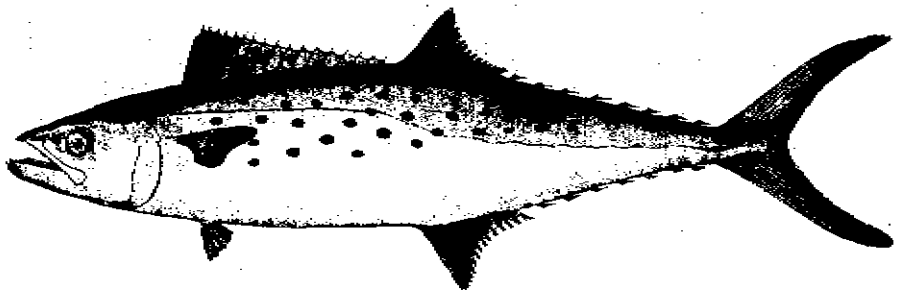

BIOLOGICAL & FISHERIES DATA
ON
SPANISH MACKEREL, *Scomberomorus maculatus* (Mitchill)

NOVEMBER 1977

Biological and Fisheries Data

on

Spanish mackerel, *Scomberomorus maculatus* (Mitchill)

by

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1. IDENTITY

1.1 Nomenclature

1.1.1 Valid Name

Scomberomorus maculatus (Mitchill) 1815.

First described under the name Scomber maculatus by: Mitchill, S. L. 1815. The fishes of New York, described and arranged: Trans. Literary and Philosophical Society of N. Y., I: 355-492.

1.1.2 Synonomy (included are first records, under the following names)

Scomber maculatus - Mitchill 1815 (see reference above).

Cybium maculatum - Cuvier 1829. Règne Anim., ed. 2: p. 121.
- Agassiz 1829, Spix. Pisc. Brazil: p. 103.

Scomberomorus maculatus - Goode and Bean 1882. Proc. U. S. Nat. Mus.: p. 237.

1.2 Taxonomy

1.2.1 Affinities

Phylum - Chordata
Class - Teleostomi
Order - Scombriformes
Family - Scombridae

The family Scombridae, defined by Regan (1909) was subsequently divided by Kishinouye (1923) and Berg (1947). Most ichthyologists today agree that the mackerel-like fishes of the world belong to a single family Scombridae (Fraser-Brunner, 1950; Rivas, 1951; Collette and Gibbs, 1963; Greenwood et al., 1966; Bailey et al., 1970).

Genus: Scomberomorus Lacépède 1802. Hist. Nat. Poiss. III

Genotype: Scomberomorus plumieri Lacépède 1802 (=Scomber regalis Bloch, 1793).

The taxonomic status of this genus is not clear. Munro (1943) divided Scomberomorus into nine subgenera and 17 species, then subtracted one species (Munro, 1949). Fraser-Brunner (1950) recognized only two subgenera,

Scomberomorus and Cybium, and nine species. However, a bibliography of Scombridae by Richards and Klawe (1972) included 14 species of Scomberomorus. A recent report by an FAO committee reviewing the biology and status of small tunas (FAO, 1976) concluded that the taxonomy of Scomberomorus is not well defined, and noted that Dr. Bruce B. Collette, of the NMFS Systematics Laboratory, is presently studying the problem.

The following synonomy and description of the genus is from Jordan and Evermann (1896-1900):

"Scomberomorus, Lacépède, Hist. Nat. Poiss., III, p. 292, 1802 (plumerii).

Cybium, Cuvier, Règne Anim., Ed. 2, II, p. 120, 1829 (commersonii).

Apodontis, Bennett, Proc. Comm. Zool. Soc. I, p. 169, 1831 (immunis).

Lepidocybium, Gill, Proc. Ac. Nat. Sci. Phila., p. 125, 1862 (flavobrunneum).

Chiromitra, Lockington, Proc. Ac. Nat. Sci. Phila., p. 133, 1879 (concolor).

