NOAA Technical Memorandum

NMFS-SEFC-14

A SUMMARIZATION AND DISCUSSION OF AGE AND GROWTH OF SPOT, *LEIOSTOMUS XANTHURUS* LACÉPÈDE, SAND SEATROUT, *CYNOSCION ARENARIUS* GINSBURG, AND SILVER SEATROUT, *CYNOSCION NOTHUS* (HOLBROOK), BASED ON A LITERATURE REVIEW

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March 1980

U. S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Center
Panama City Laboratory
3500 Delwood Beach Road
Panama City, Florida 32407

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CONTENTS

ABSTRACT

The literature dealing with age and growth of spot (*Leiostomus xanthurus*), sand seatrout (*Cynoscion arenarius*) and silver seatrout (*C. nothus*) was reviewed. Length-frequency analysis was the most frequently used technique for ageing the three species; however, size overlap renders the technique progressively unsuitable as the fish grow older. Otolith and scale analysis, both of which have been verified as usable for ageing spot, yielded reported ages of up to 3 and 4.5 years respectively.

A mathematical summary of age and growth information was developed using least-squares regression analysis. A composition growth rate ($Y = \frac{X}{A+BX}$ where Y = mean total length in millimeters, X = mean age in months, $A = 6.89 \times 10^{-2}$, and $B = 2.20 \times 10^{-3}$) was obtained.

Length-frequency analysis was the only successful method reported for ageing the two seatrouts. Up to three age classes have been identified for sand seatrout. The life span for silver seatrout has been estimated as being little more than one year.

Analysis of growth of the seatrouts was not possible due to insufficient data.

The techniques used and the problems involved are discussed and recommendations for future work are made.

INTRODUCTION

As fisheries science in the United States moves into an era of new emphasis on fisheries resource management, requirements for particular types of information are becoming more pronounced. Among the informational needs are evaluations of the age and growth of various species. In this report, we summarize the available literature reporting age and growth results for spot (*Leiostomus xanthurus*), sand seatrout (*Cynoscion arenarius*), and silver seatrout (*Cynoscion nothus*); these three sciaenids have been identified among the predominate species on the fishing grounds utilized by the northcentral Gulf of Mexico groundfish fishery (draft Groundfish Fishery Management Plan; Gulf of Mexico, April 1979).

Spot are distributed along the western Atlantic and Gulf of Mexico from Massachusetts to Mexico (Hoese and Moore, 1977). Maturation probably occurs in the second or early part of the third year of life (Dawson, 1958). Spawning is protracted, occurring from October or November through March, with the peak in November to February, depending on location (Hildebrand and Cable, 1931; Music, 1974; Parker, 1971). Spawning occurs offshore and the young fish enter nearby sounds and estuaries, where they remain until their second year of life (Pearson, 1929; Parker, 1971).

Sand seatrout have been reported only in the Gulf of Mexico where they are common to bays and shallows (Hoese and Moore, 1977). Spawning apparently occurs from early spring to late summer (Chittenden and McEachran, 1976). Very little information is known of the sand seatrout's life history.

The silver seatrout is found from New York to Florida and throughout the Gulf of Mexico. Although silver seatrout are sometimes confused with sand seatrout, the species can be differentiated visually by an experienced observer (Gunter, 1945). In addition, the silver seatrout is usually found farther offshore than the sand seatrout. During the winter, however, silver seatrout move closer to shore and may be found in bays (Hoese and Moore, 1977). Spawning occurs from late spring to early fall (Chittenden and McEachran, 1976). Further details about the life history of the silver seatrout are unavailable.

Twenty-two studies were identified as dealing with the age and/or growth of spot, sand seatrout, silver seatrout, or some combination of the three species. To aid the reader in evaluating these works, they are categorized in Table 1. Each citation is identified with its collection time and place, sampling gear, and age determination method. The citations are presented chronologically within four research categories: general faunal inventories, faunal inventories with life history emphasis, life history studies, and age and growth studies.

