shepard, 1980), but age groups III and IV were most abundant in Chesapeake Bay (Figure 4). These differences could be due to different sampling gears; fish from Florida and along the Gulf coast were taken most often by hook and line, whereas fish from Chesapeake Bay were taken most often with haul seines. However, since haul seines sample all sizes of the population equally, sampling gear differences can probably be discounted.

Spotted seatrout in Chesapeake Bay live substantially longer than more southern populations. *Pomatomus saltatrix* (Wilk, 1977) and *Brevoortia tyrannus* (Nicholson, 1975) were larger and older at the northern limit of their range. Gunter (1950) noted differences in sizes of certain fishes of the Gulf of Mexico and mid-Atlantic coast. This phenomena has been documented in Sciaenids, also: *Micropogonias undulatus* (White and Chittenden, 1977) and *Cynoscion nothus* (D. DeVries, pers. comm.) are much smaller along the Gulf coast than the Atlantic coast, while *Cynoscion regalis* are larger, older, and exhibit faster growth rates in Long Island Sound than in North Carolina (Shepard, 1981). Environmental conditions in the Bay area are more rigorous than those along the Gulf coast. Fish living in cooler water temperatures have a slower metabolism (and therefore take a longer time to reach their maximum length) than fish living in warmer waters (ie. southern populations, where metabolic costs are high). Often, the increase in age in northern populations is more striking than the increase in size (Ricker, 1979).

Female spotted seatrout in the Chesapeake Bay were substantially older than males; females reached age XII and males reached age VIII. This tendency of female spotted seatrout to outlive males is widespread; Pearson (1929), Guest and Gunter (1958), Klima and Tabb (1959), Moffett (1961), Stewart (1961), Tabb (1961), Hein and Shepard (1979) and Wade (in press) documented that females lived at least one year longer than males in Texas, Florida, Louisiana and Alabama. Tabb (1961) found that females were longer than males at age I, and the difference in size at age increased throughout life. A similar situation likely exists for Chesapeake Bay fish. Females in my samples were smaller than males at age I, though I examined only one age I female. Female *C. nebulosus* were significantly larger than males at each later age, and there was a significant difference in actual growth rate between the two sexes. Tabb (1961) also concluded that females at all ages grew more rapidly than males in an east-central Florida population of spotted seatrout. Yet growth rates were not significantly different between males and females in western Florida (Moffett, 1961) and Alabama (Wade, in press). Male and female spotted seatrout in northwest Florida show similar growth rates up to age II; thereafter the growth rate of males decreases, while the female rate remains constant (Klima and Tabb, 1959). This would help account for the disparity in sizes between sexes in older age classes.

Substantial overlap in size of *Cynoscion nebulosus* in Chesapeake Bay occurred between ages II and III and ages VI and VII. Spotted seatrout from west Florida also exhibited significant overlap between ages II and III (Moffett, 1961). Klima and Tabb (1959) found *C. nebulosus* overlapped significantly in size between ages III and IV. Since this species has a protracted spawning season (Section II), progeny from an early spawn may be as much as 90 mm larger than fish from a late spawn. Environmental conditions may accentuate an already large size difference among fish of the same year class, favoring the larger juvenile fish over the smaller young-of-the-year. The smaller size of male spotted seatrout at a given age also contributes to this overlap. The combination of a protracted spawning season and size differential between the sexes guarantees a wide spread in length at age, particularly for younger age groups.

Rosa Lee's phenomena was not evident in the Chesapeake Bay spotted seatrout examined. Pearson (1929) also found no evidence of Lee's phenomena in fish from Texas. In fact, he found a "reverse Lee phenomena" which he attributed to the predominance of smaller males in the younger year classes, or to the high incidence of growth-slowing parasitic isopods among young fish.

Growth increments for *Cynoscion nebulosus* from Chesapeake Bay, sexes combined, were slightly erratic. A steady decrease in growth increments occurred until age IV; from age IV to age XII, growth fluctucated around a mean of 40 mm/year. These inconsistencies could be due to small sample sizes, particularly among older ages. Several abnormally large fish in a year class could also affect growth increment calculations.

Spotted seatrout grow very rapidly during their first year of life, attaining an average of 170 mm by the end of their first winter. Both Fable *et al* (1978) and Taniguchi (1979) reported rapid growth of larval spotted seatrout. Juvenile spotted seatrout in Louisiana grew 2.08 mm/day during October, although growth slowed substantially to 0.37 mm/day during November (Sackett *et al*, 1979). Rapid growth reduces the amount of time spent in the ichthyoplankton and allows young fish to be able to feed on a larger variety of prey items. By age II, spotted seatrout growth slows considerably. Matlock and Weaver (1979) found the growth rate of adult *C. nebulosus* in Louisiana to be -0.55 ± 0.82 mm/day for an eleven month sampling period.

Empirical lengths and back calculated lengths agreed fairly well for males, females and the sexes combined, particularly as the fish grew older. The von Bertalanffy growth curve yielded a more accurate estimate of length at age than a simple age-length regression. Elimination of the oldest age groups from back calculations and estimates of the von Bertalanffy growth equation because of the small sample sizes in those age groups is valid (Ricker, 1975). The von Bertalanffy equation will predict lengths most accurately at ages II through VI for all fish, ages I through IV for males and ages II through IV for females. The von Bertalanffy equation for my data approximates linearity.

This could be due to small sample sizes among older fish, or to differential mortality by size within year classes, which could result in a greater true mean growth rate than what is indicated by the von Bertalanffy curve (Ricker, 1975).

Calculated L_∞ values depend upon the lengths of the fish sampled and the maximum length observed. Even though my sample sizes were small, the calculated L_∞ values appear reasonable. The L_∞ values for females would be expected to be higher than the value for males, since it has been shown that females attain a greater age than males. It is reasonable to expect L_∞ for the population as a whole to be greater than L_∞ for males or females, since some of the older fish were not sexed. Although I am reasonably sure that the older fish were all females, this assumption was not included in the calculations. If it had been, perhaps L_∞ for females would have been the same as L_∞ for the population as a whole.

Spotted seatrout growth in the Chesapeake Bay area is not significantly different from growth in west and northwest Florida (Table 6). This indicates that although the spotted seatrout in Virginia endure cooler water temperatures during their lifetime, they do not exhibit a significantly different rate of growth. Back calculated lengths are significantly different between Chesapeake Bay *C. nebulosus* and central Florida and Texas fish, however. The population described by Tabb (1961) grew substantially faster than any of the other populations; in fact, it appears his fish may be one year older than shown. Growth of male and female spotted seatrout in Virginia is significantly different from growth

Table 6

Comparison of Mean Back Calculated Total Lengths at Age for Several Populations of *Cynoscion nebulosus*

Study	Present Study	Moffett (1961)*	Tabb (1961)*	Pearson (1929)	Klima & Tabb (1959)*	Present Study	Moffett (1961)*	Klima & Tabb (1959)*	Present Study	Moffett (1961)*	Klima and Tabb (1959)*
Location	Virginia	West FL	Central FL	Texas	Northwest FL	Virginia	West FL	Northwest FL	Virginia	West FL	Northwest FL
Sex	Both	Both	Both+	Both+	Both	Male	Male++	Male+++	Female	Female**	Female++
I	170	159	201	146	142	153	156	140	191	160	143
II	260	254	303	239	232	244	251	229	279	255	233
III	353	322	387	304	311	313	316	305	347	325	315
IV	414	390	468	353	381	378	378	371	404	393	384
V	441	449	558	397	450	432	432	416	449	453	454
VI	475	525	650	440	515	440	533	450	493	499	516
VII	521		684	487	533	501			523	526	533
VIII	561		761	519		554			560	534	
IX	603			598					588		
X	648								644		
XI	687										
XII	721										

* Converted from standard lengths to total lengths using the formula TL = 1.22SL
** Significant at a = 0.025
\+ Significant at a = 0.005
\++ Significant at a = 0.10
\+++ Significant at a = 0.05

of west and northwest Florida *C. nebulosus* (Table 6), although growth for the population as a whole was not significantly different. This suggests a significant difference in length between sexes for each of these areas; however, the fish Moffett (1961) sampled showed no differences.

Differences in growth rates and length-weight relationships of *Cynoscion nebulosus* from different areas indicate there may be discrete populations of this species along the Atlantic and Gulf coasts. Spotted seatrout along the Gulf coast are essentially non-migratory (Miles, 1950; Moody, 1950; Guest and Gunter, 1958; Moffett, 1961; Fontenot and Rogillo, 1970; Adkins *et al*, 1979). Tagging studies showed *C. nebulosus* did not move more than 30 miles from their natal estuary in Florida (Iverson and Tabb, 1962); this suggested each estuary contained a separate subpopulation of spotted seatrout. Electrophoretic studies showed each estuary in Florida and along the Gulf coast has separate seatrout populations and that there is little mixing or recruitment among populations in different estuaries (Weinstein and Yerger, 1976). Spotted seatrout in Georgia stay in tidal creeks or near beaches (Mahood, 1975); a current tagging study indicates *C. nebulosus* is also non-migratory in Georgia (Music, 1981).

The data presented here indicate the existence of a discrete population of *Cynoscion nebulosus* in the Chesapeake Bay. Many of these fish are probably recruited from more southern waters; the lack of a distinct age I annular mark in many individuals supports this hypothesis. Recruitment of fish spawned in the Bay is also likely. The Chesapeake Bay population is more migratory than southern populations; fish must leave the Bay in the fall to avoid lethal winter temperatures. Where this population overwinters is unclear, although large catches of spotted seatrout in deep water off Hatteras, North Carolina during the winter have been reported. Massman (*In* Tabb, 1958) reported resident spotted seatrout in Lynnhaven River, Virginia during the winter, and fishermen have reported large *C. nebulosus* under the ice in both Lynnhaven River and Hungars Creek. Whether these fish represent a more temperature resistent element of the Chesapeake Bay population or yet another stock of spotted seatrout is unclear.

SECTION II

REPRODUCTIVE BIOLOGY

INTRODUCTION

The reproductive biology of spotted seatrout *Cynoscion nebulosus* (Cuvier) along the Atlantic coast is little known, but along the Gulf coast it has been documented thoroughly. In Texas, Pearson (1929) found that spotted seatrout spawn from March through October, with a peak in April and May. Miles (1950, 1951) confirmed these findings, although he found a spawning peak in July. In Louisiana spotted seatrout spawn from April to October (Fontenot and Rogillo, 1970, Sundaraj and Suttkus, 1962 and Hein and Shepard, 1979). The latter authors reported a second spawning peak in July. Adkins et al (1979) reported more intensive spawning activity following each full moon of the summer.

Some disagreement in the reported peak spawning time of *Cynoscion nebulosus* exist for Florida waters. Moody (1950) reported spawning in the Cedar Key area from late March through September, with a peak in July. Klima and Tabb (1959) cited a similar spawning season in northwest Florida and a peak in May or early June. They also hypothesized a fall spawning peak, which Stewart (1961) later documented for spotted seatrout in Everglades National Park. Jankee (1971), however, found no evidence of a secondary spawning peak in the fall.

The most comprehensive studies of spotted seatrout reproductive biology on the East Coast were done in Georgia. Mahood (1975) found ripe seatrout from April through August, with a peak in spawning activity in May. In North Carolina Welsh and Breder (1924) postulated that this species spawned in May and June; Hildebrand and Cable (1935) cited May through August as the spawning season. Hildebrand and Schroeder (1928) reported no ripe *Cynoscion nebulosus* from the Chesapeake Bay area.

Information available on the seasonality of ripe male and female spotted seatrout is based on gonadosomatic indices, macroscopic inspection of the gonads, or the appearance of larvae and juveniles. Only Moody (1950) histologically inspected the gonads of female spotted seatrout to determine ripeness.

In this section I document the reproductive biology of *Cynoscion nebulosus* from a macroscopic and histologic perspective; determine the spawning season and age at which spotted seatrout first spawn; and finally assess larval survival as an indication of a successful spawn in the Chesapeake Bay.

MATERIALS AND METHODS

Three hundred sixty-six spotted seatrout were collected during 1979 and 1980 from the Ware River and mouth of Hungars Creek, Chesapeake Bay. Weights to the nearest 10 grams and total lengths to the nearest millimeter were recorded; a scale sample was removed from under the tip of the pectoral fin on the left side of the fish. Temperature and salinity data were collected from Hungars Creek area at the time samples were taken. Temperature and salinity data from the Ware River were collected by the VIMS Physical Oceanography Department on a weekly and monthly basis.

Gonads were excised from 153 fish (65 males, 88 females), weighed to the nearest 0.1 gram and preserved whole in Davidson's Fixative. Anterior, posterior and mid sections from each pair of gonads were prepared as paraffin embedded sections, stained with Harris' Hematoxylin and counterstained with Eosin. Tissue preparations were microscopically inspected at 4X, 10X, 40X and 100X to determine stages of maturity.

Male gonadal tissue was classified in six stages following Hyder (1969): immature (I): immature/recovering (II); maturing (III); mature (IV); ripe (V); and spent (VI). Female gonadal tissue was classified into seven catagories using Combs (1969) as a guide: immature (I and II); maturing (III); mature (IV); ripe (V); spent (VI); and recovering (VII(II)).

A Gonadosomatic Index (GSI) [(gonad weight/body weight) X 100] and condition factors [$K = 100000 \times weight/length^{2.973}$, weight in grams, length in millimeters] were calculated for each fish used in this section. Factors contributing to variability in gonad weight were examined by multiple regression techniques (SPSS).

Juvenile *C. nebulosus* were collected using a 16 foot otter trawl over beds of *Zostera marina* and *Ruppia maritima* in Sarah's Creek and Guinea Marshes. Juvenile spotted seatrout were collected in Pamlico Sound, North Carolina by the North Carolina Division of Marine Fisheries, using a 13 foot trawl with 1/4 or 3/4 inch mesh in the cod end.

RESULTS

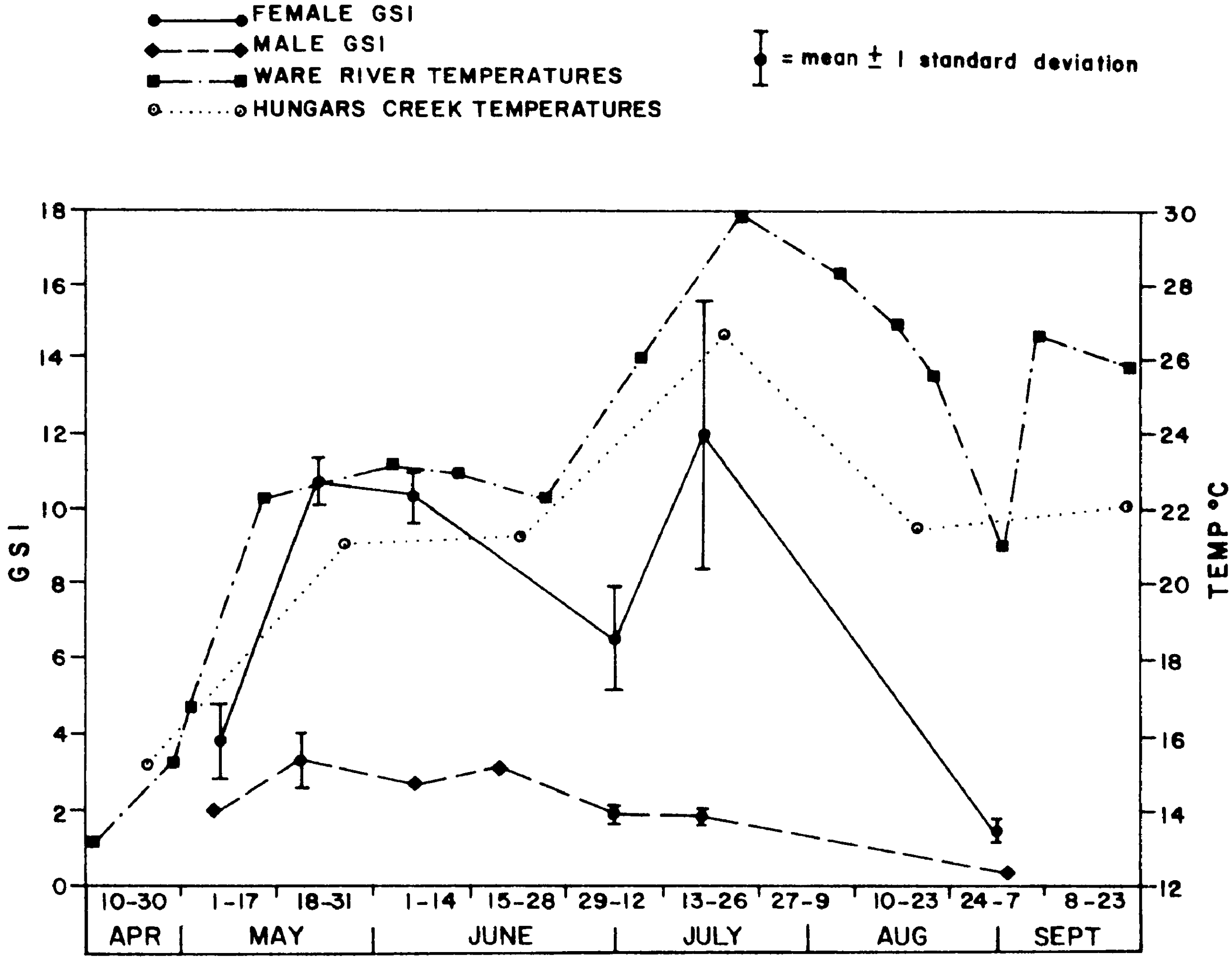
The gonads of *Cynoscion nebulosus* from the Chesapeake Bay were macroscopically similar to descriptions by Moody (1950), Miles (1951) and Tabb (1961). The right and left lobes are approximately the same size. In immature fish, ovaries are small, cylindrical, and translucent pink in color. The ovary changes from pink to yellow in color, greatly increases in size, and takes on a granular appearance as spawning time approaches.

When immature, testes are small, have an elongate triangular shape with smooth walls, and are translucent white in color. As the testes develop, the triangular shape becomes more pronounced. The walls remain smooth and firm, and the color becomes bright white.

The GSI values for female spotted seatrout ranged from 0.81 for immature fish to 32.7 for running ripe fish. Average GSI values for females during the 1980 spawning season showed two definite peaks in gonadal activity; 1) from May 18 to June 14 and 2) from July 13-26 (Figure 9). The peaks correspond to early maturing and late maturing groups of fish. The 1979 data revealed the same peaks in GSI. None of the females examined appeared to spawn more than once a year.

Male GSI values ranged from 3.17 for mature and ripe fish to 0.26 for spent fish. No immature males were collected. In 1980 there was a single peak in GSI values, from May 18 to June 28 (Figure 9).

Figure 9. Gonadosomatic indices for male and female *Cynoscion nebulosus* and water temperatures in the Ware River and Hungars Creek, by two-week intervals, April through September.


FEMALE GSI
MALE GSI
WARE RIVER TEMPERATURES
HUNGARS CREEK TEMPERATURES
= mean ± 1 standard deviation
GSI
TEMP °C
0
2
4
6
8
10
12
14
16
18
12
14
16
18
20
22
24
26
28
30
10-30
1-17
18-31
1-14
15-28
29-12
13-26
27-9
10-23
24-7
8-23
APR
MAY
JUNE
JULY
AUG
SEPT

Water temperatures in Hungars Creek and the Ware River also had two definite peaks in 1979 and 1980 (Figure 9). Average temperatures increased approximately 6^{o} C between April 30 and May 15 and corresponded almost exactly with the first peak in female GSI values. A second 6^{o} C temperature rise occurred between June 30 and July 15 and corresponded with the second peak.