Scomberodon, Van Beneden (fossil).

Body elongate, wholly covered with rudimentary scales which do not form a distinct corselet. Head pointed, comparatively short and small. Mouth wide, the strong teeth in the jaws more or less compressed or knife-shaped; villiform or sandlike teeth on the vomer and palatines; maxillary not concealed by preorbital. Gill rakers few. Caudal peduncle with a single keel. Spinous dorsal low, of 14 to 18 feeble spines. Soft dorsal and anal short, similar, somewhat elevated and falcate, each followed by 7 to 10 finlets; ventrals small; pectorals moderate, near the level of the eye. Air bladder present. Vertebrae normally formed, 45 in number."

Mago-Leccia (1958) has shown that there are 14 to 19 spines in the first dorsal fin and from 40 to 53 vertebrae found in the various species of this genus.

Fraser-Brunner (1950) reported that the air bladder may be either present (in subgenus Cybium) or absent (in subgenus Scomberomorus).

Species: Scomberomorus maculatus, Mitchill. The type specimen of S. maculatus was described by Mitchill (1815). The type locality is New York.

The following key to three species of Scomberomorus is from Rivas (1951); the key pertains to the species present in the western north Atlantic Ocean.

1 Gill-rakers 7 to 9 on lower limb of first arch. Dorsal spines 15 or 16. Lateral line abruptly curving downward below second dorsal fin. First dorsal fin not black anteriorly (except in young). Scomberomorus cavalla.

1[1] Gill-rakers 10 to 13 on lower limb of first arch. Dorsal spines 17 to 18. Lateral line not abruptly curving downward below second dorsal fin. First dorsal fin black anteriorly.....2

2 Gill-rakers 12 or 13 on lower limb of first arch. Maxillary not quite reaching to vertical from posterior margin of orbit. Pectoral fin scaled. Sides of body with spots and one or two longitudinal stripes. Scomberomorus regalis.

2[1] Gill-rakers 10 or 11 on lower limb of first arch. Maxillary reaching to vertical from posterior margin of orbit. Pectoral fin not scaled. Sides of body with spots but without longitudinal stripes. Scomberomorus maculatus.

The following two tables from Mago-Leccia (1958) present data on several differential characters of the three species of Scomberomorus from the western north Atlantic Ocean (Tables 1 and 2).

1.2.2 and 1.2.3 Taxonomic Status and Subspecies

The status of Spanish mackerel of the eastern Atlantic Ocean is in question, for it has been reported under the names Cybium tritor and Scomberomorus maculatus by various authors. Mather and Day (1954) examined specimens from both the western and eastern Atlantic and concluded that there are some slight, probably racial, differences in specimens from the two areas, but that the differences are not great enough for the two forms to be considered separate species. If the two forms are subspecific or racial in relation to each other the name S. maculatus has priority.

TABLE 1. Meristic characteristics of the Florida species within the genus Scomberomorus (from Mago-Leccia, 1958).

Character	cavalla	maculatus	regalis
Total number of vertebrae	42-43	52-53	47-49
First closed haemal arch at vertebra number	10	13-15	12
First haemal spine at vertebra number	18-19	22-24	20-21
Dorsal spines	15-16	16-18	16-18
Dorsal rays	16-17	15-18	16
Dorsal finlets	8-9	8-9	8-9
Anal spines	2	2	2
Anal rays	14-17	15-17	14-15
Anal finlets	8-10	8-9	8
Gill rakers upper limb	1	2-3	3-4
Gill rakers angle	1	1	1
Gill rakers lower limb	6-7	10-12	11-13
Gill rakers total	8-9	13-15	15-18

TABLE 2. A synopsis of differential characteristics for Scomberomorus cavalla, S. maculatus, and S. cavalla. * indicates that regalis is similar to maculatus (from Mago-Leccia, 1958).