FINDINGS

Age of Spot

Through length-frequency analysis, the most frequently used method for age determination of spot, only two age classes have been identified. Pearson

(1929) and Gunter (1945) felt that separation of the first two age groups was discernible despite the extended spawning season. Hildebrand and Cable (1931), however, found overlapping sizes between age classes 0 and 1 as early as 6 or 7 months. Other authors indicated that differential growth and the extended spawning season make separation of the age classes of spot by length-frequency analysis difficult (Dawson, 1958; Pacheco, 1962; Nelson, 1967; Music, 1974).

Scales and otoliths, when analyzed, have indicated that spot reach ages greater than 2. Scale analysis (Welsh and Breder, 1924; Pacheco, 1962) identified spot up to 4.5 years of age. Evidence verifying that scales can be used for making valid age determination for spot was presented by Sundararaj (1960) and Pacheco (1962). Sundararaj (1960) also validated otoliths for age determination of spot and identified fish up to 3 years of age.

Growth of Spot

In order to determine the usefulness of the growth results reported for spot, the results must be organized in a manner that facilitates evaluation. The originally reported values were presented numerically in text and tables, and visually in figures. Standard, fork, and total lengths were used to represent the lengths of specimens. The time periods within which data were grouped varied. A method that would produce a uniform expression of these diverse reports was required. The organizational process used to transform original growth results to a common form is defined below:

1. Extract values for the length of an age class by month, observing any of the following rules that pertain to a given situation.

   a. Use textual or tabular values when available.

   b. Reduce ranges to a single value by determining the range midpoint.

   c. Estimate values illustrated in figures when textual or tabular values are unavailable.

   d. Assign year-end values to the month representing the appropriate multiple of twelve; e.g., a report of spot reaching total length (TL) of 200 mm at the end of their second year of growth is expressed as month = 24, TL = 200 mm.

   e. Use separate values for each reported time period, sampling gear, or ageing technique, rather than consolidated or averaged results.

   f. Include all reported values, ignoring all sources of bias.

   g. Determine the mid-date of non-monthly time intervals and assign the reported length to the month in which the mid-date falls.

2. Tabulate and illustrate these values in terms of total length in millimeters.

    a. Convert standard length (SL) to total length by:

    $TL = 1.233\ SL + 2$ (Dawson, 1958)

    b. Convert fork length (FL) to total length by:

    $TL = FL$ if $FL < 57.7$ mm

    $TL = \frac{(FL - 6.17)}{.893}$ if $FL \geq 57.7$ mm (Dawson, 1958)

The results of the above process are presented in Table 2. Estimates of the central tendency of each age group's length by month are listed, as well as the area studied and ageing technique employed by the authors. January was chosen to represent the first month of life of the fish since it corresponds with the peak spawning period, the approximate mid-point of the spawning season, and the beginning of the calendar year. Age-in-months values were based on this January starting point.

A mathematical summary of the age and growth information (Table 2 and Figure 1) was developed using least-squares regression analysis. Monthly, quarterly, and semi-annual mean ages and mean total lengths were computed. Using these respective values for independent and dependent variables, regression and correlation coefficients were obtained for a linear function, an exponential function, a "power" function, and three hyperbolic functions (Table 3). Correlation coefficients of data grouped into semi-annual intervals were greater than or equal to correlation coefficients from all other groupings, so composite growth analysis was based on the semi-annual grouping.

Of the six regression equations, the highest correlation coefficient ($r = 0.99$) was associated with a hyperbolic function of the form:

$$Y = \frac{X}{A+BX}$$

where Y = mean total length in millimeters

X = age in months

$A = 6.89 \times 10^{-2}$

$B = 2.20 \times 10^{-3}$

This "compositive growth rate" curve is displayed in Figure 1.

<u>Age of Sand and Silver Seatrout</u>

Length-frequency analysis has resulted in reports of from one to three age classes for sand seatrout, and no more than two for silver seatrout.

Chittenden and McEachran (1976) stated that one to two years is probably the lifespan for sand seatrout and a little over one for silver. (Swingle (1971) reported three classes of sand seatrout, but no length information was given.

No reports of ageing either sand or silver seatrout with methods other than length-frequency analysis were found, with the exception of one unsuccessfu attmept to use scales. Benefield (1971) attempted to age sand seatrout with scales but was not able to find well-defined annuli.