Oocyte development and spermatogenesis were similar to that described by Mercer (1978). Oocyte development takes place along the margin of the lamellae. Stage I oocytes (Figure 10A) are characterized by a thin basophilic cytoplasm and single nucleolus. Although most abundant in immature and early developing ovaries (Classes I, II and III), stage I oocytes were present in all stages of development. Stage 2 oocytes are previtellogenic and have a dark staining basophilic cytoplasm and multiple nucleoli (Figure 10A). They were found predominantly in Class I, II and III ovaries, but some were present in all stages of gonadal development. Stage 3 oocytes (Figure 10B) have a less basophilic and more granular cytoplasm due to the presence of yolk globules. Many perivitelline nucleoli are evident. The presence of stage 3 oocytes marks the initiation of ovarian maturation activity. They were found most frequently in Class III ovaries. Stage 4 oocytes (Figure 10D) show increased yolk globules, cytoplasmic vacuoles and a well developed zona radiata. Stage 4 oocytes were most common in Class IV ovaries; well developed stage 4 eggs were also present in Class V ovaries. Stage 5 oocytes (Figure 11A) are highly acidophilic, and often irregular in shape. The nucleus is uniform in appearance due to coalescence of the yolk globules. Stage 5 eggs were most common

Figure 10. Histological stages of gonadal tissue from *Cynoscion nebulosus*.

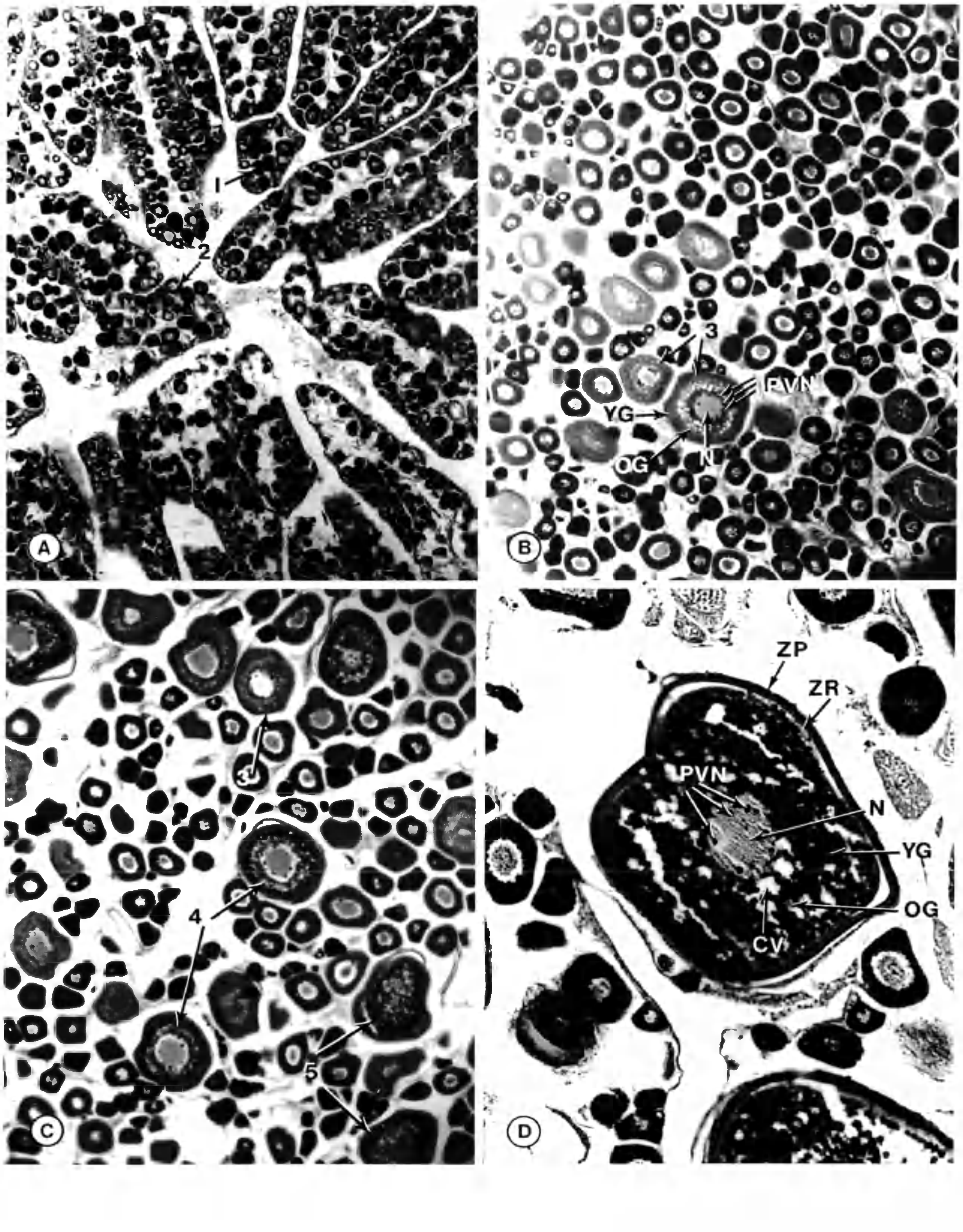
A. Immature ovary (Class II) Stages 1 and 2 oocytes (magnification 65X).

B. Maturing ovary (Class III) Stages 1, 2 and 3 oocytes (magnification 63X).

C. Mature ovary (Class IV) Stages 1, 2, 3, 4 and 5 oocytes (magnification 63X).

D. Stage 4 oocyte (magnification 162.5X).

Abbreviations: CV, cytoplasmic vacuole; N, nucleus; OG, oil globule; PVN, perivitelline nucleoli; ZP, zonal pellucida; ZR, zona radiata.



A
1
2
B
3
PVN
YG
OG
N
C
3
4
5
D
ZP
ZR
PVN
N
YG
OG
CV

Figure 11. Histological stages of gonadal tissue from *Cynoscion nebulosus*.

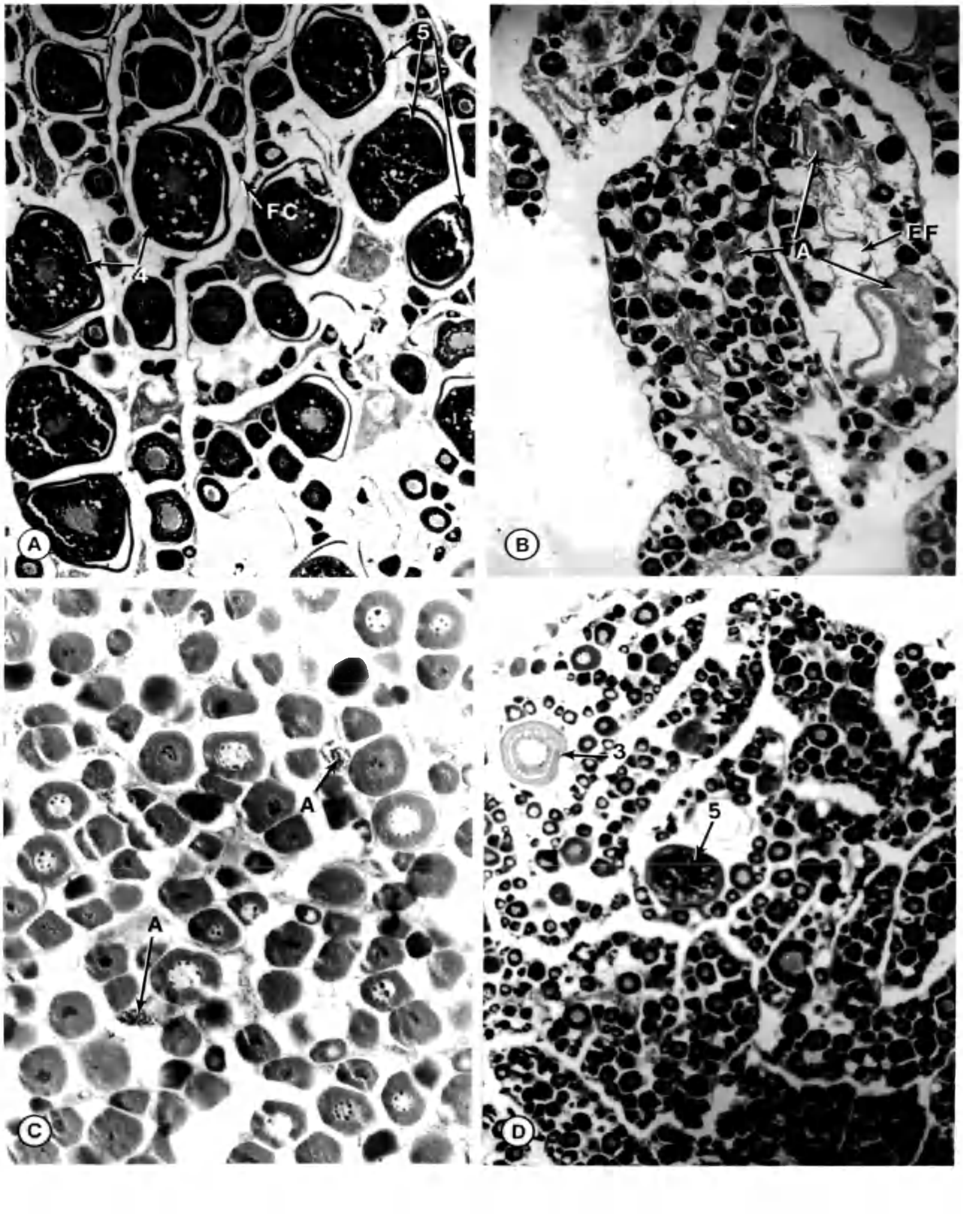
A. Ripe ovary (Class V) Stages 1, 2, 4 and 5 oocytes (magnification 63X).

B. Spent ovary (Class VI) Stages 1 and 2 oocytes, atretic bodies (magnification 63X).

C. Recovering ovary (Class VII (II)) Stages 1 and 2 oocytes, atretic bodies (magnification 100X).

D. Immature, precocious ovary (Class II) Stages 1, 2, 3 and 5 oocytes (magnification 63X).

Abbreviations: A, atretic body; EF, empty follicule; FC, follicle cell.


A
5
FC
4
B
A
EF
C
A
A
D
3
5

in Class V ovaries, and indicated that spawning was imminent. Atretic body formation takes place following spawning. Unshed mature eggs (oocyte stages 4 and 5) degenerate to form corpora atretica (Figure 11B and 11C). The cellular debris is gradually withdrawn by adjoining cells, forming the characteristic brownish bodies. The presence of atretic bodies in inactive mature ovaries indicated previous spawning.

Spermatogenesis takes place along the margin of the germinal lamellae. Primary spermatogonia (Figure 12A) occur singly and are highly acidophilic. They are the largest cells found in the testes and are most common in immature (Stage I and II) testes. Secondary spermatogonia (Figure 12A) are also acidophilic but are smaller than primary spermatogonia. They stain a deeper color, occur in cysts and are also most common in immature testes. Primary spermatocytes (Figure 12A) have no visible nuclear membrane and are composed of deeply staining chromatin material. They are slightly smaller than secondary spermatogonia, and occur primarily in maturing (Stage III) testes. Secondary spermatocytes (Figure 12B) are basophilic with densely clumped chromatin material. They are smaller than primary spermatocytes and occur most frequently in mature (Stage IV) testes. Spermatids (Figure 12C) are highly basophilic and have densely condensed chromatin material. They are smaller than secondary spermatocytes, and occur primarily in mature and ripe (Stage IV and V) testes. They give rise to tailed spermatozoa (Figure 12C). Spermatozoa stain very dark due to the dense clumping of chromatin material; occasionally acidophilic tails can be distinguished. Spermatozoa always occur in the center of the lobule, and were most numerous in ripe (Stave V) testes.

Figure 12. Histological stages of gonadal tissue from *Cynoscion nebulosus*.

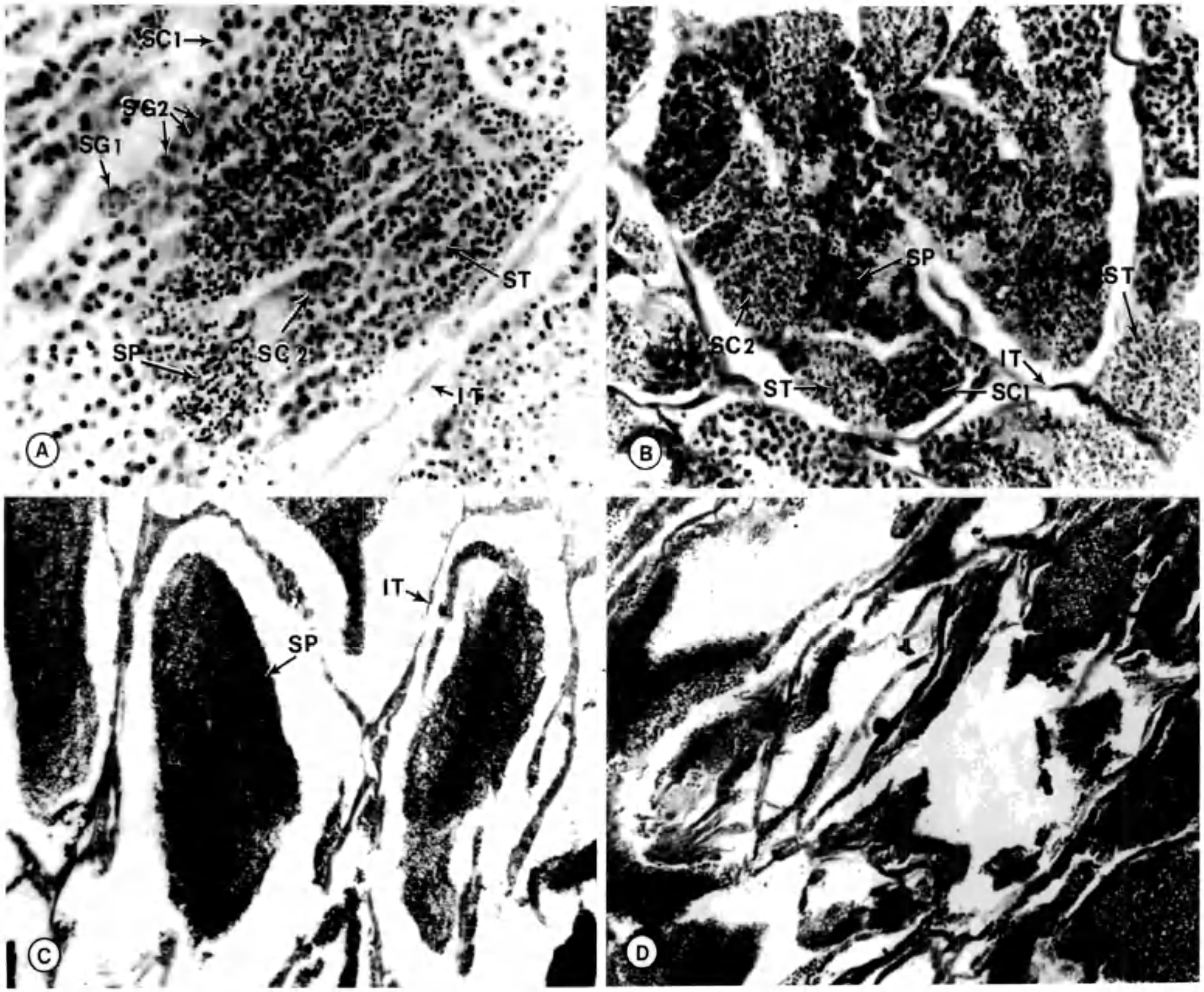
A. Maturing testis (Stage III) magnification 630X.

B. Mature testis (Stage IV) magnification 250X.

C. Ripe testis (Stage V) magnification 100X.

D. Spent testis (Stage VI) magnification 100X.

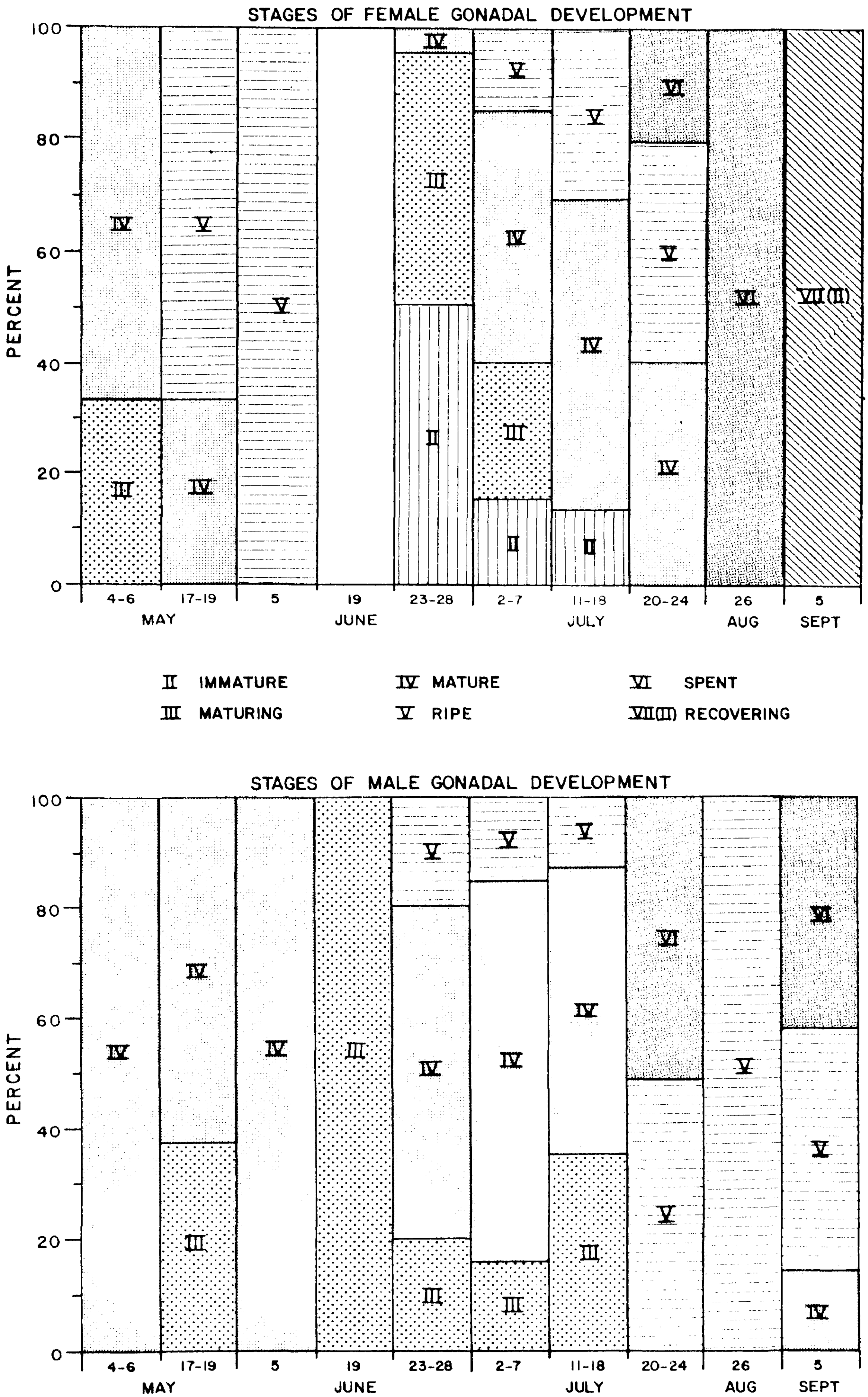
Abbreviations: IT, interstitual tissue; SCI primary spermatocytes; SC2, secondary spermatocytes; SG1, primary spermatogonia; SG2, secondary spermatogonia; SP, spermatozoa; ST, spermatids.