Character	cavalla	maculatus	regalis
1. Temporal ridge	Straight or slightly convex. Not prolonged posteriorly.	Concave. Prolonged posteriorly.	*
2. Auxilliary ridge	Low	High	*
3. Vomer	Thick and somewhat pointed	Thin and spatulate	*
4. Frontals	The slit (pineal window) at the level of alisphenoids.	The slit (pineal window) inconspicuous and carried a little forward from the level of alisphenoids.	*
5. Alisphenoids	Slightly separated at the median line. Brain chamber opening relatively small.	Widely separated at the median line. Brain chamber opening relatively large.	Widely separated at the median line. Brain chamber opening very large.
6. Parasphenoid	Broad. The median keel not forming a cutting-edge.	Narrow. The median keel forming a cutting-edge.	*
7. Basisphenoid	Median anterior process broad, not needle-shaped.	Median anterior process needle-shaped.	*
8. Hyomandibular	Lamella broad.	Lamella narrow.	*
9. Scapula	Foramen small.	Foramen small.	Foramen very large.
10. Pelvic girdle	Anterior external portion broad.	Anterior external portion narrow.	Anterior external portion narrow.
11. Vertebral column	First closed haemal arch occurring at vertebra number 10. First haemal spine at 18th or 19th vertebra. Total number of vertebra 42 or 43.	First closed haemal arch occurring at vertebra number 13 to 15. First haemal spine at 22nd to 24th vertebra. Total number of vertebra 52 or 53.	First closed haemal arch occurring at vertebra number 12. Total number of vertebrae 47 to 49.

Likewise the Spanish mackerel found off the west coast of Central America and Mexico has been variously referred to as Scomberomorus sierra and S. maculatus (Meek and Hildebrand, 1923).

1.2.4 Common Names

Spanish mackerel, Sierra, pintada, serrucho, Spaniard, spotted cybium, bay mackerel, spotted mackerel.

1.3 Morphology

1.3.1 External Morphology

The following meristic and morphometric characters are compiled from several sources: Jordan and Evermann, 1896-1900; Dresslar and Fesler, 1889; Hildebrand and Schroeder, 1928; Nichols, 1929-1930; Beebe and Tee-Van, 1933; Rivas, 1951; Bigelow and Schroeder, 1953; Mather and Day, 1954; Mago-Leccia, 1958; Bastos, 1966b; Menezes, 1972; Miller and Jorgenson, 1973. Dorsal fin XVI to XVIII - 14 to 19 + VIII or IX; anal fin II, 14 to 17 + VII to IX (Miller and Jorgenson, 1973 report four anal spines); gill rakers, total 13 to 15, 2 or 3 + 1 + 9 to 12; vertebrae 21 + 31 or 32 = total 52 or 53; and lateral line, about 175 pores. Figure 1 is from Goode (1884).

The body is slender, 4.5 to 5 times as long as deep and the head length goes into the body length 4 to 4.5 times. The following are expressed as how many times they go into the head length; snout 2.4 to 3.1, maxillary 1.6 to 1.8, eye 4.5 to 4.9, and pectoral fin length 1.5 to 2.8.

Mather and Day's (1954) meristic and morphometric characters of geographically separated specimens are presented here (Tables 3 and 4).

Scales cover the entire body; a corselet is not developed. The pectoral fin reaches a vertical from the 9th or 10th dorsal spine. The two dorsal fins are hardly separated. The pectoral fins are naked. The ventral fins originate behind the origin of the first dorsal fin. The caudal peduncle is keeled. The lateral line is wavy. The first dorsal fin is triangular, the second is concave and originates before the anal fin, which is similar in size and form. The caudal fin is lunate. An air bladder is absent.