Growth of Sand and Silver Seatrout

Growth results for sand and silver seatrout are insufficient for analysis. Those data reported in the literature are presented in Table 4. While two age groups have been identified for each species through the evaluation of these length-frequency distributions, further interpretation is pure conjecture. Most of the citations lack an identified peak spawning month, or month in which the first year of life is completed. This shortcoming makes size-at-age discussion impossible. In addition, no study techniques other than length-frequency distribution analysis have produced any results. As stated earlier, Benefield (1971) attempted to age sand seatrout by scale analysis, but reported that "clearly defined annuli were difficult to distinguish," and was therefore unable to extract any growth information through scale reading. No citations for either species were found.

DISCUSSION

There are several shortcomings in the age and growth literautre for spot, sand seatrout, and silver seatrout. Those pertaining to the seatrouts are obvious; research results were inadequate to show either the maximum age of the two species or their growth rates. The situation for spot is more complex, but can be broken down into two main problem areas: age determination techniques and sampling techniques.

Age Determination Techniques

As stated earlier, the age of spot was most frequently determined through length-frequency distribution analysis. This method can be useful if a species shows rapid and uniform growth and has a short spawning season. Spot, however, are reported to exhibit differential growth rates (Parker, 1971) and a protracted spawning season. These factors can cause length-frequency modes to overlap, causing confusion as to whether intermediate modal groups represent slow-growing old fish or fast-growing young ones. Therefore, length-frequency distribution analysis is not the age determination technique of choice for spot. Since the two seatrouts also have protracted spawning seasons, length-frequency distribution analysis is an inadequate technique for ageing them.

Hardpart analysis is the age determination technique best suited for spot, since scales and otoliths have been shown to be valid for use in ageing spot.

The validation procedures have not been performed for the two seatrouts, so suitable age determination technique for sand and silver seatrout has yet to be established.

Sampling Techniques

The fundamental requirement for developing accurate estimates of the average growth rate of a fish species, based on field sampling, is that each of the fish population's age classes must be sampled randomly (Ricker, 1975). Gear selectivity, fish migrations, and fish distributions are factors that must be considered if random sampling is to take place. Unfortunately none of the sampling plans reported in the literature dealt with these problems. Uncompensated gear selectivity is present in nearly all the studies. No provisions were made for sampling fish during their migratory movements, unless they happened to be passing through an established sampling site. Finally, spot have not been sampled throughout their entire distributional range. Nearly all of the citations mention a migration of large spot from estuarine waters as winter approached, but none reported capturing them at their wintering grounds. Since these large fish do not appear in the original collections, they have not been included in any age-growth analyses. Their survival after leaving the estuary, however, is confirmed by reports of their capture during exploratory offshore fishing operations (Townsend, 1956; Dawson, 1958). We are forced to conclude, therefore, that reported growth data for spot cannot necessarily be assumed to represent accurate average growth rates. In addition, since the offshore portion of spot populations has not been aged, the maximum life span of the species is unconfirmed.

Recommendations for Future Work

More work must be done before reliable age and growth information is available for the three species. It is essential that samples be taken that represent all the age classes in the population. This will require a combination of estuarine and offshore sampling, with strict attention paid to minimizing the effects of gear selectivity and fish migrations. In addition, a reliable method of age determination must be developed for sand and silver seatrout. Hardpart analysis has the greatest potential in this area. Monthly samples from a group of fish of known age and life history would facilitate the identification of annular marks upon hardparts, but such samples may be impossible to obtain. A monthly time-series from some population is, however, essential to the verification procedures to which hardparts should be subjected. Only after these steps have been taken will definitive age and growth information for spot, sand seatrout, and silver seatrout be available.