SC1
SG2
SG1
ST
SP
SC2
IT
A
SP
ST
SC2
ST
IT
SC1
B
IT
SP
C
D

All stages of gonadal development, from immature (II) to recovering (VII(II)) were present in female fish samples examined. The percent for each stage of ovarian development changed during the spawning season (Figure 13). Immature (Class II, Figure 10A) fish were present only from June 23 through July 18. Maturing (Class III, Figure 10B) gonads appeared twice during the course of the spawning season: May 4 through 6 and June 23 to July 17. Mature (Class IV, Figure 10C) ovaries also appeared at two distinct times: from May 4 through 19 and June 23 to July 24. Ripe ovaries (Class V, Figure 11A) were observed from May 17 to June 5 and July 2 through 24. No spent ovaries were observed after the first spawning peak. Spent fish (Class VI, Figure 11B) appeared on July 20 and by August 26 all mature female fish were spent. By September 5 all female gonads were in the recovering stage (Class VII(II), Figure 11C). Several age II females showed evidence of precocious ovarian development (ripe eggs in an otherwise immature ovary, Figure 11D).

Histological inspection of the testes revealed four stages of development (Maturing through Spent). The percent of each stage of development shifted during the spawning season (Figure 13). Maturing (Stage III, Figure 12A) testes were found May 17 through 19 and June 19 through July 18 but they contained very few primary spermatogonia. Secondary spermatogonia, spermatocytes, spermatids and spermatozoa were present in abundance. Mature (Stage IV, Figure 12B) testes were observed May 4 through June 5, June 23 to July 18 and on September 5. Ripe testes (Stage V, Figure 12C) were observed from June 23 to September 5. Some ripe testes showed evidence of continuing spermatogenic development by the presence of

Figure 13. Percentage of each gametogenic stage of male and female *Cynoscion nebulosus*, May through September, 1979-1980.


STAGES OF FEMALE GONADAL DEVELOPMENT
PERCENT
4-6
17-19
MAY
5
19
JUNE
23-28
2-7
11-18
JULY
20-24
26
AUG
5
SEPT
II IMMATURE
III MATURING
IV MATURE
V RIPE
VI SPENT
VII(II) RECOVERING
STAGES OF MALE GONADAL DEVELOPMENT
PERCENT

a few spermatids. Spent males (Stage VI, Figure 12D) were taken from July 20-24 and on September 5. No recovering males were examined.

I found no evidence of hermaphroditism in *C. nebulosus* examined. Hermaphroditic spotted seatrout specimens have been found in South Carolina (J. Smith, pers. comm.) and Georgia (J. Music, pers. comm.).

A plot of the percent of sexually mature individuals for both sexes of spotted seatrout by total length (Figure 14) showed that all male fish were sexually mature (Stages III through VI) in their second year (approximately 250 mm TL). Many ripe and several spent two-year-old males were found during the spawning season. A ripe one-year-old male was found on 5 September 1980.

Twenty percent of the two-year old female *C. nebulosus* showed evidence of active gonads (Classes III through VII(II)). None of the mature two-year olds were ripe during the first or second spawning (GSI) peak. Eighty-six percent of three-year-old females (300-400 mm TL) had sexually active ovaries and all age IV and older females were sexually mature.

Mean GSI values of females increased slightly as the fish grew older, and were greatest for running ripe fish (Table 7). Male GSI values stayed constant with increasing age, and were greater for mature than for ripe fish.

Male and female spotted seatrout caught at dusk in May and July in beds of *Zostera* and *Ruppia* off Hungar's Creek were running ripe.

Figure 14. Percent of sexually mature fish within 25 mm total length intervals for male and female *Cynoscion nebulosus*. Includes stages III - VI for males and classes III - VII (II) for females.

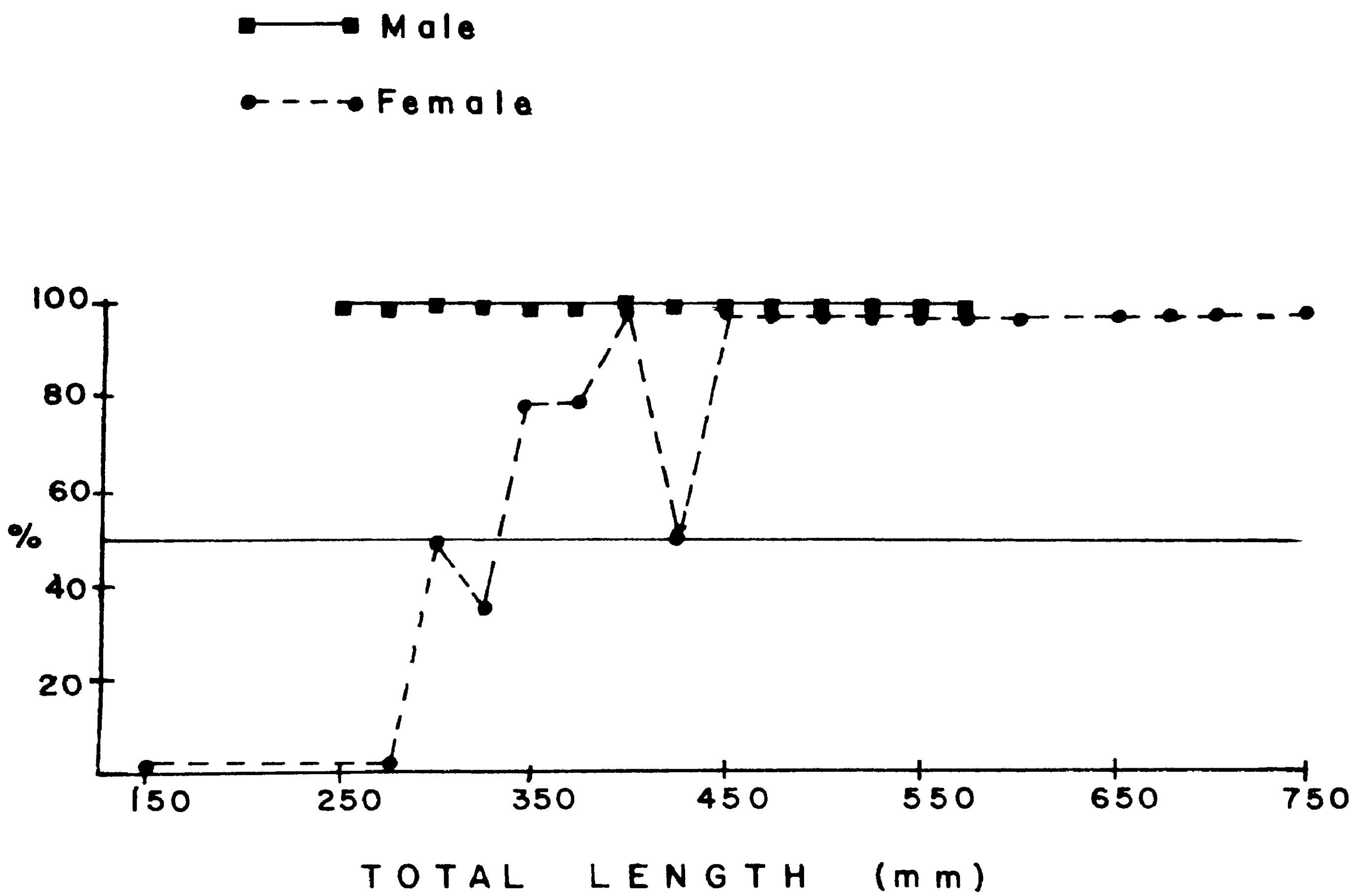

Male
Female
100
80
60
%
40
20
150
250
350
450
550
650
750
TOTAL LENGTH (mm)

Table 7

Mean GSI Values for Mature, Ripe and Running Ripe Male and Female

Cynoscion nebulosus by age group

				Age 1	2	3	4	5	6	7	8	9	10	11	12
Mature	F	GSI	$\bar{X}$			7.96	6.65	6.78	11.81	12.17	10.08				11.28
			S.E.			2.93	0.44	0.94	1.47	0.09	1.17				
			N			3	3	7	2	2	2				1
	M		$\bar{X}$		1.3	2.04		2.88	2.5	2.05					
			S.E		0.08	0.18		0.19	0.72	0.72					
			N		4	19		3	3	3					
Ripe	F	GSI	$\bar{X}$			9.57	9.27	11.59			11.53	8.34	11.02	12.0	8.56
			S.E			3.86	0.74	1.89			1.67	1.24			
			N			5	2	3			3	2	1	1	1
	M	GSI	$\bar{X}$	0.23	2.60	1.65	0.8	2.49							
			S.E			0.51	0.37								
			N	1	1	6	4	1							
Running Ripe	F	GSI	$\bar{X}$			7.1			32.7			20.39			
			S.E												
			N			1			1			1			
	M	GSI	$\bar{X}$					2.49		2.85					
			S.E												
			N					1		1					

Cynoscion nebulosus caught in the same areas during other times of the day were ripe or mature.

Condition factors (K) plotted against time for both male and female spotted seatrout showed two distinct peaks the first May 18 through 31 and the second July 13 through 26 (Figure 15). GSI and K-factor of female spotted seatrout were correlated (r=.844) but males were not (r=.03).

Juvenile spotted seatrout ranging from 24 to 92 mm TL were collected in seagrass beds from July 30 through September 9. Small and large juveniles appeared in the same catch, and would represent progeny from the two spawning peaks. Some young-of-the-year spotted seatrout were caught by trawl in 18 to 23 meters of water in the York and James Rivers in November; presumably these fish had migrated from the shallower nursery areas in those river systems to the deeper channel areas.

Juvenile spotted seatrout ranging from 25 to 125 mm TL were collected in Pamlico Sound, North Carolina from June 15 through October 21 during 1977-1981. Depths at capture locations ranged from 0.3 to 3 meters and averaged 1 meter. Water temperatures in July ranged from 19.8^{o} C to a high of 32^{o} C. October water temperatures were 17^{o} C. Length-frequency distribution of juvenile spotted seatrout in Rose Bay indicate two or possibly three spawning peaks, one during the first week of May, the second during early July and the third during mid-August (Figure 16). Length-frequency distributions from other areas in Pamlico Sound suggested protracted spawning.

Figure 15. Condition factors for male and female *Cynoscion nebulosus* by two-week intervals, May through September.

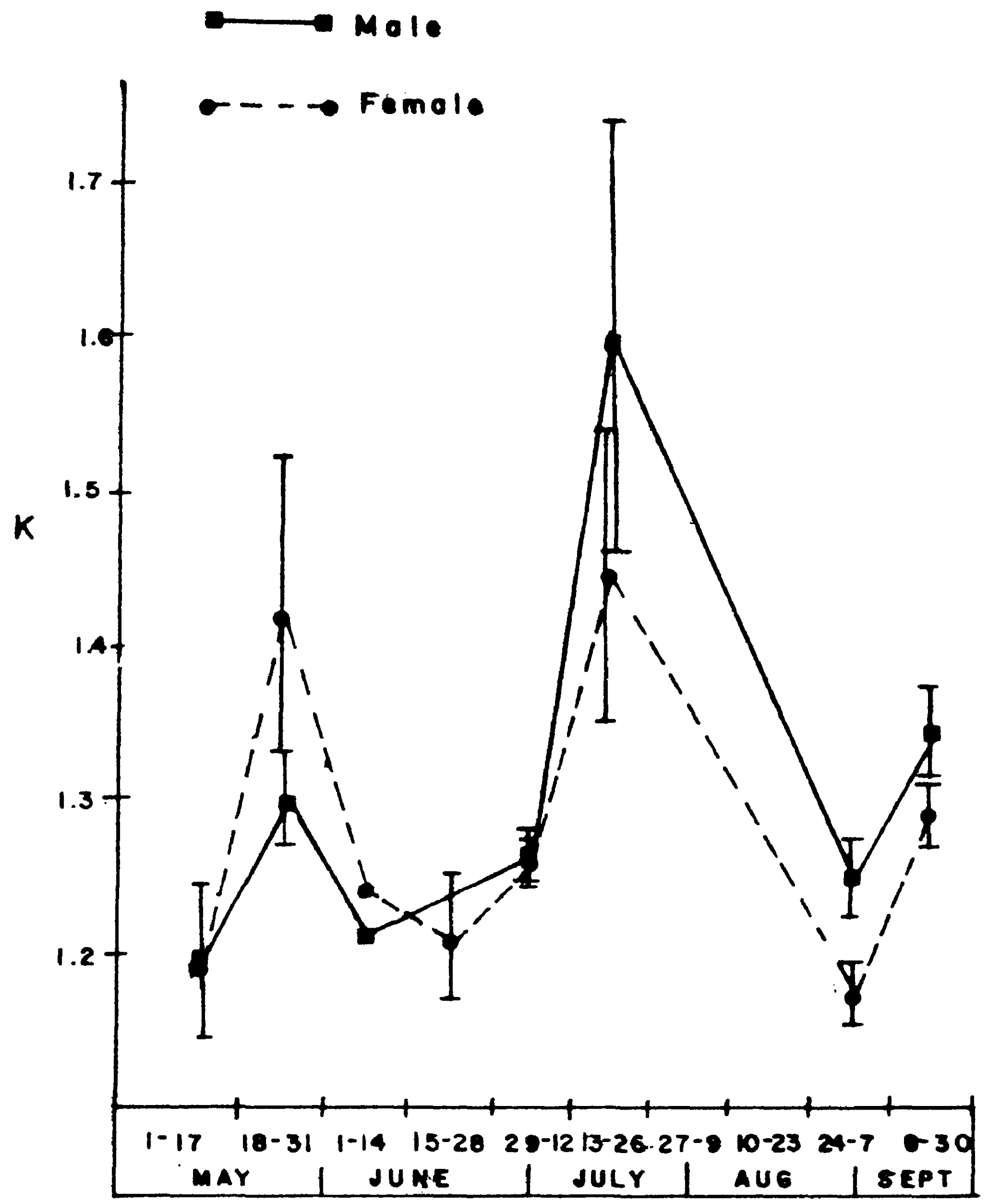
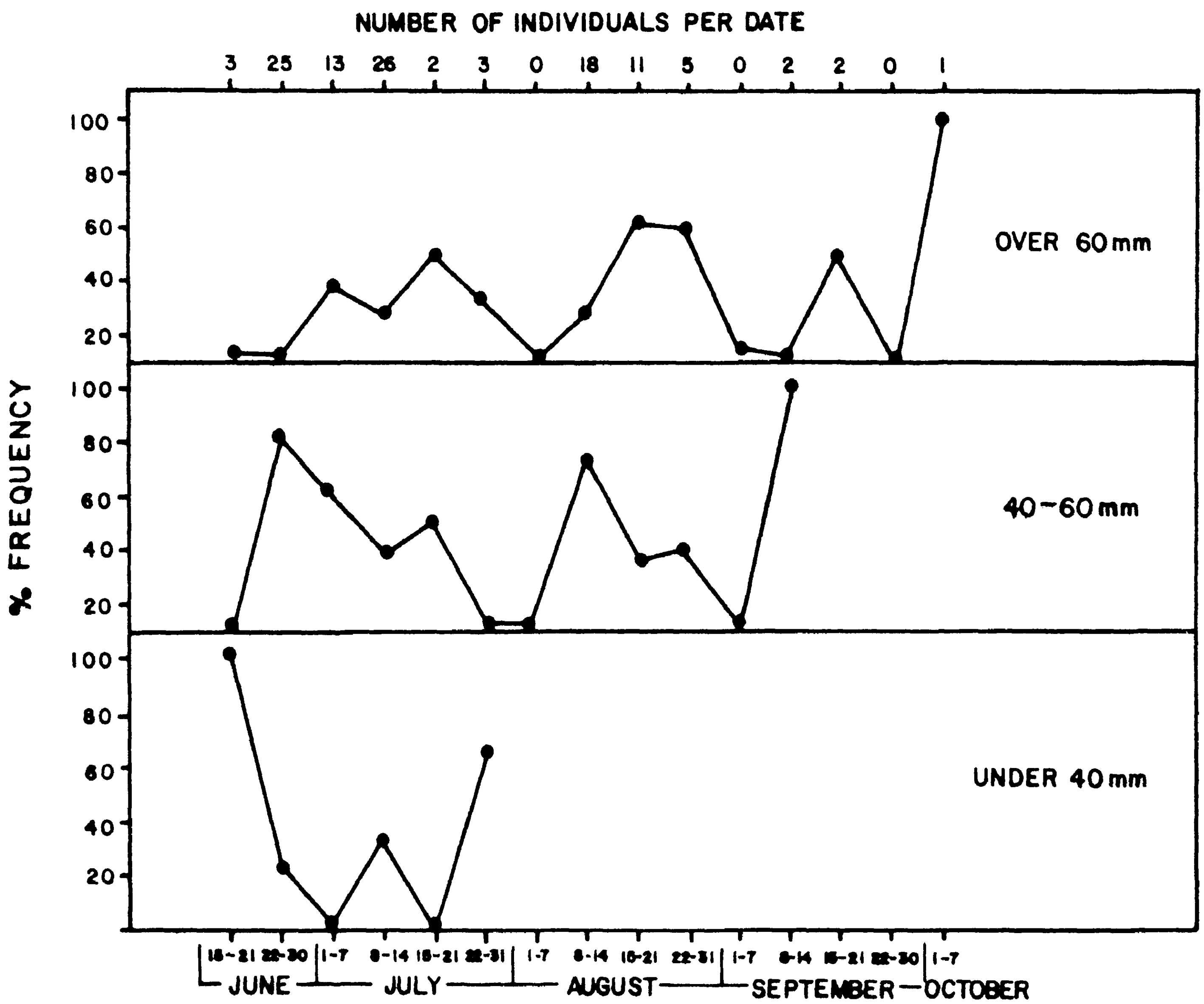

Male
Female
1.7
1.6
1.5
1.4
1.3
1.2
K
1-17
18-31
1-14
15-28
29-12
13-26
27-9
10-23
24-7
8-30
MAY
JUNE
JULY
AUG
SEPT

Figure 16. Length frequencies of juvenile *Cynoscion nebulosus* in Rose Bay, North Carolina by one week intervals, June through October.