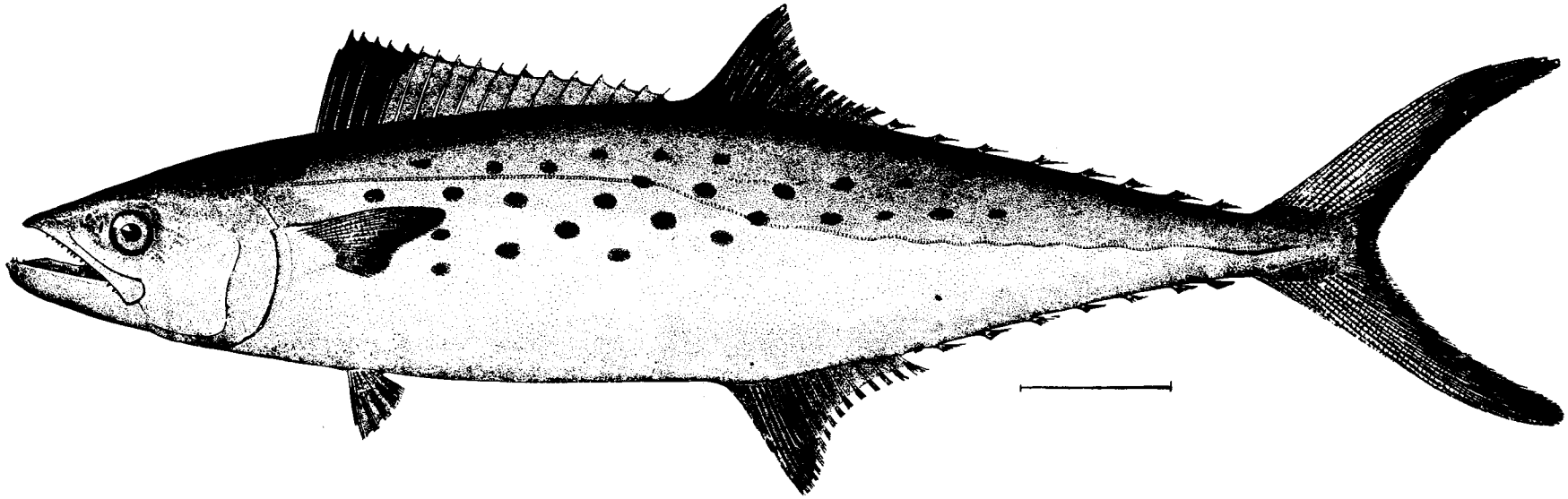

Figure 1. Adult Scomberomorus maculatus (from Goode, 1884).

TABLE 3. Measurements of Scomberomorus maculatus from western and eastern Atlantic waters. Average measurements in percentage of fork length (from Mather and Day, 1954).

Measurement	Locality and Number of Specimens			
	Gulf and Caribbean (7)	Sierra Leone (1)	Canary Islands (1)	Dakar (142)
Head length	.214	.222	.211	.205
Snout to 1st dorsal insertion	.250	.259	.255	.245
Snout to 2nd dorsal insertion	.502	.515	.513	.515
Snout to ventral insertion	.250	.276	.260	.260
Snout to anal insertion	.533	.530	.513	.532
Maximum depth	.180*	.175	.177	...
Depth at 1st dorsal insertion	.150*	.161	...	.156**
Length of pectoral	.125	.138	.144	.136
Length of maxillary	.120	.125	.119	...
Length of snout	.088	.091	.088	...
Diameter of iris	.035	.037	.029	...

* One Gulf of Mexico specimen much deeper than all the others was omitted.
** Average for June and October specimens. January specimens were much deeper and were believed to constitute a different population.

TABLE 4. Meristic characters of Scomberomorus maculatus from western and eastern Atlantic waters (from Mather and Day, 1954).

Character	Locality and Number of Specimens				
	Gulf and Caribbean (7)	Sierra Leone (1)	Canary Islands (1)	Liberia (1)	Dakar (142)
First dorsal spines	17-18	16	16	17	...
Dorsal finlets	8-9	9	9	8	7-9
Anal finlets	8-9	9	8	8	7-9
Upper gill rakers	2-3	2-3	3	4	...
Lower gill rakers	9-11	9-10	9-10	12	...