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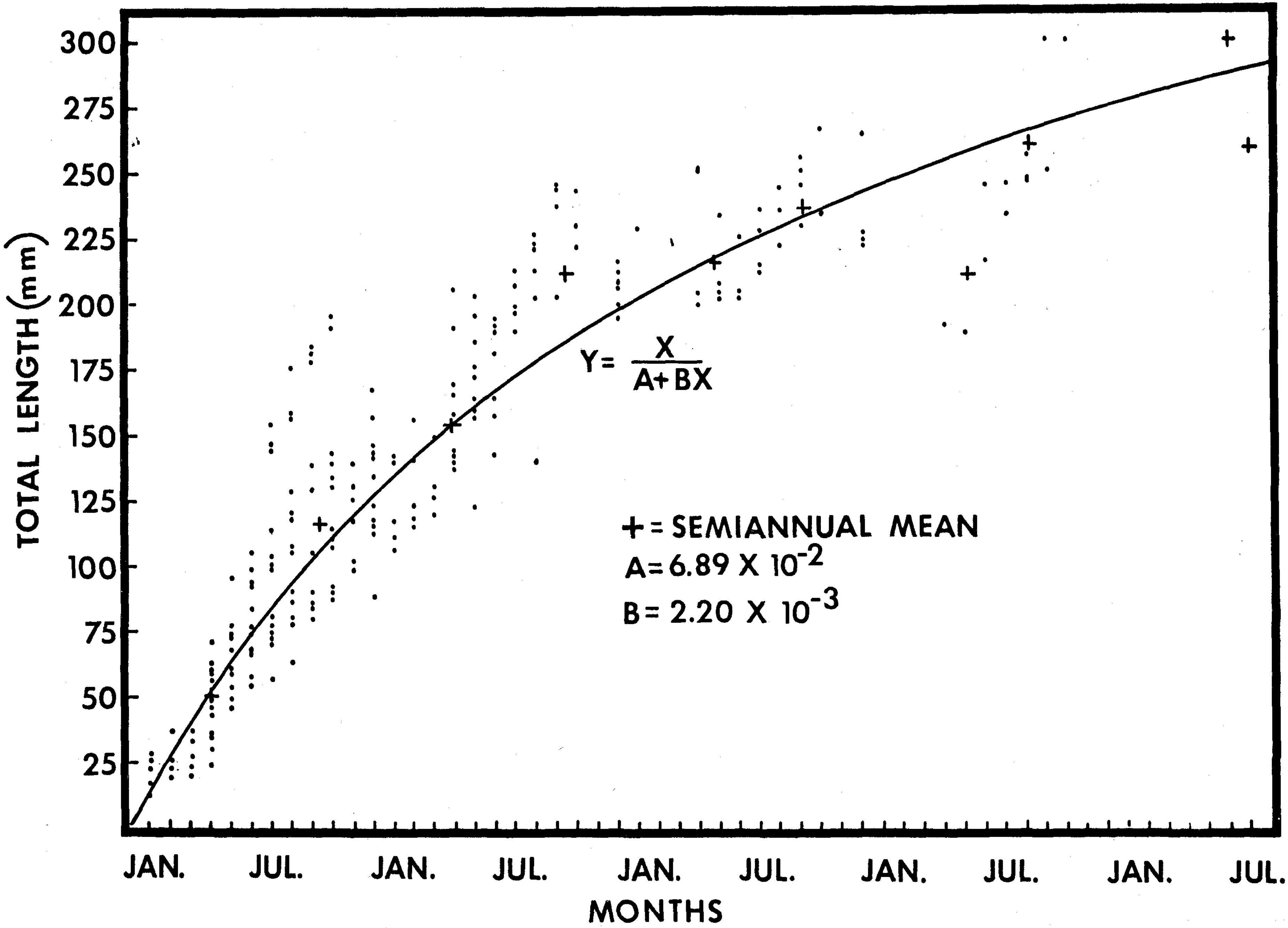

TOTAL LENGTH (mm)
300
275
250
225
200
175
150
125
100
75
50
25
JAN.
JUL.
MONTHS
Y= X / A+BX
+ = SEMIANNUAL MEAN
A=6.89 X 10-2
B= 2.20 X 10-3

Table 1. Categorization of age and growth studies of spot, sand seatrout, and silver seatrout.