NUMBER OF INDIVIDUALS PER DATE
3 25 13 26 2 3 0 18 11 5 0 2 2 0 1
% FREQUENCY
OVER 60mm
40–60mm
UNDER 40mm
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER

DISCUSSION

The observed peaks in GSI values for male and female spotted seatrout corresponded well in May through June, but only the females had a noticeable second peak in GSI during late July. Thus, the May-June GSI peak of males and females could represent the primary spawning period in the Chesapeake Bay area, as it did in Texas (Pearson, 1929), Louisiana (Hein and Shepard, 1979), Florida (Klima and Tabb, 1959; Stewart, 1961), Georgia (Mahood, 1975) and North Carolina (Hildebrand and Cable, 1934). However, the secondary peak in July is also successful; larger juveniles (corresponding to a May spawn) as well as small juvenile spotted seatrout (corresponding to a July spawn) were present in August and September. Gunter (1945) postulated a bimodal female spawning peak in Texas as did Stewart (1961) in Florida (May and September), and Hein and Shepard (1979) in Louisiana (May and July or August). Juvenile data from the Pamlico Sound, North Carolina, indicate two spawning peaks (May and early July, Figure 16); there are insufficient data to confirm a possible third peak.

Male GSI values are unreliable indicators of sexual activity peaks. A high percent of the males examined histologically were ripe during July through September even though GSI values did not show a second peak. Hein and Shepard (1979) also reported a single GSI peak for male spotted seatrout in Louisiana. Although there is a minimal investment of energy, as indicated by the low GSI values, there is a renewable supply of sex products throughout the reproductive season. Egami and Hosokawa (1973) reported almost constant spermatogenic activity for *Oryzias latipes*. It seems that it is not the volume of sperm available but rather the temporally extended ability to spawn that is important with male spotted seatrout. Continual spermatogenesis seems likely during the spawning season. This is suggested by lower GSI values in ripe than mature males. Once males become ripe, they can spawn repeatedly. Female GSI values were a more reliable indicator of reproductive ripeness. The secondary spawning period in July was shown in the GSI graph. The July spawning peak has two possible explanations: 1) late maturing females from the group already in the Chesapeake Bay area during May (Tabb, 1961, postulated a similar explanation for late spawning female spotted seatrout in Florida) or 2) new adult recruitment to Chesapeake Bay from more southern waters.

Condition factors appear to be a fairly good indicator of sexual maturity in that peaks in K corresponded closely with peaks in GSI values. Several authors have recognized the importance of K factors in predicting spawning activity (Austin and Tollefson, MS: Gorbach, 1971; and Hein and Shepard, 1979). Correlation between male condition factors, GSI and gonad weight was not good. The peaks in condition factors of males may result from an increase in liver weight prior to spawning (J. Music. pers. comm.). Gorbach (1971) found males had a much higher percentage of body cavity fat during the spawning season than females, contributing to a higher condition factor.

Correlation between condition factor of female spotted seatrout and GSI indicated that condition factors were a good predictive index of spawning season. Correlation was not high between K values and ovarian weight, most likely due to the disparity between ovary weights of young and old fish.

The only surprise from the multiple regression analysis of variables affecting gonad weight was that predicted gonad weight for spent fish was greater than recovering fish. Spent ovaries are flaccid and contain residual stage 5 oocytes and atretic bodies. Recovering ovaries are more compact and contain fewer atretic bodies, and therefore probably weigh less.

Water temperature seems to be a primary environmental cue for spawning of *C. nebulosus*. Tabb (1966) reported an optimal temperature range for spawning of 20 to 30^{o} C. Jannke (1971) found most intense spawning at 24^{o} C in Florida. Hein and Shepard (1979) believed water temperatures played a significant role in spawning of spotted seatrout in Louisiana. Immediately preceeding each spawning peak in Chesapeake Bay there was a rapid 6^{o} C rise in water temperature. The 6^{o} C increase in early May brought water temperatures up to 21.5^{o} C, and the 6^{o} C rise in July resulted in an average temperature of 28^{o} C (Figure 9). It appears that a period of increasing temperature within the acceptable range is the triggering factor for *C. nebulosus* spawning. According to Taniguchi (1979), 28^{o} C is the optimal temperature for larval survival. Thus the second spawning peak in Chesapeake Bay should be highly successful in terms of larval survival.

Salinity does not appear to be a critical factor for *C. nebulosus* spawning in Virginia. Salinities at my collection sites ranged from 12.5 to 21.5 o/oo during the peak spawning times. Tabb (1966) reported spawning of spotted seatrout in Florida in salinities of 30 to 35 o/oo. Taniguchi (1979) found that salinities of 28.1 o/oo were optimal for larval survival. At a water temperature of 28^{o} C he predicted 100% larval survival at salinities of 18.6 to 37.5 o/oo. On the basis of salinity and temperature data alone, the progeny spawned during July in Chesapeake Bay have a much greater chance of survival than those spawned in May. Juvenile collections strongly support this hypothesis.

Hein and Shepard (1979) considered photoperiod an important environmental cue for spawning. Spawning peaks in Louisiana (Hein and Shepard, 1979) and Chesapeake Bay occurred on dates having about 14 hours of light.

The lack of ripe males in my data set during the early part of the spawning season is no doubt a sampling artifact. Hein and Shepard (1979) found male seatrout in Louisiana were ripe prior to females and Miles (1951) reported ripe male spotted seatrout in Texas almost all year long.

A protracted spawning season is a typical reproductive strategy of many sciaenids which ensures better larval survival in an environment where temperature, salinity, abundance of food and predators all fluctuate during the spawning season. Cushing (1975) suggested that protracted summer spawning offers a greater chance of matching first feeding larvae with zooplankton peaks. Histological data provided evidence of a protracted spawning season for

Cynoscion nebulosus in Chesapeake Bay. Jannke (1971) encountered larval spotted seatrout during most months of the year in Everglades National Park confirming Stewart's (1961) report of low to moderate spawning throughout the year. Miles (1951) cited protracted spawning in Texas with December and January as the only period of sexual inactivity. Evidence of protracted spawning in Georgia (Mahood, 1975) and North Carolina (J. Hawkins, pers. comm) has been presented. Miles (1951) observed partially spent ovaries and hypothesized multiple spawnings by a given female over several days or perhaps as long as three to four weeks. I found no histological evidence of extended or multiple spawning by an individual female.

Sexual maturation of spotted seatrout in Chesapeake Bay environs agrees with findings for more southern populations in that all two-year-old males were sexually mature and 20% of the two-year-old females had active ovaries. Generally female *C. nebulosus* spawn for the first time at a size of 290 to 350 mm TL, a range which includes two- and three-year-old fish. The two-year-old females were not ready to spawn during either of the spawning peaks. Thus two-year-old females either need water temperatures warmer than 21.5^{o} C or a longer growth and gonadal developmental period than three-year-olds. These findings are consistent with Moody (1950), Hein and Shepard (1979), Stewart (1961) and Pearson (1929) on size at first spawning. Miles (1950, 1951) indicated that 10% of the female spotted seatrout in Texas were sexually mature by their first year, and 50% were mature by their second summer. Sundaraj and Suttkus (1962) found a few sexually mature age I females in Louisiana. In contrast, Tabb (1961) rarely found sexually mature females less than 350 mm SL (427 mm TL) in east-central Florida. Warmer water temperatures, which would provide a longer growing season along the Gulf could explain the earlier maturation reported by Miles (1950) and Sundaraj and Suttkus (1962). Higher temperatures, resulting in increased metabolic rate and Q_{10} values would stimulate earlier maturation and formation of sexual products, and lead to a younger age at first spawning. The slow maturing population of *C. nebulosus* Tabb (1961) described remains an anomoly, although the aging of this population is questionable (Section I).

Once female *C. nebulosus* reach their minimum spawning size, first spawning would be controlled by hormone levels of the individual fish. Merriner (1976) found a parallel situation with *C. regalis* females. Whether a given female spawns first as an age II or III could depend upon the spawning peak of origin or the local availability of food for the individual in question. A similar situation may occur with males. The biomodality in length frequency of young of the year may be carried over in the year class and manifest itself in two spawning season peaks as well as differential maturation at age II or III.

Gonadosomatic indices of ripe three- and four-year-old females were lower than GSI values of five- to eleven-year-old fish (Table 7). Histological inspection revealed the same percentage of ripe eggs in ovaries of the three-to ten-year-old females. Gonads of the older fish were in many cases more than twice the size of ovaries of younger fish (Table 7, running ripe females), indicating many more potential eggs to be spawned, and a much greater fecundity. *Cynoscion nebulosus* is a very fecund species, as reported by Miles (1951), Tabb (1961) and Sundaraj and Suttkus (1962). The metabolic costs of such a large percentage of available energy going to reproduction are perhaps compensated for by heavy feeding and lack of migrations during the spawning season. Summer flounder must allocate more energy to repeat spawning and extensive migrations during the spawning season; consequently, ovaries only account for 1.2 to 2.1% of total body weight in ripe females (Morse, 1981). Species such as spotted seatrout that are broadcast spawners and lack parental care allocate a greater portion of their available energy to sexual products, and are generally very fecund.

The GSI values of ripe males were similar regardless of age, indicating the proportion of gonad to body weight remains fairly constant in males across all ages (0.3 to 2.9%). These are similar to values Merriner (1976) reported for male *C. regalis*. Male spotted seatrout probably spawn more than once in a season. Testes contained some spent lobules while others were ripe, most frequently toward the end of the spawning season. The lower GSI values of ripe males relative to mature males (Table 7) also support this conclusion.

It is generally agreed that spotted seatrout spawn in inshore areas over grass beds or in channels adjacent to grass beds (Miles, 1950; Tabb, 1961; Stewart, 1961; Pearson, 1929; and Futch, 1970, for instance). The running ripe fish collected in Chesapeake Bay were caught over beds of *Zostera* and *Ruppia* within several hundred feet of a channel. Though ripe *C. nebulosus* were collected at all times of the day in grass beds, running ripe fish were only captured at dusk. This indicates rapid final maturation and ovulation in females. My data indicate dusk or evening spawning of spotted seatrout in the Chesapeake Bay area. This agrees with findings of Taniguchi (1979) and Tabb (1966).

Eggs and larvae of *C. nebulosus* have not been reported in the Chesapeake Bay area due in large part to the difficulty of ichthyoplankton collecting over grass beds or in nearby shoal areas. Further, spotted seatrout larvae would be quite scarce relative to other dominant Sciaenids.

Young juvenile spotted seatrout tend to be associated with beds of submerged aquatic vegetation (Miles, 1950; Jannke, 1971; J. Hawkins, pers. comm.). Collections of juvenile spotted seatrout as small as 24 mm TL from several areas indicate that *Cynoscion nebulosus* spawn successfully in Chesapeake Bay and the wide size range of juveniles (24 to 92 mm TL) captured suggested protracted spawning. Appropriate spawning temperatures and an abundant food source are maintained during the summer, insuring survival of larval and juvenile spotted seatrout in Chesapeake Bay. As temperatures begin to drop, young of the year fish join the adults in annual fall migrations from the Bay in search of warmer, deeper water in more southerly latitudes.

SECTION III

RECREATIONAL FISHERY

INTRODUCTION

Cynoscion nebulosus was the most abundant species caught by recreational fishermen in the 1970 angling survey (Deuel, 1973). In states along the Gulf and southeastern Atlantic coasts angling accounts for a larger percentage of total spotted seatrout landed than the commercial fishery (Tabb, 1958; Guest and Gunter, 1958; Idyll and Fahy, 1975; Adkins *et al,* 1979; Merriner, 1980). Texas, Louisiana, Mississippi and Alabama have enacted laws prohibiting commercial fishing for *C. nebulosus* in selected areas (Perret *et al,* 1980.) Presumably these actions were based upon comparison of economic and sociological values in the recreational and commercial fisheries in these states.

Much larger commercial and recreational fisheries for *C. nebulosus* exist on the Gulf Coast than the Atlantic Coast. On the Atlantic coast, only North Carolina and Florida have substantial commercial landings of spotted seatrout (Merriner, 1980). South Carolina, Georgia and Florida all boast an extensive recreational fishery for this species and feature their excellent spotted seatrout fishing in tourist information brochures (Merriner, 1980). North Carolina and Virginia support small, though active sport fisheries for this species. An annual Saltwater Fishing Tournament in both states includes spotted seatrout as one of the species for which citations are awarded.

The Virginia Saltwater Fishing Tournament began in 1958 and is administered by the Department of Conservation and Economic Development.

The tournament includes 22 species of fish in the citation program. A minimum weight for a citation is assigned to each species by the tournament committee. There are 86 marinas and tackle shops in coastal Virginia (bayside and seaside) designated as official tournament weighting stations. The angler fills out an application for a citation (Appendix A, Figure 1). Any citation-size fish caught between April 1 and November 30 is eligible for entry in the Tournament. Tournament rules are straight forward: the fish must be equal to or exceed a minimum weight, the angler must land his fish unaided, and all fish must be caught using a fishing rod. No fish caught by gill nets, seines, pound nets, dip nets or gaff in the surf are eligible. There are no line strength, age or sex classes in the tournament. Only one citation per species per angler per year will be issued. Therefore, an angler will not enter every citation size fish caught if a larger fish of the same species was entered earlier in the year.

Each angler entering a fish receives a hand lettered citation plaque showing the angler's name and species and weight of the fish. Trophies are awarded for the largest fish of each species during the tournament year and for each state record size catch. A photograph must accompany the citation application for any fish believed to be a new state record.

Cynoscion nebulosus has been an eligible species since the beginning of the Tournament. The minimum citation weight for spotted seatrout in 1958 was four pounds (1800 grams). In 1975, the minimum citation weight was raised to five pounds (2270 grams) where it stands today.

The North Carolina Saltwater Fishing Tournament began in 1974 and is sponsored by the North Carolina Division of Travel and Tourism. North Carolina tournament rules are the same as the Virginia tournament (Appendix A, Figure 2). Twenty-five species of fish are included in the North Carolina citation program and 57 marinas and bait and tackle shops in coastal North Carolina are designated as official weighing stations. Spotted seatrout have been an eligible species in the North Carolina tournament since 1974 and the minimum weight for a citation spotted seatrout is still four pounds (1800 grams).

My purpose in this section is to describe the historical recreational catch of spotted seatrout in Virginia through analysis of the Virginia Saltwater Fishing Tournament Citation records. Several years of North Carolina Saltwater Fishing Tournament citation records were examined for comparison of trends in the recreational fisheries of North Carolina and Virginia. Data from an independent survey of spotted seatrout anglers are tabulated and compared with trends from the analysis of tournament citations. A short discussion of spotted seatrout fishery management is included.

MATERIALS AND METHODS

Spotted seatrout citations from 22 years (1958-1980) of the Virginia Saltwater Fishing Tournament (2445 citations) were coded and recorded on magnetic computer tape. Variables coded included weight (pounds, ounces), total length (inches), girth (inches), date and location of capture, fishing technique, type of rod, reel, line and bait, and the angler's name and zip code. All weights and lengths were converted to grams and millimeters, and metric units were used in subsequent analyses. Analysis were performed using the Statistical Analysis System (SAS) and Statistical Analysis System Graphics (SASGRAPH) on an IBM 370 computer and Calcomp 1150 plotter.

Spotted seatrout citations from the North Carolina Saltwater Fishing Tournament (1977-1978) were analyzed for fish weight, date and location of capture, bait used and home state of angler.

"Speckled Trout Catch Information" data sheets (Appendix A, Figure 3) were distributed in 1979 and 1980 to all the major marinas on the Eastern and western shores of the Chesapeake Bay, enthusiastic spotted seatrout fishermen and cooperating fishing clubs in the area. Anglers recorded the total length and weight of each spotted seatrout caught, date and location of capture, bait used and whether they were fishing specifically for spotted seatrout. A scale envelope was appended to each form, with a diagram explaining how to remove scales from under the pectoral fin on the left side of the fish. Completed forms were collected from marinas and fishing clubs in the fall of

1979 and 1980. The scales were cleaned, mounted on acetate strips and pressed at 175°C and 2100 psi for 1.5 minutes on a Carver Laboratory Press. Scale images were projected on an Eberbach scale reader at a magnification of 48X. Annuli were measured from the origin diagonally to the edge of the scale. Scales were read twice; if counts did not agree, a third reading attempt was made. Disagreement after three readings precluded use of that fish in any further analysis. Length-age regression analysis was performed using SPSS.

RESULTS

Virginia Citation Analysis

Analysis of 22 years of data from the Virginia Saltwater Fishing Tournament showed that spotted seatrout were caught in 124 different locations in Virginia. Twenty locations accounted for 84% of all fish caught (Figure 17). Subsequent analysis deals only with the 20 most important locations.

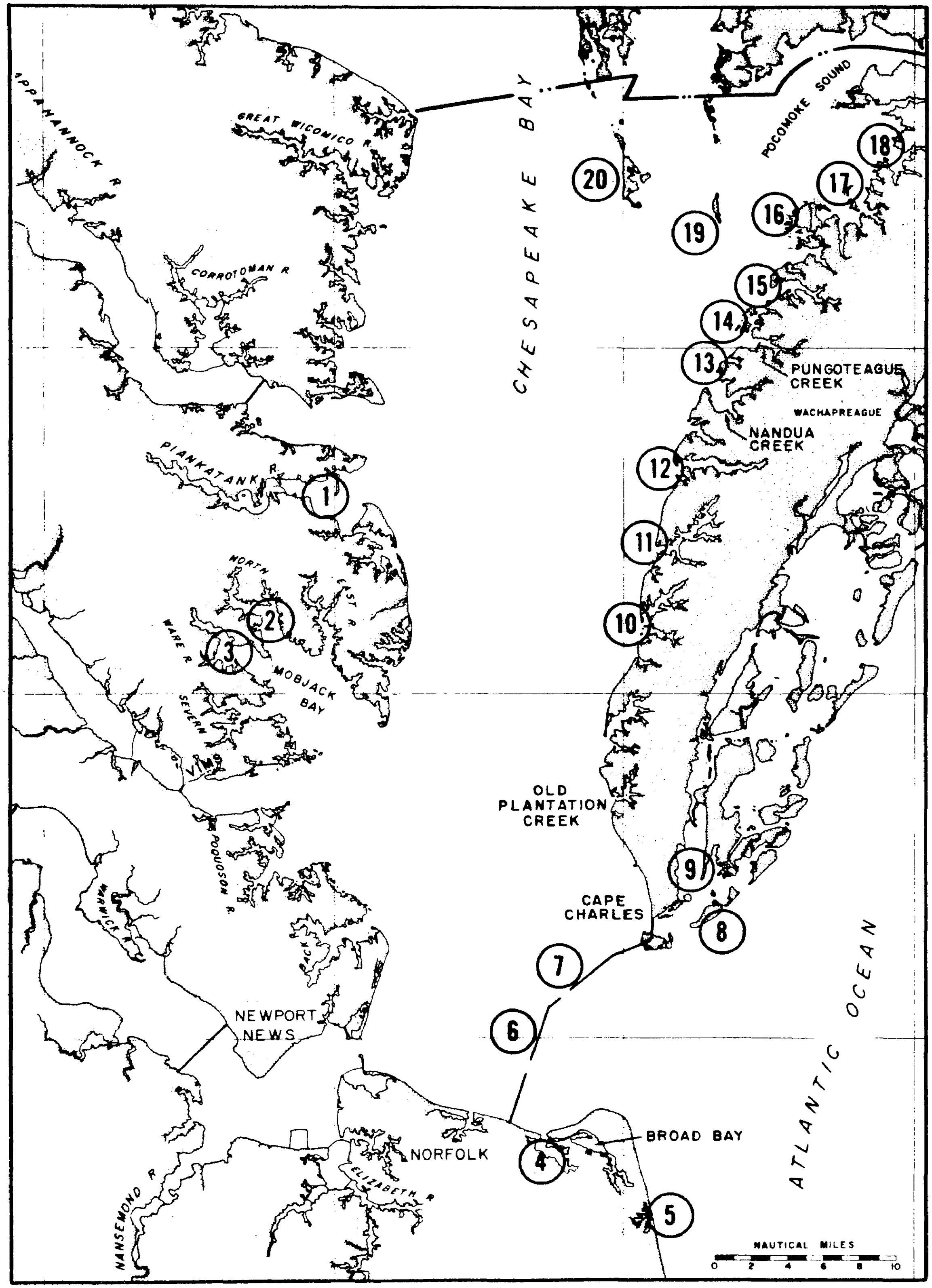
Historically the best location to catch spotted seatrout of citation size in Virginia was the Chesapeake Bay Bridge Tunnel (including the fourth island area). The second best area was the Piankatank River followed by Nassawadox Creek, Masons Beach, and Parkers Island on the Eastern Shore (Figure 18). Thirteen of the twenty most important catch locations were on the Eastern Shore. Nassawadox Creek most consistently produced citation spotted seatrout (citation fish were caught there 19 out of the 22 years). Lynnhaven River and Occohonnock Creek had the next best records (Table 8). Tangier Island area was the least consistent producer of citation spotted seatrout although it yielded more total *C. nebulosus* than Magothy Bay, Watts Island, Smith Island, Rudee Inlet and Hungars Creek over the 22 year period (Table 8).