In color S. maculatus is bluish or greenish above, has silvery sides and is pale yellow beneath; its sides are marked with many oval, dull orange or yellowish spots, both above and below the lateral line. The membrane of the anterior third of the spinous dorsal fin is black while the rear part is greenish white. The second dorsal and pectoral fins are pale yellowish with dusky edges; the anal and ventral fins are white.

1.3.2 Cytomorphology

Engel and Davis (1964), Bastos (1966a), and Pitombeira and Martins (1970) have studied hematology of Scomberomorus maculatus. Pitombeira and Martins compared the three studies and concluded that hematocrit and hemoglobin values and erythrocyte counts for S. maculatus were similar among the studies and areas compared (Atlantic coast of northeastern Brazil and southeastern United States). Experimental values obtained during these studies are presented in Table 5.

Engel and Davis (1964) attempted to relate activity levels (benthic-sluggish vs pelagic-active) to hemoglobin levels and erythrocyte counts among seven species of fish. Table 5 shows that S. maculatus, a pelagic species, has higher hematocrit, hemoglobin content, and erythrocyte counts than do the benthic species investigated.

In a study which compared bone composition among some marine vertebrates, Tont et al. (1977) found that S. maculatus vertebrae are more dense and harder than those of rattails (Coryphaenoides sp.) and guitarfishes (Rhinobates productus). The authors surmised that the hardness of the bones and consequent skeletal rigidity in S. maculatus is related to the active, pelagic behavior of this species as compared to that of the relatively inactive benthic species.

Pitombeira et al. (1971) examined red blood cell fragility in S. maculatus from Brazil by observing the percent of cells hemolyzed at various strength salt solutions. They found a relatively high, year-round red blood cell osmotic fragility which they felt may be due to high water temperatures (>26°C) throughout the year. They also observed a decrease in red cell osmotic fragility in adult S. maculatus in spring and summer which they feel is related to sexual activity, for this decrease was not apparent among immature fish.

TABLE 5. Comparison of blood characteristics for 7 species of teleosts in U. S. waters (from Engel and Davis, 1964) and values for S. maculatus in Brazilian waters (from Bastos, 1966a; and Pitombeira and Martins, 1970).

Species	Hematocrit Percent of Volume		Hemoglobin Grams Percent		Erythrocytes X 10^6Cells/ml		Thrombocytes X 10^6Cells/ml		*n*
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	
Benthic									
Opsanus tau	23.0-33.7	27.50	5.3-7.1	6.21	0.61-0.84	0.68	10.0-40.0	23.50	10
Paralichthys sp.	25.5-37.0	29.25	5.6-7.9	6.64	2.22-3.86	2.91	--	--	10
Micropogon undulatus	18.0-39.8	29.00	4.7-9.8	7.30	1.69-4.90	3.33	12.0-32.0	20.30	30
Pelagic									
Roccus saxatilis	36.0-41.3	38.70	8.6-10.4	9.50	3.42-4.53	3.95	--	--	5
Pomatomus saltatrix	29.0-57.0	43.35	7.0-15.4	10.40	3.12-5.63	4.21	0.0-21.0	10.27	34
Scomberomorus cavalla	32.0-43.0	36.30	7.3-10.3	9.30	2.66-4.59	3.54	--	--	6
Scomberomorus maculatus	26.5-48.0	38.80	7.6-12.2	10.40	3.15-6.13	4.54	--	--	58
S. maculatus (Bastos, 1966a)	32-60	46.87	7.0-14.0	9.70	2.90-4.41	3.64	--	--	100
S. maculatus (Pitombeira and Martins, 1970)	34-61	47	6.4-15.0	11.1	1.50-5.43	3.48	7.4-90.4	37.76	100

1.3.3 Protein Specificity

No information found.