STUDY TYPE	CITATION AND PUBLICATION DATE	YEAR(S) SAMPLED	AREA SAMPLED	PRINCIPAL SAMPLING GEAR	AGE DETERMINATION TECHNIQUE	SPECIES STUDIED		
						SPOT	SAND SEATROUT	SILVER SEATROUT
General Faunal Inventory	Gunter, 1945	1941-42	Aransas Bay Area, Texas	1.5" stretched mesh (SM)	Length frequency	X	X	X
	Reid, 1954	1951	Cedar Key, Florida	0.75" SM trawl	Length frequency	X		
	Kilby, 1955	1948	Cedar Key and Bayport, Florida	Seine	Length frequency	X		
	Hellier, 1962	1958-59	Upper Laguna Madre, Texas	Drop-net	Length frequency	X		
	Swingle, 1971	1968-69	Mobile Bay Area Alabama	Trawl and seine	Length frequency	X	X	X
	Shealy, Miglarese, and Joseph, 1974	1973-74	South Carolina Estuaries	1" S.M. trawl	Length frequency	X		
	Chittenden and McEachran, 1976	1973-74	Texas Shrimping Grounds	Trawl	Length frequency		X	X
Inventory With Life History Emphasis	Hildebrand and Scroeder, 1928	Circa 1920	Chesapeake Bay	Trawls, pound nets, haul seines	Length frequency	X		
	Springer and Woodburn, 1960	1957-58	Tampa Bay Area, Florida	Trawls, seines, pushnets	Length frequency	X		
	Herke, 1971	1967-68	Louisiana		Length frequency	X		
	Music, 1974	1970-73	Georgia Estuaries	Trawls, seines, gillnets	Length frequency	X		
Life History Investigation	Welsh and Breder, 1924	1920	Atlantic City, NJ and Fernandino, FL	Pound net and other (unspecified)	Length frequency and scale analysis	X		
	Pearson, 1929	1926-27	Aransas Pass, Texas	Multiple nets	Length frequency	X		

Table 1. Continued

STUDY TYPE	CITATION AND PUBLICATION DATE	YEAR(S) SAMPLED	AREA SAMPLED	PRINCIPAL SAMPLING GEAR	AGE DETERMINATION TECHNIQUE	SPECIES STUDIED SPOT	SAND SEATROUT	SILVER SEATROUT
	Hildebrand and Cable, 1931	1926-30	Beaufort, North Carolina	Trawl (for large specimens)	Length frequency	X		
	Townsend, 1956	1955-58	Alligator Harbor, Florida	Seines and trawls, 0.25''-2.5'' mesh	Length frequency	X		
	Dawson, 1958	1957-58	South Carolina	2'' SM trawl	Length frequency	X		
	Nelson, 1967	1963-64	Mobile Bay, Alabama	1.5'' SM trawl	Length frequency	X		
	Benefield, 1970	1968-70	Galveston Bay, Texas	Hook and line	Scale analysis		X	
	Parker, 1971	1959-61 1963-65	Lake Borgne and Galveston Bay, Texas	1.5'' SM trawl 1.125'' SM bag	Length frequency	X		
Age and Growth Investigation	Sundararaj, 1960	1953-55 1958-59	Lake Pontchartrain, Louisiana	Trawls, seines, rotenone	Scale analysis Otolith analysis Length frequency	X		
	Pacheco, 1962	1955-58	Chesapeake Bay	Pound nets	Scale analysis	X		

Table 2. Total length of spot by year of life and month developed by standardizing reported values.