The Piankatank River historically is one of the best spotted seatrout fishing locales, but since 1978 no citation size fish have been reported. The North and Ware Rivers experienced increased numbers of citation *C. nebulosus* during those same years. In 1980,

Figure 17

Twenty most frequently reported locations for catching *Cynoscion nebulosus* in the Virginia Saltwater Fishing Tournament

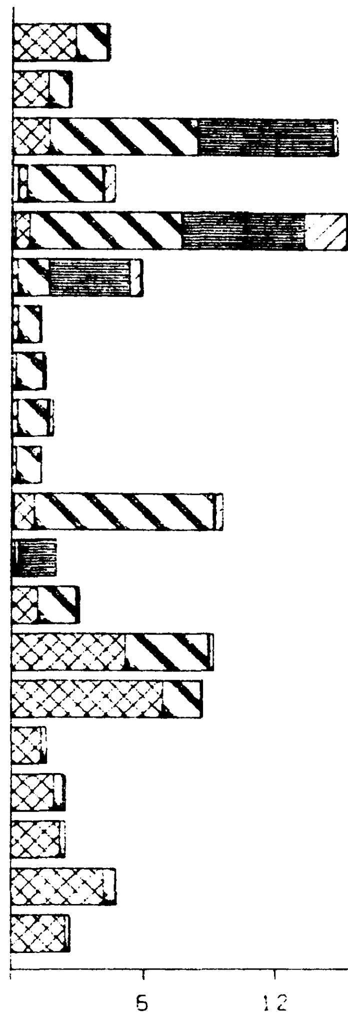
1. Piankatank River
2. North River
3. Ware River
4. Lynnhaven River
5. Rudee Inlet
6. Chesapeake Bay Bridge Tunnel (CBBT)
7. Fourth Island, CBBT
8. Smith Island
9. Magothy Bay
10. Hungars Creek
11. Nassawadox Creek
12. Occohonnock Creek
13. Masons Beach
14. Parkers Island
15. Onancock Creek
16. Deep and Pompco Creeks
17. Halfmoon Island
18. Guard Shore
19 Watts Island
20. Tangier Island



RAPPAHANNOCK R.
GREAT WICOMICO R.
CHESAPEAKE BAY
POCOMOKE SOUND
CORROTOMAN R.
PIANKATANK R.
NORTH
EAST R.
WARE R.
MOBJACK BAY
SEVERN
VIMS
POQUOSON R.
WARWICK R.
BACK R.
NEWPORT NEWS
NORFOLK
ELIZABETH R.
NANSEMOND R.
BROAD BAY
ATLANTIC OCEAN
CAPE CHARLES
OLD PLANTATION CREEK
PUNGOTEAGUE CREEK
WACHAPREAGUE
NANDUA CREEK
NAUTICAL MILES
0 2 4 6 8 10
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

Figure 18. Number and percent of citation size *Cynoscion nebulosus* taken at 20 locations by fishing technique, 1958-1980.

LOCATION	FREQ	PERCENT
WARE RIVER	90	4.37
NORTH RIVER	55	2.67
PIANKATANK RIVER	304	14.75
LYNNHAVEN RIVER	96	4.66
BRIDGE-TUNNEL	314	15.24
4TH ISLAND,CBBT	122	5.92
RUDEE INLET	27	1.31
SMITH ISLAND	32	1.55
MAGOTHY BAY	39	1.89
HUNGARS CREEK	27	1.31
NASSAWADOX CREEK	197	9.56
TANGIER ISLAND	42	2.04
OCCOHONNOCK CK	63	3.06
MASONS BEACH	188	9.12
PARKERS ISLAND	179	8.69
WATTS ISLAND	33	1.60
ONANCOCK CREEK	50	2.43
DEEP,POMPCO CRKS	50	2.43
HALFMOON ISLAND	98	4.75
GUARD SHORE	55	2.67
	2061	



LEGEND:

CHUMMING
CASTING
UNKNOWN
JIGGING
BAIT FISHING
TROLLING
INELIGIBLE

Table 8

Total Number of Citations for *Cynoscion nebulosus* from Twenty Catch Locations and Number of Years Citations Issued, 1958-1980.

Location	Number of years issued citations	Total number citations
Ware River	10	90
North River	8	55
Piankatank River	10	304
Lynnhaven River	17	96
Chesapeake Bay Bridge Tunnel	9	314
4th Island, CBBT	6	122
Rudee Inlet	9	27
Smith Island	13	32
Magothy Bay	13	39
Hungars Creek	11	27
Nassawadox Creek	19	197
Tangier Island	4	42
Occohonnock Creek	15	63
Masons Beach	12	188
Parkers Island	10	179
Watts Island	6	33
Onancock Creek	9	50
Deep and Pompco Creeks	6	50
Halfmoon Island	9	98
Guard Shore	10	55

the Ware and North Rivers were the two top locations for citation seatrout in the Bay area.

The number of locations for which citation spotted seatrout were reported increased from an average of 4.6 before 1970 to an average of 14.6 per year after 1970. The number of catch locations per year that yielded citation *C. nebulosus* remained high after 1976, while the number of citations per year decreased to about 25% of its 1972-1976 level (Table 9).

Three basic fishing techniques - bait fishing, casting and trolling - were most often employed by spotted seatrout anglers. In some areas preferences for certain fishing techniques were evident (Figure 18). Casting was the primary fishing method at Nassawadox Creek, Lynnhaven River, Rudee Inlet, Smith Island, Magothy Bay, Hungars Creek and Occohonnock Creek. Casting and trolling were equally effective in the Piankatank River and at the Cheaspeake Bay Bridge Tunnel, although trolling was more effective at the fourth island of the Chesapeake Bay Bridge Tunnel and around Tangier Island. Bait fishing was the most effective technique for other beach and island locations along the Eastern Shore, and in the Ware and North Rivers.

The largest spotted seatrout caught in the Virginia Saltwater Fishing Tournament was a 16 pound fish from the Masons Beach area in May, 1977. This fish also represents the IGFA record spotted seatrout. The heaviest and longest spotted seatrout were caught during May, June and November. The largest fish in the tournament were caught at the Ware and North Rivers, Smith Island, Tangier Island and Masons Beach (Table 10). The smaller citation fish were caught in the Ware River, Chesapeake Bay Bridge Tunnel, Nassawadox Creek, Masons Beach, Parkers

Table 9

Cynoscion nebulosus Catch by Year from the

Virginia Saltwater Fishing Tournament

Year	Number of Citations	Number of Catch Locations
1958	5	4
1959	15	4
1960	22	6
1961	5	3
1962	22	7
1963	3	3
1964	4	3
1965	19	5
1966	8	3
1967	8	4
1968	7	5
1969	5	5
1970	51	8
1971	168	17
1972	322	18
1973	403	18
1974	386	19
1975	215	17
1976	208	12
1977	61	11
1978	39	11
1979	23	12
1980	62	11

Table 10

Number of citation size *Cynoscion nebulosus* by 25 mm length increments taken at 20 locations

Location	Length Increment (25 mm) 533	558	583	608	633	658	683	708	733	758	783	808	826	Total
Ware River	3	9	21	15	15	18	6	6	2	8	3	-	1	107
North River	-	2	3	10	15	9	8	1	3	-	1	2	1	55
Piankatank River	1	9	21	25	18	18	14	12	10	5	3	-	-	136
Lynnhaven River	-	10	21	15	5	5	2	1	-	-	-	1	-	60
Chesapeake Bay Bridge Tunnel	5	3	21	30	30	33	28	25	20	11	4	-	-	210
Fourth Island, CBBT	-	4	5	25	10	10	12	1	1	5	-	-	-	73
Rudee Inlet	-	-	-	3	1	2	-	-	-	-	-	-	-	6
Smith Island	1	3	10	3	3	-	-	-	-	-	-	-	3	23
Magothy Bay	-	3	10	8	1	1	2	1	-	-	-	2	-	28
Hungars Creek	-	2	3	2	-	2	6	1	-	-	-	-	-	16
Nassawadox Creek	5	13	35	45	30	25	16	14	3	3	3	-	-	192
Tangier Island	-	-	-	1	5	1	2	10	7	7	3	-	2	38
Occohonnock Creek	-	9	8	10	5	2	-	2	-	-	-	-	-	36
Masons Beach	12	8	20	25	23	18	12	11	3	1	1	2	5	141
Parkers Island	3	12	20	25	15	9	9	9	6	1	-	1	-	110
Watts Island	-	3	2	3	7	-	4	2	-	-	1	2	-	24
Onancock Creek	3	3	6	10	2	2	5	-	1	1	-	-	-	33
Deep and Pompco Creeks	1	3	6	5	5	8	5	2	1	-	1	-	-	37
Halfmoon Island	5	18	28	18	15	7	5	2	-	-	1	-	-	99
Guard Shore	-	1	21	10	8	6	10	-	1	1	1	1	-	60
Total	39	115	261	288	213	176	146	100	58	43	22	11	12	1484

Island, Onancock Creek, Deep Creek, Pompco Creek and Halfmoon Island. Size of spotted seatrout submitted for citations have increased during the 22 years of the tournament. No fish heavier than 3000 grams (6.6 pounds) nor longer than 700 mm (27.5 inches) were registered before 1971. Of all the spotted seatrout caught since 1971, 972 individuals (52% of total) exceeded 3000 grams. Most of the citation *C. nebulosus* (63%) were between 575 and 675 mm TL. Ninety percent of citation fish were less than or equal to 725 mm TL and the largest citation was 826 mm TL (the state and IGFA record fish). The vast majority of citation spotted seatrout weighed 3500 grams or less (86%) and the largest reported catch was 7258 grams (16 pounds).

A graph of the length-weight relationship for citation spotted seatrout (Figure 19) was

$$\text{Weight} = 8.168 \text{ X Length} - 2488.76;\ r^2 = 0.55.$$

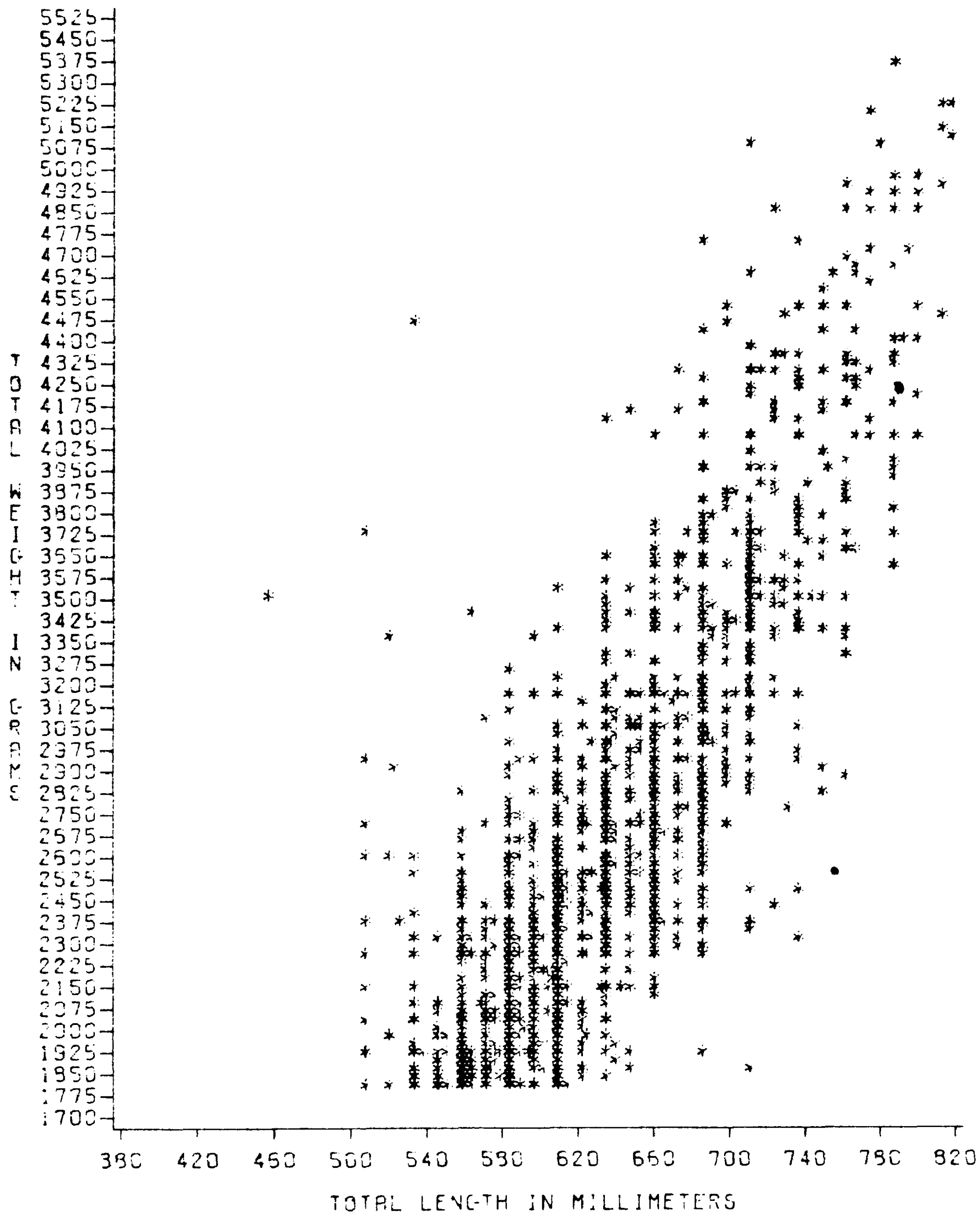
The equation to predict age of citation spotted seatrout was derived from the von Bertalanffy calculations (Section I):

$$\text{Age} = (\ln(935-\text{length}) - 5.609) / 0.059.$$

Calculated ages for citation fish ranged from 4 to 18 years.

The best years for catching citation sized spotted seatrout were 1972, 1973 and 1974. Overall, May has been the best month for catching citation seatrout (28.8% of the total citation fish). The next best months for catching *C. nebulosus* in descending order were October (20.3%), June (16.4%), September (12.4%), November (12.2%), July (5.5%) and August (4.5%). The Ware, North and Piankatank Rivers on the western shore, or Masons Beach, Parkers Island, Halfmoon Island and Guard Shore on the Eastern Shore yielded the greatest number of citation fish in May (Figure 20). Most spotted seatrout citations in June were from Eastern Shore locations (Masons Beach, Parkers Island,

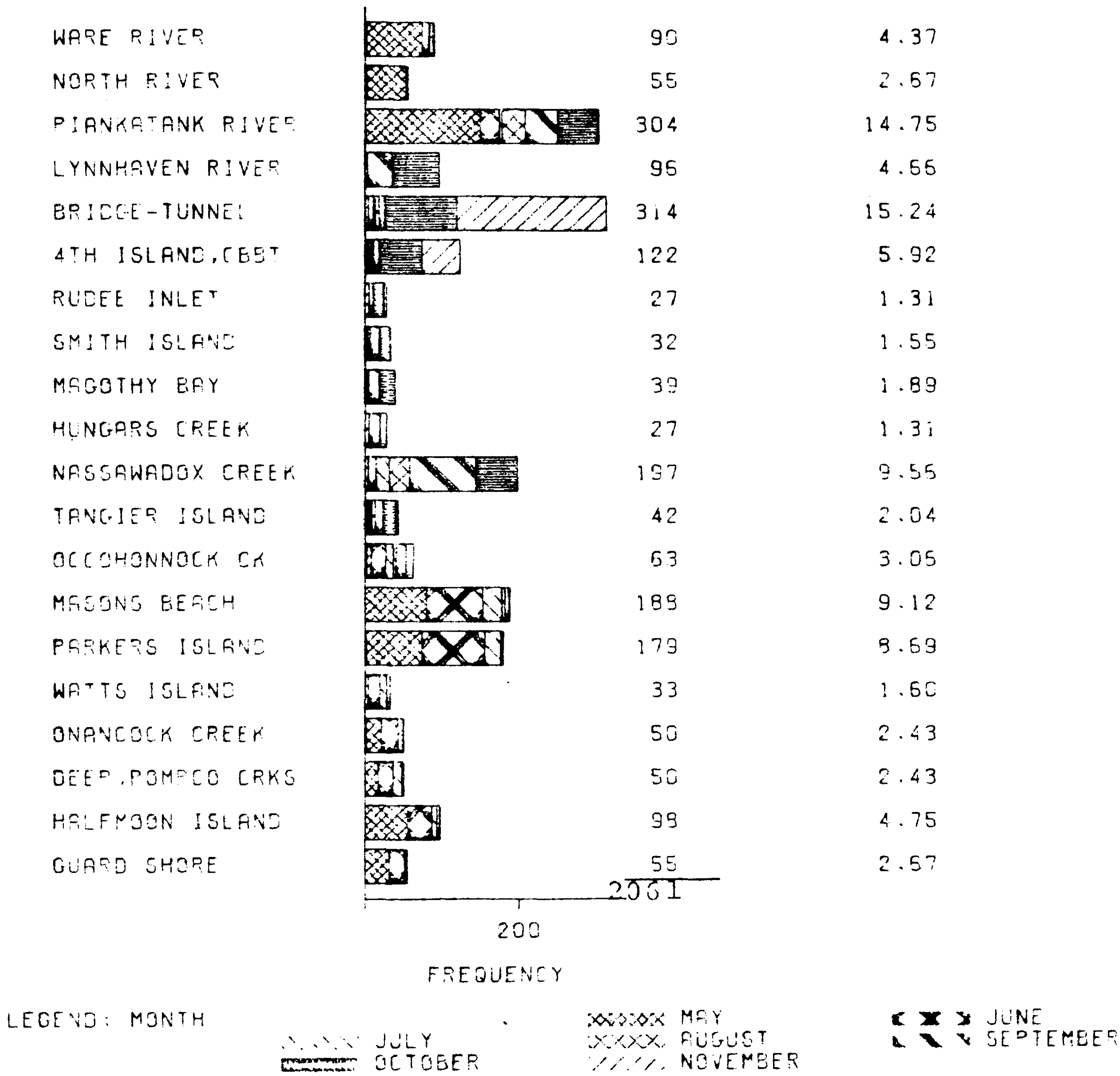
Figure 19. Weight vs. Length for citation size *Cynoscion nebulosus*, 1958-1980.