2. DISTRIBUTION

2.1 Total Area

Scomberomorus maculatus from the western Atlantic Ocean is found from Maine and Bermuda to Santos, Brazil, including the Gulf of Mexico and the waters around Cuba, but is absent from the rest of the West Indies (Erdman, 1949; Briggs, 1958; Klima, 1959; Randall, 1968). Within this range Florida is reported as the center of abundance. It is a summer visitor along the northeastern United States coast, regularly to New York and less frequently to southern New England with occasional strays to the Gulf of Maine (Arnold, 1951; Bigelow and Schroeder, 1953; Beaumariage, 1970).

S. maculatus (Cybium tritor in some papers) from the eastern Atlantic Ocean is reported from waters off tropical West Africa, from the Canary Islands to Sierra Leone (Smith, 1961; Mather and Day, 1954).

S. maculatus (referred to as S. sierra) from the eastern Pacific Ocean ranges from Santa Monica, California, through the Gulf of California, along the coasts of Mexico and Central America and south to Peru; it also occurs around the Galapagos Islands (Klawe, 1966).

2.2 Differential Distribution

2.2.1 Spawn, Larvae and Juveniles

Young Scomberomorus maculatus have been found at the following locations in the western Atlantic and eastern Pacific oceans.

Hildebrand and Cable (1938) reported larval and juvenile S. maculatus (14 to 20 mm in length) were found off North Carolina during July and September, while young (to 80 mm) occurred in August and October. Their reports concerning smaller larvae cannot be trusted because of incorrect identification, see section 3.2.2. Hildebrand and Cable (1938) conclude that limited spawning occurs in outside waters near Beaufort, North Carolina and not in waters inside of the barrier beach.

Juvenile S. maculatus were taken in a seine survey near Beaufort, North Carolina (Tagatz and Dudley, 1961). Two juveniles, 18 and 20 mm, were taken in June at Atlantic Beach, and one juvenile, 131 mm, in the Neuse River in September.

Wollam (1970) reported taking larval and juvenile S. maculatus 3.1 to 35.0 mm, at several locations off the west coast of Florida during the months of June to September.

Dwinell and Futch (1973) reported on the occurrences of larval and juvenile (2.8 to 42.2 mm) S. maculatus from the Gulf of Mexico off northwest Florida and Alabama during the months of June, August and September.

Hoese (1965) reported taking 159 larval (2.0 to 8.5 mm) and 12 juvenile (22.5 to 67.0 mm) S. maculatus from May through September off Port Aransas, Texas.

Perrett (1971) reported taking 121 juveniles (45 to 250 mm, average size 113 mm) along the coast of Louisiana during the months of June through October.

Springer and Woodburn (1960) reported catching seven juveniles (36 to 158 mm) in Tampa Bay, Florida during September. Sykes and Finucane (1965) also sampled Tampa Bay and caught three juveniles (35 to 94 mm) between June and November.

Nakamura (1976) caught three juvenile S. maculatus, 26.5 to 26.8 mm, during August, in St. Andrew Bay, Florida, on the northeastern border of the Gulf of Mexico.

Larval and juvenile S. maculatus were found in the eastern Pacific Ocean from Baja, California to Peru throughout most of the range of the adults (Klawe, 1966).

2.2.2 Adults

The adults occur in the same areas as mentioned for the larvae and juveniles, as well as over a greater known range (see Total Distribution, section 2.1), particularly to the north on the United States east coast. Whether the adults occur over a greater range than the young stages in the south Atlantic Ocean is not known.

2.3 Determinants of Distribution

Temperature is believed to be a governing factor in the distribution of Scomberomorus maculatus which inhabits tropical and subtropical waters. Munro (1943) reported that the species of Scomberomorus are restricted in distribution in that they occur where temperatures are greater than 68°F. Based on this temperature, Beaumariage (1970) predicted a northerly range limit in the vicinity of

Block Island, Rhode Island. Arnold (1951) reporting on an unusually northerly occurrence of S. maculatus in North Bay, Massachusetts during October 1949, suggested that this occurrence was due to abnormally high temperatures during the summer of 1949.