Publication type	Citation	Location	Aging technique	Collection years	Year 1												Year 2											Year 3									Year 4							Year 5	
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Dec	Jan	Apr	May	Jun	Jul	Aug	Sep	Oct	Dec	Apr	May	Jun	Jul	Aug	Sep	Oct	Jun	Jul
General inventory	Gunter, 1945	Aransas Bay, TX	Length frequency (LF)	1941-42				58		83		118								158		158		213																					
	Reid, 1954	Cedar Key, FL	LF	1951	25	27																																							
	Kilby, 1955	Cedar Key to Bayport, FL	LF	1948						98																																			
	Hellier, 1962	Upper Laguna Madre, TX	LF	1958-59			27											156																											
	Swingle, 1971	Mobile Bay, AL	LF	1968-69	25												142											229																	
	Shealty, Miglarese, & Joseph, 1974	South Carolina	LF	1973-74				35			70			90						140																									
Inventory with life history emphasis	Hildebrand & Schroeder, 1928	Chesapeake Bay	LF	Circa 1920				24	49	54	57					127																													
	Springer & Woodburn, 1960	Tampa Bay, FL	LF	1957-60	27	36	36	47	58	76	98	80	80	90	102	113																													
	Music, 1974	Georgia estuaries	LF	1970-73 1/		23	23	43	63	98	113	128	138	143		143 3/																													
				1970-73 2/	17	25	37	56	73	73																																			
Life history studies	Welsh & Breder, 1924	Atlantic City, NJ	LF	1920								80												140																					
			Scale analysis	1920												90											195									265								300	
		Fernandino, FL	LF	--													140																												
	Pearson, 1929	Aransas Pass, TX	LF	1926				60						139						206																									
				1927				60	77												195						206																		
	Hildebrand & Cable, 1931	Beaufort, NC	LF	1926-30	13	19	20	30	46	58	81	105	116	130	139	116 139 3/	117	116	130	137	123	143																							
	Townsend, 1956	Alligator Harbor, FL	LF	1955-56			33	46	72	93	103	107	129	133	131			140	149	155																									
	Dawson, 1958	South Carolina	LF	1957-58				70				119				141 153 3/											212																		
	Nelson, 1967	Mobile Bay, AL	LF	1963-64					95	105	100	105		110	125	115 138 3/											200																		
	Parker, 1971	Lake Borgne, TX	LF	1959-61		18	27	58	68	74	83	90	105	114	126																														
		Galveston Bay, TX	LF	1963				34	60	67	72	78	84	92	99	88	111	118	126	142	157																								
				1964			23	34	54	66	77	86	85	88	102	112	106	123	120	144	159	164																							
				1965				47	59	67	74	63	90	108	117	117																													
Age and growth studies	Sundararaj, 1960	Lake Ponchartrain, LA	Scale analysis	1953-54												146											198									223									
				1955												156											207									227									
				1958-59												123											216																		
			Otolith analysis	1955												167											212									225									
				1958-59												134											212																		
			LF	1953-55	22	27	37	62	67	92						142					172		197			222																			
	Pacheco, 1962	Chesapeake Bay	Scale analysis	1955							145	158	181	196							185	194	199	223	244	230				208	205	213		251	234										
				1956							144	175	184	191						191	203	192	213	222	246				251	234	226	237	236	256					245	246	247	251			259
				1957																169	164	181	190	203	203				204	205	203	215	223	230				189			248	301			
				1958							154	157	178			184 3/				165	176	190	207	226	238	243	239 3/		200	202	222	228	245	245	267		192	211	217	234	256		301		
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	24	25	28	29	30	31	32	33	34	36	40	41	42	43	44	45	46	54	55

Age in months, based on convention of January is being the first month of life 4/

1/ Data from trawl-caught specimens
2/ Data from seine-caught specimens
3/ Size at end of year of life as stated by indicated source. This value may conflict with monthly data from same source
4/ This does not imply unanimous selection of January as the first month of life by all sources.

Table 3. Results of least-squares regressions of mean reported total length of spot versus age in months.

General form	Curve type	Correlation coefficient (r)	A	B
$Y + A+BX$	linear	0.92	8.42×10^{1}	3.82×10^{0}
$Y = Ae^{BX}$	exponential	0.84	8.56×10^{1}	2.47×10^{-2}
$Y = AX^{B}$	power	0.97	2.67×10^{1}	6.05×10^{-1}
$Y = A+{}^{B}/X$	hyperbolic	0.90	2.59×10^{2}	-9.41×10^{2}
$Y = \frac{1}{A+BX}$	hyperbolic	0.72	1.25×10^{-2}	-1.99×10^{-4}
$Y = \frac{X}{A+BX}$	hyperbolic	0.99	6.89×10^{-2}	2.20×10^{-3}

Table 4. Reported spawning month(s) and reported total lengths (mm) by calendar month of sand and silver seatrout.

Citation	Spawning Month(s)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
					Sand seatrout (*Cynoscion arenarius*)								
Gunter, 1945	April to September						70-150			120-180			
Chittenden and McEachran, 1976	April to October				23-38 103-203		88	93	123 128	138			
					Silver seatrout (*Cynoscion nothus*)								
Gunter, 1945	May			88-93		93-138	113-143 143				163-183	78	
Swingle, 1971	Not stated									49			
Chittenden and McEachran, 1976	September									150-185			