TOTAL WEIGHT IN GRAMS
TOTAL LENGTH IN MILLIMETERS

Figure 20. Frequency of citation size *Cynoscion nebulosus* taken each month at 20 locations, 1958-1980.

LOCATION	FREQ	PERCENT
WARE RIVER	90	4.37
NORTH RIVER	55	2.67
PIANKATANK RIVER	304	14.75
LYNNHAVEN RIVER	96	4.66
BRIDGE-TUNNEL	314	15.24
4TH ISLAND,CBBT	122	5.92
RUDEE INLET	27	1.31
SMITH ISLAND	32	1.55
MAGOTHY BAY	39	1.89
HUNGARS CREEK	27	1.31
NASSAWADOX CREEK	197	9.56
TANGIER ISLAND	42	2.04
OCCOHONNOCK CK	63	3.06
MASONS BEACH	188	9.12
PARKERS ISLAND	179	8.69
WATTS ISLAND	33	1.60
ONANCOCK CREEK	50	2.43
DEEP,POMPCO CRKS	50	2.43
HALFMOON ISLAND	98	4.75
GUARD SHORE	55	2.67
	2061	



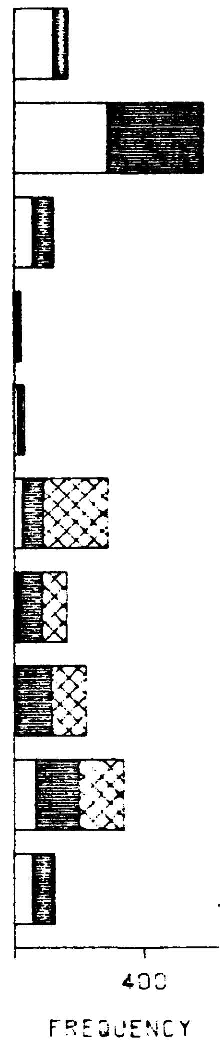
Watts Island and Onancock Creek). July was a slow month for citation fish, although almost all of the Eastern Shore locations did produce a few large spotted seatrout. In general, August was the poorest month to fish for large *C. nebulosus* in Virginia since only the Piankatank River and Nassawadox Creek produced reasonable numbers of citation size fish. The Piankatank River, Lynnhaven River and Nassawadox Creek were the best fishing areas in September. October fishing was best in the Piankatank and Lynnhaven Rivers, the Bridge Tunnel, Magothy Bay, Rudee Inlet, Smith Island, Nassawadox Creek and Tangier Island. In November, citations were issued for spotted seatrout caught only around the Chesapeake Bay Bridge Tunnel (Figure 20).

During the 22 years of the tournament fishermen reported 48 types of lures and bait to capture spotted seatrout. Of these, the ten most popular lures and baits caught 83.3% of all citation fish. By far, the most effective bait was peeler crabs (Figure 21). Stingray grubs, bucktails and mirrolures were the most effective lures. Bait (soft crabs, peeler crabs, cut fish) was used only during the spring and summer; no citation spotted seatrout were caught with natural bait in the fall (Figure 21). Bucktails were used more frequently in the fall than in any other season; mirrolures and stingray grubs were used with equal frequency in the summer and fall. The predominant trend during the spring was to use crabs as bait though some anglers were successful using bucktails and singray grubs.

Peeler crabs were the most commonly used bait at Mason Beach, Parkers Island, Onancock Creek, Deep and Pompco Creeks, Halfmoon Island and Guard Shore (Figure 22). Other types of natural bait were successful at these locations but no citation fish were caught with

Figure 21. Frequency of citation size *Cynoscion nebulosus* taken each season by 10 preferred baits, 1958-1980.

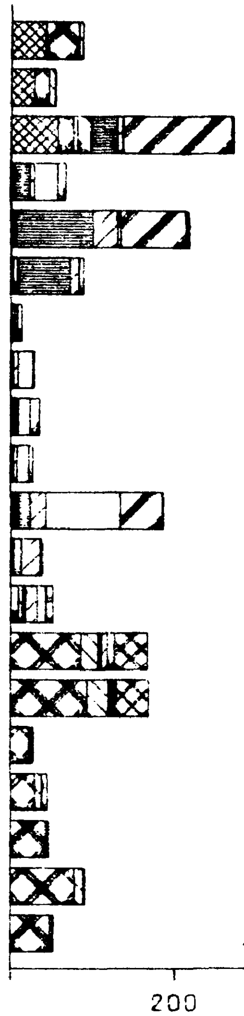
BAIT	FREQ	PERCENT
SOFT CRABS	164	8.06
PEELER CRABS	581	28.54
CRABS,GENERAL	118	5.80
CUT FISH	19	0.93
SPOON	30	1.47
BUCKTAIL	286	14.05
LURES,GENERAL	160	7.86
MIRRO-LURE	219	10.76
STING-RAY GRUB	339	16.65
BAIT,UNSPECIFIED	121	5.94
	2036	



LEGEND: SEASON . SPRING
SUMMER XXXXX FALL

Figure 22. Bait used at 20 locations to catch citation size *Cynoscion nebulosus*, 1958-1980.

LOCATION	FREQ	PERCENT
WARE RIVER	86	4.93
NORTH RIVER	54	3.09
PIANKATANK RIVER	271	15.52
LYNNHAVEN RIVER	66	3.78
BRIDGE-TUNNEL	216	12.37
4TH ISLAND,CBBT	88	5.04
RUDEE INLET	13	0.74
SMITH ISLAND	28	1.60
MAGOTHY BAY	34	1.95
HUNGARS CREEK	26	1.49
NASSAWADOX CREEK	185	10.60
TANGIER ISLAND	38	2.18
OCCOHONNOCK CK	50	2.86
MASONS BEACH	166	9.51
PARKERS ISLAND	167	9.56
WATTS ISLAND	27	1.55
ONANCOCK CREEK	44	2.52
DEEP,POMPCO CRKS	46	2.63
HALFMOON ISLAND	90	5.15
GUARD SHORE	51	2.92
	1746	



LEGEND: BAIT

- SOFT CRABS
- CRABS,GENERAL
- SPOON
- LURES,GENERAL
- STING-RAY GRUB
- PEELER CRABS
- CUT FISH
- BUCKTAIL
- MIRRO-LURE
- BAIT,UNSPECIFIED

artificial lures. Citation fish from the Ware and North Rivers were also caught exclusively on natural bait. Soft crabs were cited as bait only in the Ware, North and Piankatank Rivers. At the Chesapeake Bay Bridge Tunnel, Lynnhaven River, Smith Island, Magothy Bay, Hungars Creek, Nassawadox Creek and Tangier Island citation fish were taken almost exclusively on artificial lures. Citation spotted seatrout were taken with both bait and lure only in the Piankatank River and Occohonnock Creek areas.

Peeler crabs tended to yield the heaviest fish caught in the tournament. Citations for fish weighing less than 5500 grams (12 pounds) suggested equivalent preference for all bait and lure types (Figure 23).

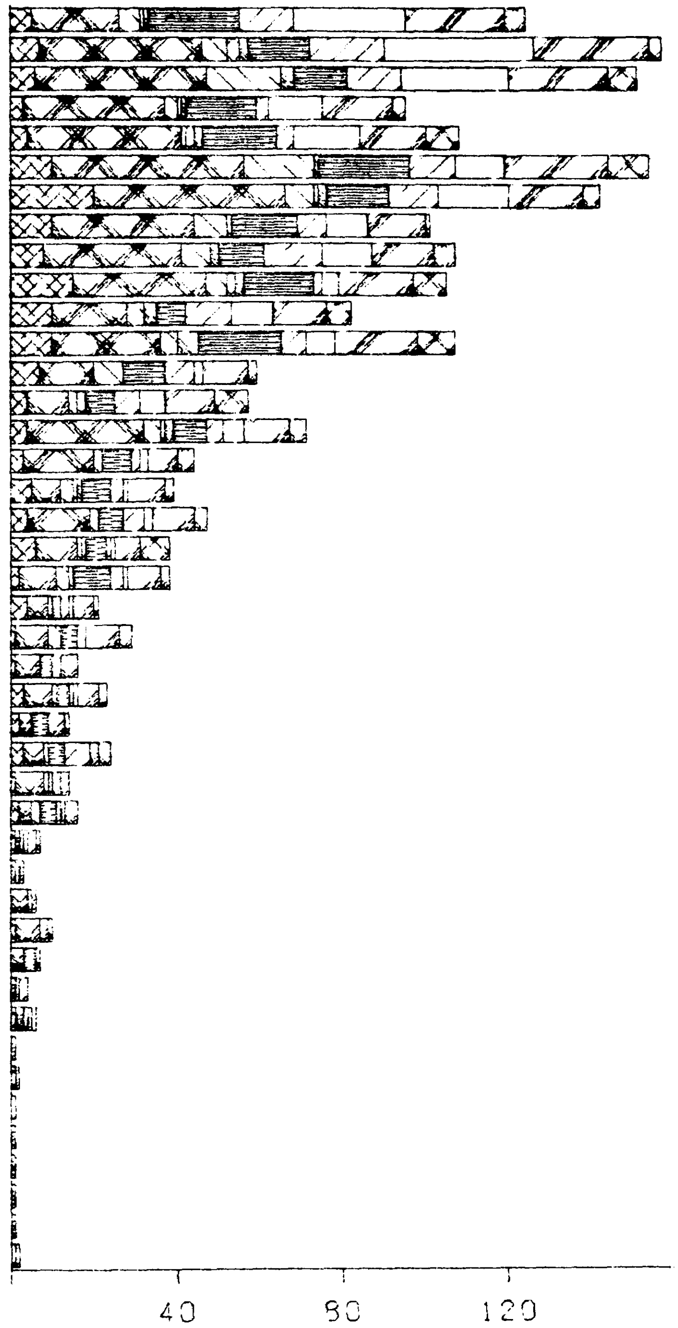
A fairly large percent (29%) of the anglers either did not know or did not record the make or brand of fishing gear they were using (Table 11). This was less true for reels than rods or lines. Penn reels were most frequently used to catch citation *C. nebulosus* (30% of the reporting fishermen).

Citation spotted seatrout entered in the Virginia Saltwater Fishing Tournament were caught almost exclusively by Virginian anglers (95%, Table 12). Successful anglers from out-of-state were mostly from Maryland and North Carolina.

<u>North Carolina Citation Analysis</u>

Fewer citation spotted seatrout were reported in North Carolina than in Virginia. In 1977-1978 only 24 citations were issued in the North Carolina Saltwater Fishing Tournament, compared with 100 citations for the same time in Virginia. Thirty-seven percent of the citations in North Carolina were under five pounds (2270 grams) and some just made

Figure 23. Ten preferred baits of citation size *Cynoscion nebulosus* in 100 gram weight increments.



MIDPOINT GRAMS	FREQ	PERCENT
1800	124	6.09
1900	157	7.71
2000	151	7.42
2100	95	4.67
2200	108	5.30
2300	154	7.56
2400	142	6.97
2500	101	4.96
2600	107	5.26
2700	105	5.16
2800	82	4.03
2900	107	5.26
3000	59	2.90
3100	57	2.80
3200	71	3.49
3300	44	2.16
3400	39	1.92
3500	47	2.31
3600	38	1.87
3700	38	1.87
3800	21	1.03
3900	29	1.42
4000	16	0.79
4100	23	1.13
4200	14	0.69
4300	24	1.18
4400	14	0.69
4500	16	0.79
4600	7	0.34
4700	3	0.15
4800	6	0.29
4900	10	0.49
5000	7	0.34
5100	4	0.20
5200	6	0.29
5300	1	0.05
5400	2	0.10
5500	1	0.05
5600	1	0.05
5900	1	0.05
6000	1	0.05
6100	1	0.05
7259	2	0.10
	2036	

Table 11

Gear (Brands) used for Catching *Cynoscion nebulosus*

in the Virginia Saltwater Fishing Tournament

Gear	Number	Percent of Total
Rod Manufacturer		
True Temper	391	16.0
Garcia	220	9.0
Custom made	129	5.3
Shakespeare	121	5.0
Berkley	114	4.7
Unknown	712	29.0
Total	1687	69.0
Reel Manufacturer		
Penn	739	30.2
Mitchell	289	11.8
Garcia	240	9.8
Shakespeare	76	3.1
Daiwa	69	2.8
Unknown	597	24.4
Total	2010	82.2
Line Manufacturer		
Monofiliment	341	13.9
Trilene	270	11.0
Stren	186	7.6
Berkley	159	6.5
Garcia	99	4.0
Unknown	908	37.1
Total	1963	80.3

Table 12

Out of State *Cynoscion nebulosus* Anglers Fishing in the Virginia Saltwater Fishing Tournament

State	Number	Percent of Total Citations
Maryland	49	2.0
North Carolina	18	0.7
Delaware	9	0.4
Washington, D. C.	8	0.3
Pennsylvania	8	0.3
Southeast	7	0.3
New York	6	0.2
Midwest	5	0.2
West Coast	4	0.2
West Virginia	3	0.1
Vermont	3	0.1
Southwest	2	0.1
Total	122	4.9

the minimum weight of four pounds (1800 grams). The largest spotted seatrout in the 1977-1978 tournaments weighed ten pounds (4540 grams). The average weight of all citation fish in North Carolina was 5.4 pounds (2464 grams).

Pamlico Sound was the most frequently cited area in the North Carolina tournament (50% of the catch, Table 13) and was followed by Oregon Inlet (37.5% of the citation catch). Fall and summer were the best seasons for capture of citation size *C. nebulosus* in North Carolina.

A total of 70.8% of the citation spotted seatrout caught in North Carolina waters were landed by out-of-state anglers. Virginia anglers accounted for almost half of the citation spotted seatrout in the North Carolina tournament during 1977-1978 (Table 14). North Carolina fishermen caught 29.2% of the citation *C. nebulosus*. The remaining few citation fish were landed by vacationers from the Northeastern United States.

In contrast with the Virginia tournament natural baits accounted for only 25% (6/24) of the citation spotted seatrout caught in the North Carolina tournament. Sting ray grubs (6) and Hopkins-type jigs (5) in particular were popular. The generic categories lures (6) and spoons (1) completed the bait listing from North Carolina *C. nebulosus* citations. Several lures or baits which were popular in Virginia (peeler crabs, mirrolures and bucktails) were not listed on citations from North Carolina.

Fishing Form Returns

The returns of "Speckled Trout Catch Information" data sheets were disappointing; only 77 were received. The majority of the anglers

Table 13

Catch Locations and Seasons for *Cynoscion nebulosus* from the North Carolina Saltwater Fishing Tournament

	Oregon Inlet	Pamlico Sound	Outer Banks	Total	% Total
Spring	2	1	2	5	20.8
Summer	2	6	1	9	37.5
Fall	5	5	-	10	41.7
Total	9	12	3	24	
% Total	37.5	50	12.5		

Table 14

Home State of *Cynoscion nebulosus* Anglers Fishing in the North Carolina Saltwater Fishing Tournament

State	Number	Percent
Virginia	11	45.8
North Carolina	7	29.2
Pennsylvania	2	8.3
Ohio	2	8.3
New Jersey	2	8.3
Total	24	

(92.2%) indicated they were fishing specifically for spotted seatrout. Only six anglers reported "accidental" capture of *C. nebulosus*.

As expected the size composition of the spotted seatrout recreational catch obtained from the fishing form returns differed substantially from citation data. Fish ranged from 250 mm to 775 mm and 39% were less than 525 mm TL (Figure 24). Ages of the fish ranged from 1 to 12 years (Figure 24) with 21% less than seven years old and 40% in ages VII to VIII. The range in size was broad for some age groups (age VII were 425 to 650 mm TL and age VIII were 500 to 700 mm). Most other age groups spanned a 100 mm TL range.

Hungars Creek was the most popular fishing location among anglers who recorded their catch information on the data sheets (Figure 25). The Ware and North Rivers produced the next largest numbers of spotted seatrout (mostly citation size *C. nebulosus*). Eastern Shore catches were the most numerous (57% of the returns). Ware Neck Point area was the most often reported location on the western shore of the Bay, with 34% of the total returns.

October was the peak month for catching spotted seatrout (39% of total fish) and May was second best (34% of returns). Few *C. nebulosus* were reported during the summer (2 in June, 0 in July and 4 in August). The Ware River, North River and Parkers Island were the reported locations for spotted seatrout in May during 1979-1980 (Figure 25). Hungars Creek provided the only reports of spotted seatrout in August and the majority of the September and October reports. Fall was the best season for catching *Cynoscion nebulosus* in a variety of locations and most reports were from Lynnhaven River and Hungars Creek.

The most popular bait reported on the fishing forms was mirrolures (39%, Figure 26) followed by stingray grubs, peeler crabs,

Figure 24. Length frequency histograms of *Cynoscion nebulosus* (ages I to XII) caught in the recreational fishery.

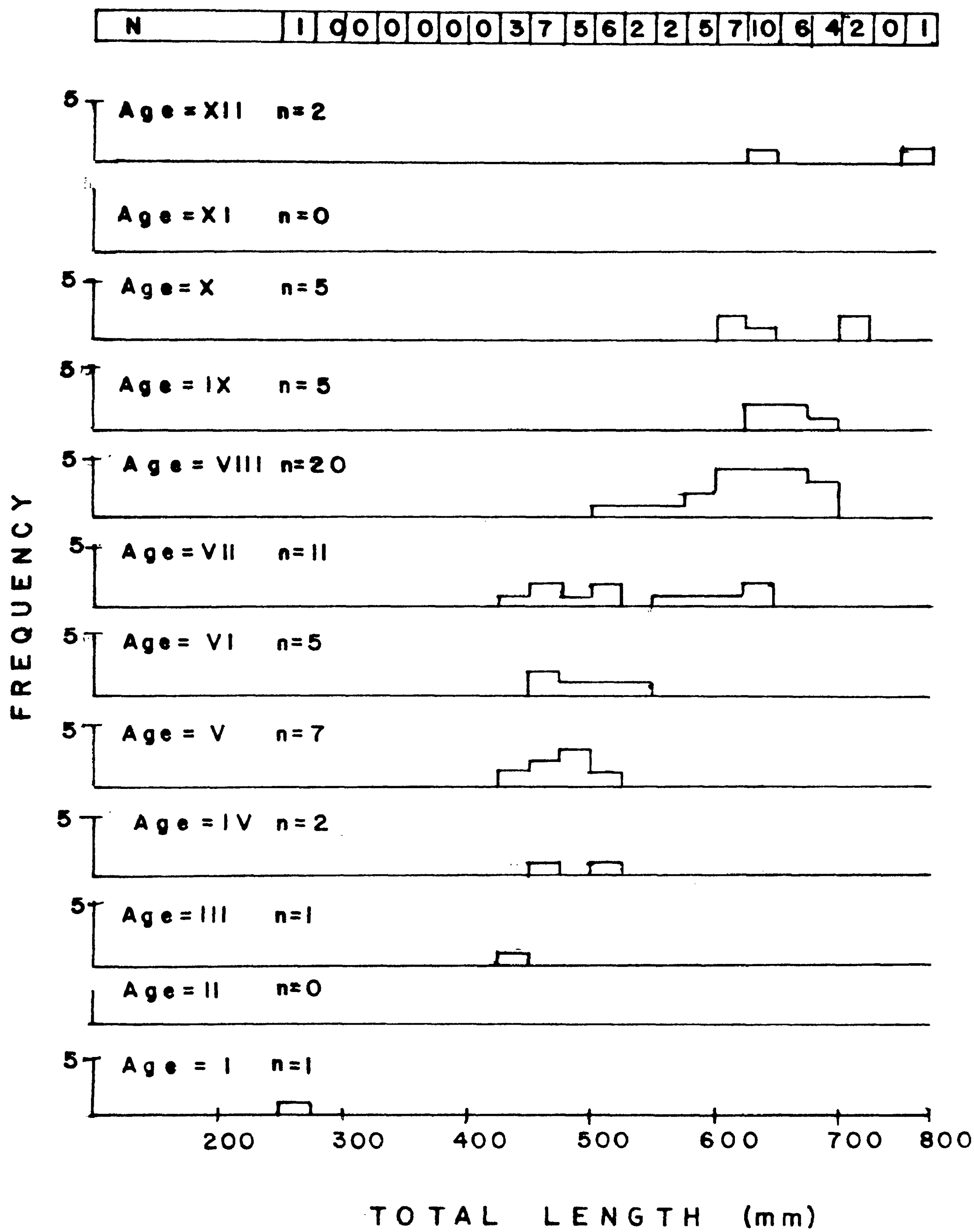

N
1 0 0 0 0 0 0 3 7 5 6 2 2 5 7 10 6 4 2 0 1
Age = XII n = 2
Age = XI n = 0
Age = X n = 5
Age = IX n = 5
Age = VIII n = 20
Age = VII n = 11
Age = VI n = 5
Age = V n = 7
Age = IV n = 2
Age = III n = 1
Age = II n = 0
Age = I n = 1
5
FREQUENCY
200
300
400
500
600
700
800
TOTAL LENGTH (mm)

Figure 25. Frequency of *Cynoscion nebulosus* captured by month at 9 locations reported on fishing form returns.

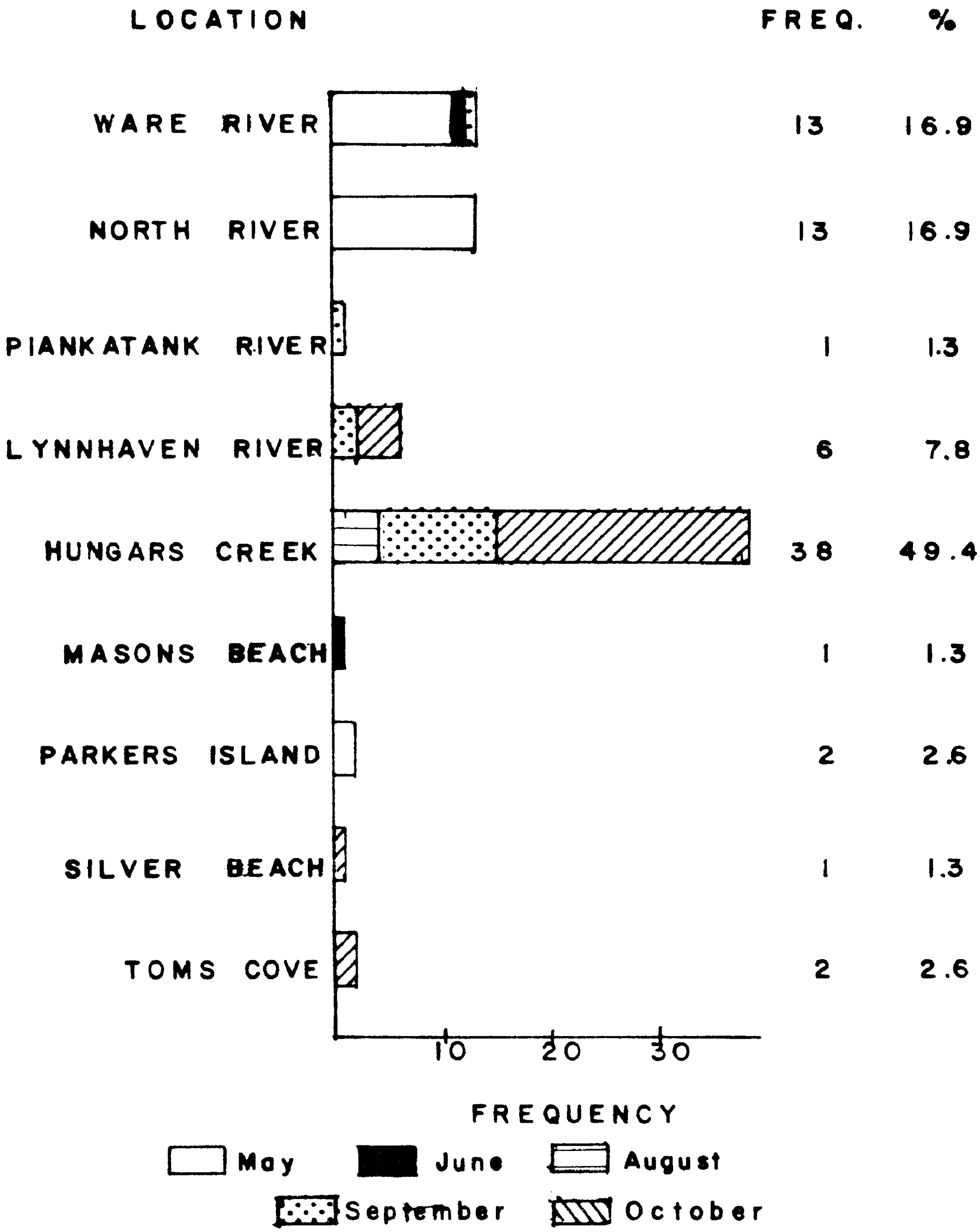
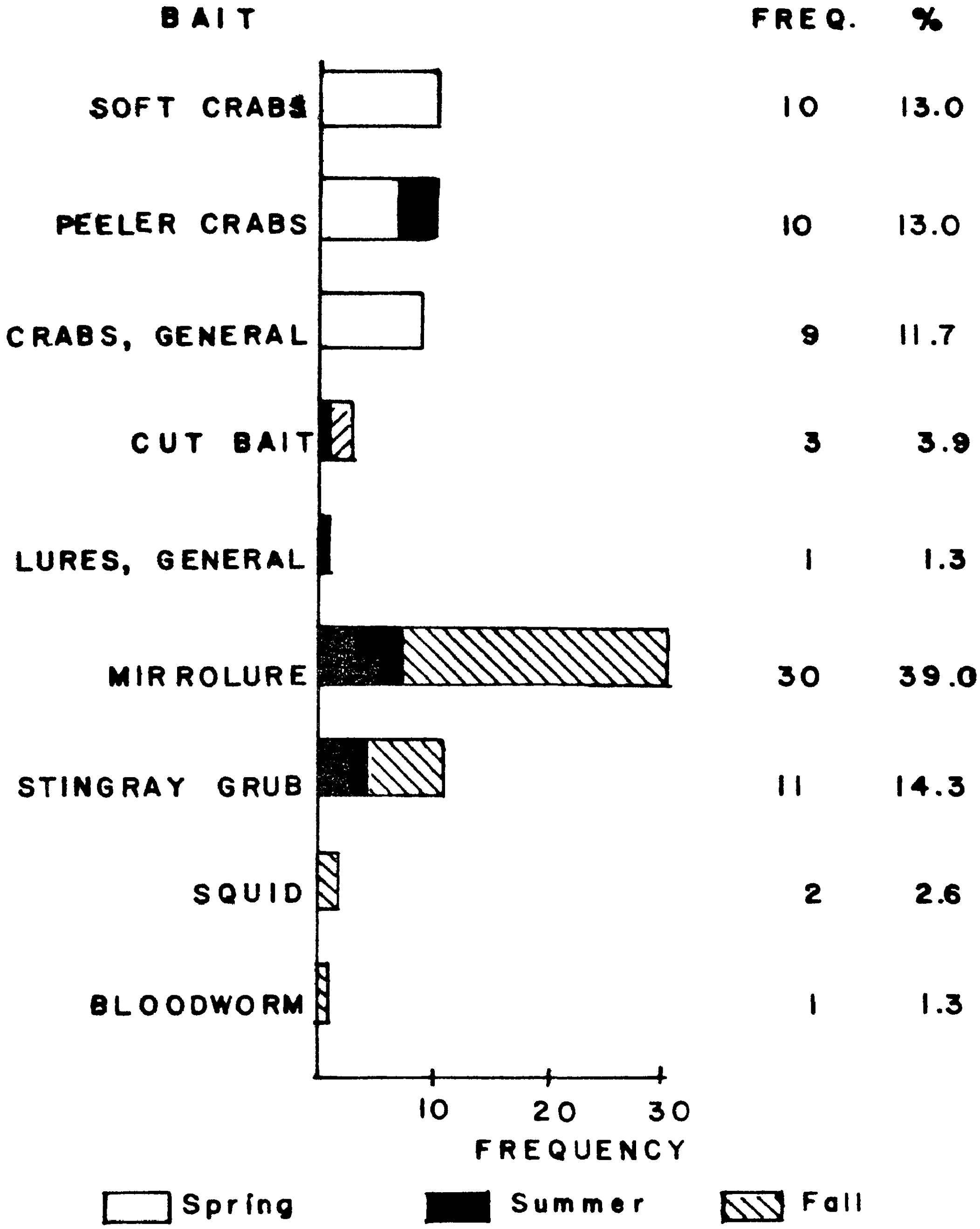

LOCATION
FREQ.
%
WARE RIVER
13
16.9
NORTH RIVER
13
16.9
PIANKATANK RIVER
1
1.3
LYNNHAVEN RIVER
6
7.8
HUNGARS CREEK
38
49.4
MASONS BEACH
1
1.3
PARKERS ISLAND
2
2.6
SILVER BEACH
1
1.3
TOMS COVE
2
2.6
10
20
30
FREQUENCY
May
June
August
September
October

Figure 26. Frequency of *Cynoscion nebulosus* by 9 lures or baits by season as reported on fishing form returns.


BAIT
FREQ.
%
SOFT CRABS
10
13.0
PEELER CRABS
10
13.0
CRABS, GENERAL
9
11.7
CUT BAIT
3
3.9
LURES, GENERAL
1
1.3
MIRROLURE
30
39.0
STINGRAY GRUB
11
14.3
SQUID
2
2.6
BLOODWORM
1
1.3
10
20
30
FREQUENCY
Spring
Summer
Fall

soft crabs and crabs in general. Stingray grubs and mirrolures accounted for most of the spotted seatrout in the fall although a few succumbed to natural bait. Crabs were the only successful bait reported in the spring. Mirrolures and stingray grubs proved most successful lures during the slow summer fishing, although a few anglers had success with peeler crabs and cut bait.

DISCUSSION

Citation and Fishing Form Analysis

Data from the Virginia Saltwater Fishing Tournament revealed that 95% of the citation *Cynoscion nebulosus* caught in Virginia waters were landed by Virginians. Since spotted seatrout are never abundant in the Chesapeake Bay area, the citation files provided evidence that local fishermen have developed fishing for this elusive species into a fairly exacting science. Favorite locations, seasons, times and tides of successful *C. nebulosus* fishing are not widely known among the generalist fishermen. Thus a non-resident or occasional fisherman probably encounters and lands fewer spotted seatrout. This conclusion was reinforced by the data on returned fishing forms where 92% of the anglers were fishing specifically for spotted seatrout. Interviews with several experienced, highly successful spotted seatrout fishermen revealed a high degree of similarity in fishing techniques which corresponded well with data on the fishing forms. Drift fishing over beds of *Zostera marina* and *Ruppia maritima* while continually casting into the wind yields the best results. The preferred time to start a spotted seatrout fishing expedition is halfway through flood tide in the evening and most fishermen pole their boat over a grass bed and wait until the tide rises. Spotted seatrout bite best on a flooding tide at dusk.

Lascara (1981) reported movements of *C. regalis* and *C. nebulosus* in and out of submerged aquatic vegetation beds in Chesapeake Bay.

Times of peak abundance corresponded to crepuscular periods (dawn and dusk), and he believed these were times of maximum feeding activity for weakfish. Spotted seatrout have a tapeta lucida in their eyes (Arnott *et al*, 1971), allowing a greater amount of light penetration to the retina. This adaption allows for keener eyesight in dim light than potential prey items, and increases feeding duration and success during periods of low light intensity. Therefore, fishing for spotted seatrout during crepuscular periods should yield the best results. Comments of experienced fishermen confirm this.

Spotted seatrout are caught in the Eastern Shore area after the first full moon in May. After Labor Day, with the advent of more sustained northeasterly winds, they will start to school in preparation for their winter migration. Eastern shore fishermen have good catches of *C. nebulosus* until the first heavy frost, usually in October. Thereafter, spotted seatrout leave the grass beds and are unavailable to Eastern Shore anglers until the following May. May and October were cited as the best months to catch spotted seatrout on the fishing form returns, corresponding to the spring and fall migrations of this species. The spring and fall migrations were also detectable in citation data: during May spotted seatrout move into the rivers on the western shore (Ware, North and Piankatank) and up bayside eastern shore (Masons Beach, Parkers Island, Halfmoon Island, Guard Shore). Historically May has been the best month for catching citation size spotted seatrout. During the summer spotted seatrout feed and spawn near the grassy flats. Recreational catches are highest in the summer from those areas with abundant grass beds, such as Hungars Creek, Nassawadox Creek, Occohonnock Creek, Onancock Creek, Masons Beach and Parkers Island. As *C. nebulosus* school in the fall and prepare to leave the grassy creeks and Bay area, catches are good in areas with adjacent deep water, such as Smith Island, Magothy Bay, Lynnhaven River, Rudee Inlet and the Chesapeake Bay Bridge Tunnel. October has been the second best month of the year to catch citation *C. nebulosus* in Virginia. As the last of the spotted seatrout leave the Bay in November, they are caught in the deep channel areas at the Bay Bridge Tunnel, where they are often associated with *C. regalis*.

Fishermen interviewed on both the Eastern and western shores of the Bay preferred fishing at Hungars Creek, Lynnhaven River and Parkers Island. The strong preference for fishing at Hungars Creek is evident in the fishing form results. Most of the non-citation size spotted seatrout reported on the fishing forms came from Hungars Creek, but there were only a few tournament records from Hungars Creek.

Spotted seatrout tend to school until they reach age VI or VII; thereafter males die and females lead a solitary existence (Tabb, 1961). Hungars Creek and similar areas may suggest a population of schooling *C. nebulosus*, mostly under citation size, but in sufficient numbers to provide reliable recreational fishing. Thus experienced fishermen are content with a days fishing for non-citation size spotted seatrout and target their routine activity to areas of consistent success.

An inherent bias always exists in fishermen reported catches. The "Speckled Trout Catch Information" sheets were distributed to a large cross section of the recreational fishing population in lower Chesapeake Bay and Eastern Shore but only those anglers personally interested in spotted seatrout conscientiously filled in the forms. Most of these anglers were from the Eastern Shore and directed most of their fishing effort to the Hungars Creek area, thus revealing the basis of the returns from Hungars Creek. After compensation for this respondant bias, I feel the fishing form returns parallel the tournament citation landings and in general both are fairly reliable indicators of fishing pressure for spotted seatrout in Virginia. Although the fishing form results are quite different than the 22 year combined citation data base, they are remarkably similar to the 1979-1980 citation records.

The data from 22 years of the Virginia Tournament suggest that citation size spotted seatrout have moved to new locations, possibly in response to changing habitats. Orth (1976) reported a decline in beds of *Zostera marina* throughout the Bay. Submerged aquatic vegetation has been identified as a significant factor affecting survival of *Cynoscion nebulosus*. Presumably the fish will leave an area that does not offer suitable protection, spawning habitat and feeding grounds. Grass beds in the Piankatank River have disappeared during the last 7 years (Orth and Moore, 1981). The low number of citations in 1976 to 1980 suggest that spotted seatrout no longer frequent the Piankatank in numbers. Submerged aquatic vegetation beds in the Ware and North Rivers and along the bayside Eastern Shore are still adequate (Orth and Moore, 1981). Local seatrout fishermen reported SAV growth in those areas as less luxuriant than ten to fifteen years ago.

I attribute the improved recent catches in the Ware and North Rivers and Hungars Creek to the continued availability of submerged aquatic vegetation habitat. The Ware and North Rivers ranked as twelfth and tenth most important catch locations, respectively, for the period 1958-1980. During 1979-1980 they were ranked as first and second, respectively. The Ware and North Rivers were tied as the second best fishing locations on fishing form returns. Hungars Creek was the number one location on fishing form returns and fourth for citation fish in 1979-1980. It was the least productive of the top 20 locations over the period 1958-1980 in the tournament.

While the Chesapeake Bay Bridge Tunnel was the best location for citation spotted seatrout over the 22 year period it fell to the ninth ranked catch location during 1979-1980. Nineteen hundred seventy-nine was the poorest year for citation seatrout, indicating either poor recruitment into the Bay or a preferrential fishing pressure on other species. A record number of *C. regalis* were caught in 1979 and 1980 at the Bridge Tunnel. Perhaps the sheer abundance of weakfish significantly lowered the chances of catching *C. nebulosus* at the Bridge Tunnel.

Spotted seatrout recruitment into the Virginia citation fishery can only be estimated. Anglers are generally accurate when recording the weight of their catch but often lengths are measured incorrectly or recorded only to the nearest inch. The measurement error accounts for the wide spread of lengths in each age group observed which was compounded when calculating age from questionable lengths. I used the data available to estimate the age groups in the Virginia citation records. Citation fish were no smaller than 525 mm TL. This corresponds to age VIII fish (Section I). Thus *C. nebulosus* are fully recruited into the citation fishery at age VIII and a few age VI and VII fish may reach the minimum citation weight.

From my results it appears that spotted seatrout are not fully recruited into the recreational fishery of Chesapeake Bay until age

III. Most fishermen return small *C. nebulosus* (.75 to 1.0 pound, 341-454 grams) to the water (J. Sparrow, pers. comm.). This would account for the paucity of age I to IV fish on the fishing form returns. Reticence of anglers to report small fish could also account for these results, however. Although there is no minimum length or weight for spotted seatrout in Virginia, most recreational fishermen enforce their own minimum size rule. Tatum (1980) reported spotted seatrout fully recruited into the recreational fishery of Alabama at age III+. He attributed this to the minimum size limit enforced by the Speckled Trout Rodeo (11 inches, or 279 mm TL). Florida and Texas have a minimum size limit on the recreational catch of spotted seatrout (12 inches or 305 mm TL; Perret *et al*, 1980). Spotted seatrout were recruited into the recreational fishery in the Everglades National Park at age III (Higman, 1967). At age III spotted seatrout spawned one time (Section II). Therefore, the majority of the spotted seatrout recruited into the recreational fishery in Virginia and along the Gulf Coast have spawned at least once. The apparent voluntary minimum size followed by Virginia anglers is consistent with the general conservation strategy of assuring recruitment after attainment of sexual maturity.

The Virginia and North Carolina citation data highlighted the importance of quiet, grassy estuaries and inlet areas as habitats for *Cynoscion nebulosus*. Pamlico Sound, North Carolina, is a large, quiet fairly shallow estuary with extensive submerged aquatic vegetation beds. Similar habitats occur on the bayside Eastern Shore. The highest catches of citation fish annually and the only citations for summertime catches came from these areas. Oregon Inlet, North Carolina and the Chesapeake Bay Bridge Tunnel area were both very popular areas for spotted seatrout fishing in the respective state citation programs. Highest catches in both areas occurred during the fall, as spotted seatrout left the shallow waters of the estuaries and began their migration to warmer, deeper waters. The Outer Banks of North Carolina is an oceanside catch location with no corresponding successful fishing locations in Virginia. All the citation spotted seatrout caught on the Outer Banks were caught pier fishing, a technique not used in Virginia to catch *C. nebulosus*.

The heaviest spotted seatrout in Virginia and North Carolina were caught in the spring or early summer (June) and probably represent fish with well developed gonads. The IGFA world record spotted seatrout (16 pounds) was a Virginia citation fish and pictures show its abdomen greatly distended with developing or ripe ovaries.

Spotted seatrout anglers who consider themselves purists use only lures. Ten to twenty years ago, bucktails were the preferred lures, but in recent years stingray grubs and mirrolures have become more popular (J. Sparrow, pers. comm). This observation was verified in the fishing form returns; bucktails were not used during 1979-1980. Also citation data showed peeler crabs, stingray grubs and mirrolures to be the most popular baits or lures for catching *C. nebulosus*. Anglers said that lures catch better than live bait when fishing a school of spotted seatrout and live bait produces the best results when spotted seatrout are scattered in the area. Peeler crabs or live spot hooked through the eye were the best baits. Tabb (1960) found live bait was much more likely to catch spotted seatrout in Florida than lures or dead bait.

There were slight differences in preferences between fishermen in Virginia and North Carolina for lures or baits used for catching citation spotted seatrout. Peeler crabs were the most frequently used lure or bait in Virginia, but they were not listed for any citation spotted seatrout in North Carolina. Peeler crabs are not readily available as a bait in North Carolina, and are rarely used to catch any species of fish. Crabs were used almost exclusively during the spring in Virginia and 42.4% of all citation *C. nebulosus* were caught using this bait. Spring and summer are the primary shedding seasons for crabs, and soft shell crabs frequent grass beds. Fish would be more likely to bite a commonly recognized prey item, such as a crab, than an artificial lure during a season when that bait is abundant naturally. North Carolina fishermen relied on lures much more heavily for their citation catches than did Virginia fishermen. Stingray grubs were the most popular lures in both North Carolina and Virginia. Mirrolures and bucktails, popular lures in Virginia, were not used in North Carolina at all. Perhaps the reason bucktails were not used in North Carolina in 1977-1978 is the decreased popularity of this lure over the last few years. However, Hopkins-type jigs were popular in North Carolina and in Virginia, suggesting different fishing techniques between the two states.

Management Considerations

The commercial fishery for spotted seatrout has been documented since the 1800's (Collins, 1887). Merriner (1980) and Perret *et al* (1980) provided reviews of the history and regulations of the commercial fishery for *Cynoscion nebulosus* and Tabb (1960) discussed the commercial fishery in Indian River, Florida in detail. The commercial fishery will not be discussed but regulations affecting both the commercial and recreational fisheries will be considered.

Spotted seatrout fishing has become a politically important issue along the Gulf Coast. Groups of recreational anglers have organized and formed lobbies in their state governments to place restrictions on the commercial fishery for spotted seatrout. These anglers feel commercial fishing is destroying spotted seatrout habitats and killing young fish (Futch, 1970). However, Davis (1980) found that fishing mortality did not alter the age structure or abundance of spotted seatrout stocks in Florida. Most Gulf Coast states have foung the only way to alleviate this user conflict is by developing complex laws dealing with open and closed commercial grounds, proper fishing gear and minimum size limits (Perret *et al* 1980).

User group conflicts over spotted seatrout have not been severe along the southeastern Atlantic coast. Spotted seatrout are not as abundant in the Atlantic as they are in the Gulf. The commercial fishery is incidental, or a by-product of the shrimp fishery (Moore, 1980) in many states. A large portion of the gill net fishery for spotted seatrout in South Carolina is non-commercial (Moore, 1980). Fishermen set short sections of gillnet to catch enough fish for family and friends. In eastern Florida recreational anglers catch *C. nebulosus* by hook and line, but sell their catch (Tabb, 1960). This mixture of fishing strategies or purposes make management of the recreational and commercial fisheries difficult.

Management of the spotted seatrout fishery may need to be approached along a radically new line. *C. nebulosus* along the Gulf coast are essentially a non-migratory species. Miles (1950) was the first to document that *C. nebulosus* appear to stay in one estuary during their entire lifetime. Moody (1950), Guest and Gunter (1958), Moffett (1961), Fontenot and Rogillo (1970) and Adkins *et al* (1979) reported similar findings. Iverson and Tabb (1962) documented through tagging studies that spotted seatrout do not move more than an average of 30 miles from their natal estuary, and postulated that each estuary contained a separate subpopulation of spotted seatrout. Weinstein and Yerger (1976) demonstrated with enzyme electrophoretic studies that estuaries in Florida and along the Gulf coast do have separate and identifiable spotted seatrout populations. They also discovered there is little mixing or recruitment among populations between estuaries. Therefore, once the spotted seatrout in a given estuary have been severely depleted or eradicated through overfishing, catastrophe, or some other cause, the population will not be able to return rapidly to its former level even if fishing is stopped. Results such as these indicate the necessity of separate management programs for spotted seatrout in each estuary.

Matlock *et al* (1977) found that overfishing one estuary did not affect spotted seatrout populations in surrounding estuaries. This indicates the best management technique may be to construct a schedule allowing different estuaries to be opened to fishing during the course of the year. This procedure would allow a constant level of fishing, yet not deplete any one subpopulation of spotted seatrout. A program of this nature could result in increased productivity of the population and would perhaps satisfy both the recreational and commercial fishermen.

There are indications that spotted seatrout on the Atlantic coast are also non-migratory. Mahood (1975) found that *C. nebulosus* in

Georgia stayed in tidal creeks or near beaches; an ongoing tagging study supports these conclusions (Music, 1981). The Virginia component of a yet to be defined population of spotted seatrout seems to be more migratory than their southern counterparts. Water temperatures in Virginia estuaries drop substantially below the lower limit of the *C. nebulosus* temperature range; some SAV areas freeze over completely during January and February in the Bay, and temperatures in the deeper river and creek channels drop to $0^{o}C$. Under extreme conditions such as these, spotted seatrout must either leave the area or die of the cold. Trout "numbs" and mortality occur when temperatures drop below freezing along the Gulf coast (Gunter, 1941; Gunter and Hildebrand, 1951). The increased catch rates of spotted seatrout in the fall - both recreationally and commercially - and the great success in fishing for *C. nebulosus* at the mouth of the Bay during October and November indicate that this species does indeed migrate out of the Bay in response to cooler water temperatures. Their wintering grounds are not known, but trawl catches of spotted seatrout have been made off Hatteras, North Carolina in January and February.

There is some evidence that all spotted seatrout do not leave the Bay during the winter. Fishermen have mentioned seeing large spotted seatrout under the ice in Lynnhaven River and Hungars Creek in January and February. Massman (*In* Tabb, 1958) reported the occurrence of resident spotted seatrout in Lynnhaven River during the winter. The fish were very sluggish and did not bite baits or lures. I consider the presence of these fish overwintering in the Bay as an anomoly. They could either have been fish that missed the winter migration, or were truely resident.

The spotted seatrout fishery in Virginia is completely unregulated. Commercial fishermen do catch some spotted seatrout in haul seines, although the catch of this species is incidental to other sciaenids (weakfish, Atlantic croaker, spot). Some recreational fishermen in Virginia complain bitterly about commercial fishermen depleting an area of fish with their haul seines. Adkins *et al* (1979) found that repeated fishing of an estuary in Louisiana did temporarily deplete the spotted seatrout population, but that repopulation occurred shortly thereafter and the time lag depended on environmental fluctuations and schooling characteristics of the fish. It is unlikely that commercial haul seiners would severely deplete an area of spotted seatrout as long as the commercial fishermen did not return to the same area day after day for the entire fishing season. Indeed, most seining operations rotate sets among a number of sites during the season.

Spotted seatrout anglers in Virginia have expressed the concern that commercial haul seine fishermen catch and kill many young *Cynoscion nebulosus*. The haul seine fishery does catch spotted seatrout of all ages and sizes and 22.5% of the commercial catches sampled were made up of *C. nebulosus* under three years of age. The legal minimum stretch mesh size for haul seines longer than 200 yards in Virginia is three inches (Section 28.1-51, Code of Virginia). Although young fish can escape through mesh of this size, haul seines catch so many fish that they are pushed against the sides of the net, preventing smaller fish from escaping through the mesh. Although the total weight of *C. nebulosus* taken per catch (15 to 100 pounds) is low relative to other species, the high percentage of spotted seatrout younger than spawning age being taken commercially in Virginia is a true concern. However, due to the relative unimportance of the spotted seatrout fishery to the economy of Virginia, it is extremely unlikely that a spotted seatrout management plan would be developed. The benefits from a management program for *C. nebulosus* would not offset the costs required for the development and maintenance of such a plan. There are currently more pressing environmental and fisheries issues in Virginia (ie. striped bass and summer flounder management). However, the Atlantic States Marine Fisheries Council has identified spotted seatrout as a target species for future management considerations.

If regulation to protect spotted seatrout populations were economically and politically feasible, I would recommend a 12 inch TL minimum size limit for both recreational and commercial fishermen. A regulation such as this has precedence in the Gulf Coast states (Perret *et al*, 1980), and protects fish through attainment of sexual maturity. Realistically, however, any safeguards to the spotted seatrout in Virginia will only be practiced voluntarily. I recommend that anglers continue returning any spotted seatrout less than one pound or 12 inches to the water unharmed. I also suggest that commercial fishermen inspect their catches before hauling them into the boat; if a large amount (greater than 15%) of the catch is small fish (less than 12 inches for such fish as spotted seatrout, weakfish, bluefish, drum), they should attempt to release as many of these young fish unharmed as possible. These practices would be in the interest of conservation and continual growth of the spotted seatrout population to the benefit of all types of fishermen in Virginia.

SUMMARY AND CONCLUSIONS

This study has highlighted aspects of the biology of *Cynoscion nebulosus* in waters near the limits of its range.

Spotted seatrout in the Chesapeake Bay area are larger and older than more southern populations of this species. *C. nebulosus* grows rapidly during its first three years of life; females grow at a rate different to males, attain a larger size at a given age, and live several years longer than males.

Cynoscion nebulosus has two spawning peaks in the Bay, May and July, which probably correspond to rapid increases in water temperature. All females spawn by age IV, males by age I or II; these conclusions agree well with data from southern populations. Collections of juvenile and young-of-the-year spotted seatrout in the Bay during the summer and fall indicates *C. nebulosus* does spawn successfully in the Bay area.

A small, though active recreational fishery exists for spotted seatrout in the Bay area. During the spring and summer, the best areas to catch citation size spotted seatrout are shallow, grassy bays and creeks. In the fall, areas around the Bay mouth produce the most citation spotted seatrout. *Cynsocion nebulosus* does not appear to be fully recruited into the recreational fishery until age III or IV; full recruitment into the citation fishery does not occur until age VIII.

Several areas needing additional research have been identified, and some basic questions have been raised during the course of this study. An intensive sampling effort over the course of a year, to obtain a larger number of specimens for a more adequate age and growth study should be undertaken. Mortality estimates should be made for spotted seatrout in Virginia and other areas along the Atlantic Coast. The extent of the commercial fishery for spotted seatrout should be estimated, to determine if this species is being utilized to its maximum potential along the Atlantic Coast. Intensive larval, post-larval and early juvenile sampling efforts around beds of submerged aquatic vegetation are necessary to quantify the extent of spawning and larval survival in the Bay. Two more years of data, to verify beyond doubt the existence of two spawning peaks in *Cynoscion nebulosus*, is important. Fecundity studies of female fish captured in the Bay should be done to determine if *C. nebulosus* is more or less fecund at the northern limit of its range than southern populations.

The question of different populations of spotted seatrout along the Atlantic Coast must be addressed. An interstate tagging study, between Virginia, North Carolina, South Carolina and Georgia would be ideal to determine the degree of mixing among fish inhabiting these four states. Tagging studies would be particularly valuable in Virginia and North Carolina to determine the wintering groups of spotted seatrout after they move out of the Bay and sounds. Tagging could also reveal homing tendencies and dispersion rates. Electrophoretic studies, such as those done by Weinstein (1975) in Florida and along the Gulf Coast would also determine if the East Coast does have distinctly different spotted seatrout populations. Information such as the above is basic to the development of State/ Federal management plans. In particular, if spotted seatrout in Virginia and North Carolina are determined to be one stock, any management plan North Carolina develops for this species would be of concern to Virginians. *Cynoscion nebulosus* is a valuable resource and questions such as the ones posed above must be answered in order to adequately preserve and promote the continuation of abundant, healthy spotted seatrout stocks along the East Coast.

APPENDIX A

Figure 1. Application form for entry of citation size fish into the Virginia Saltwater Fishing Tournament (reduced 25%).

(250 Pads 3/80)

VIRGINIA SALT WATER FISHING TOURNAMENT

Please notify Tournament Director if Citation has not been received within 120 days after close of Tourney – Nov. 30,
or
Change of Address

S A M P L E

WEIGHING STATION ENTRY RECORD

Kind of Fish ______________ *Wt. ______ lbs. ______ oz. Length ______ " Girth ______ "

Where Caught ______________ Date ______ 19___

How caught (check) Chumming ___ ______; bait fishing ______; Casting ______ ; Trolling ______ ,

Rod mfr. ______ Reel mfr. ______ Line mfr. ______ (test) ______ lbs.

Lure or bait? ______________

Comments:

ANGLER'S CERTIFICATION

I hereby certify that I hooked and brought to gaff, or landed, the above-described fish unaided; that the catch was made in compliance with the Rules and Regulations of the Tournament, which I have read; that I agree to the application of these Rules and Regulations to this catch and that they shall be binding on me.

______________ (ANGLER - PLEASE PRINT) Signed: ______________ (ANGLER'S SIGNATURE)

______________ (STREET & NUMBER) (ANGLER'S HOME ADDRESS -- PLEASE PRINT) Telephone: ______ AREA CODE) ______ (NUMBER)

______________ (CITY) (STATE) (ZIP #)

Angler's Home-Town Newspaper ______________

WITNESS' CERTIFICATION

I certify that I witnessed the above catch and that the fish was caught in compliance with the Rules and Regulations of the Tournament and at the time and place above stated.

Signed ______________ (WITNESS' SIGNATURE) Post office ______________ (WITNESS' POST OFFICE)

Boat: Name ______________ Charter ______ Private ______

Captain (guide) ______________ Post office ______________

WEIGHMASTER'S STATEMENT

Was this fish mutilated, shot or speared? Yes ______ No ______.

______________ (NAME OF WEIGHING STATION) ______________ (POST OFFICE)

Signed ______________ (WEIGHMASTER)

* IF WEIGHT EXCEEDS EXISTING STATE RECORD, READ STATE RECORD RULES IN CURRENT TOURNAMENT BROCHURE

For additional supplies of this form write –
Virginia Salt Water Fishing Tournament
Claude Rogers, Director, Virginia Beach, Va. 23451

WHITE (TO TOURNAMENT DIRECTOR'S OFFICE WITHIN 7 DAYS) YELLOW (ANGLER'S RECEIPT) PINK (WEIGHMASTER'S COPY)

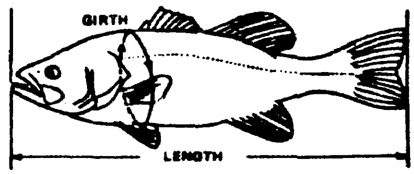
Figure 2. Application form for entry of a citation size fish into the North Carolina Saltwater Fishing Tournament (reduced 25%).

OFFICIAL NORTH CAROLINA SALTWATER FISHING TOURNAMENT

CITATION APPLICATION FORM

Open to all---------No entry fee

I hereby swear that I have complied with Official North Carolina Fishing Tournament rules and that the following information is correct.



____________________________ Signed________________________________

Angler's Name (Please Print) Angler's Signature

____

Street and Number (Please Print) City State Zip

Kind of Fish____________ Weight_____lbs.____ozs. Length____in. Girth____in.

Check here if released: (blue or white marlin, sailfish, tarpon, or channel bass only)

____

Witness to release____

(Print name and address)

Where caught______________________ Date caught________________________

Name of charter boat, marina or pier_________________________________
(if applicable)

Name of home-town newspaper____

Name of weigh station____

Signature of weighmaster____

Signature of witness to weighing____________________________________

Address of witness to weighing______________________________________

Street and Number City State Zip

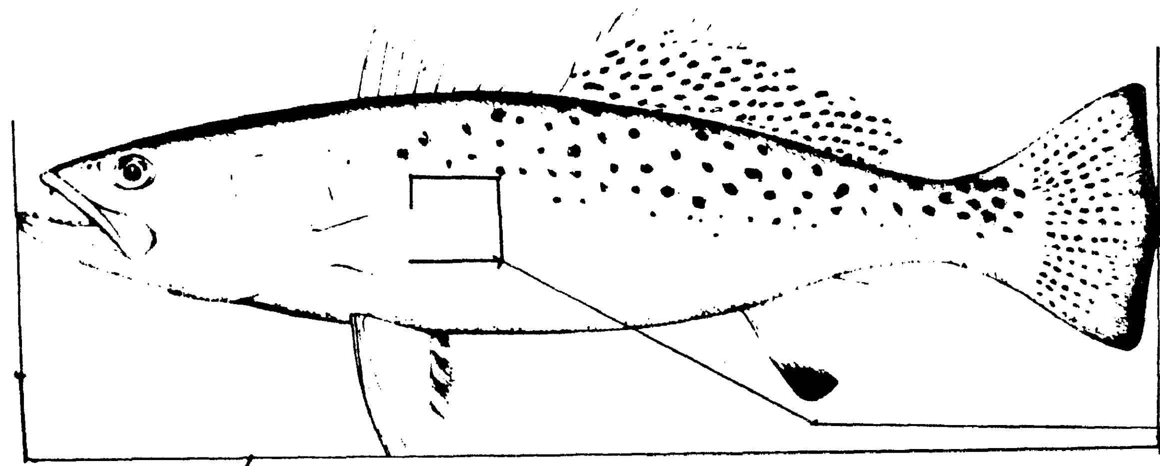
The Official Weigh Station will mail the original application to:

Joel Arrington, Director
North Carolina Saltwater Fishing Tournament
430 North Salisbury Street
Raleigh, North Carolina 27611

EXPECT CITATION NO SOONER THAN SIX MONTHS FROM DATE OF APPLICATION

Figure 3. Speckled trout catch information form distributed to fishermen (reduced 25%).

SPECKLED TROUT CATCH INFORMATION



Fish length ______________________ Fish weight ______________________

Location capture ______________________ Date ______________________

Gear ____

Fishing specifically for speckled trout?

Type lure or bait ______________________ yes no

Club Name ______________________ Angler ______________________

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