Earll (1883) reported that S. maculatus avoids fresh or very low-salinity waters near the mouths of rivers. For example, within Chesapeake Bay, where several rivers flow into the west side of the bay resulting in lower salinities on that side, this species is more often found on the east side of the bay. This relation may not be true for young stages, note the young taken in the Neuse River, North Carolina by Tagatz and Dudley (1961), the salinity at this locality was 4.7 o/oo.

All species of this genus are pelagic coastal inhabitants, found in continental-shelf waters or near islands and reefs. Most inhabit coral reefs, offshore currents, and the tide rips of clear tropical waters.

2.4 Hybridization

A 621-mm long, possible S. maculatus x S. cavalla hybrid, was reported by deSylva (1954) which was intermediate with regard to certain external morphological features, between the species S. maculatus and S. cavalla. The specimen was immature, and possibly a female. However, Beaumariage (1973) concluded that this may have been an unusually large, but still immature S. cavalla.

3. BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.1.1 Sexuality

Spanish mackerel are heterosexual. Thomas and Raju (1964) summarized known gonadal abnormalities in scombroid fishes, and did not report any instances of hermaphroditism among the Scomberomorus species. However, they felt that the absence of abnormalities in this genus may have been due to the small sample size rather than to a real lack of hermaphroditism.

No evidence of sexual dimorphism was found, except for a size difference between the sexes at maturity and at given ages subsequent to maturation (see the following section on maturity).

3.1.2 Maturity

The shortest mature female Spanish mackerel from Florida waters which Klima (1959) observed was 25 cm FL and the longest immature one was 32 cm. The shortest mature male was 28 cm and the longest immature male was 34 cm. Klima reported that these fish were between one and two years old, age II. Powell (1975), however, presented data which contradicts Klima's growth data and suggested that all of Klima's age designations are one year too great; this would make Klima's fish, just referred to, less than 1 year old, age group I. Powell (1975) also found age I females to have ripe oocytes but found many of this age group (44%) during April to September with regressing ovaries, indicating termination of spawning. Age III and older fish were not found to have regressing ovaries until September. Powell suggested that age groups I and II do not contribute significantly to spawning.

Spanish mackerel from Brazilian waters apparently mature later than those from United States waters. Gesteira (1972) examined gonads from 2,904 females taken in the trolling fishery. She determined that they reach sexual maturity between the ages of III and IV, at about 46.0 cm FL.

3.1.3 Mating

No information found.

3.1.4 Fertilization

Fertilization is external.

3.1.5 Gonads

Fecundity of Spanish mackerel in Brazil was studied by Gesteira (1972). She reported a mean fecundity of 2,204,000 ova per female and observed increases in fecundity according to length, age and weight. Gesteira (1972) reported the following fecundity estimate equations which were based on 47 mature females:

fecundity (F) vs fork length, in cm (FL)

$$F = (-3.273 + 95\ FL) \times 10^3$$

fecundity (F) vs age (A)

$$F = (-300 + 443\ A) \times 10^3$$

fecundity (F) vs weight, in grams (W)

$$F = (-241 + 1.451\ W) \times 10^3$$

The only fecundity data on this species from United States waters was given by Earll (1883) and has been repeated by Hildebrand and Cable (1938) and Klima (1959). Earll estimated a 1-lb Spanish mackerel to have 300,000 eggs in its ovary, a 6-lb specimen to have 1,500,000 eggs, and a 1-lb, 13 oz, 18½-inch specimen to have 525,000 eggs in its ovary. The ovary of this last specimen weighed 34.275 gm.

Alves and Tome (1968) presented a histological description of Spanish mackerel gonads. They characterized the ovaries in five stages which differed in relative numbers of various size oocytes. They found that the testes could not be staged in this manner.

3.1.6 Spawning

Because eggs do not ripen synchronously in an individual's ovary (Earll, 1883; Smith, 1907; Powell, 1975) and because larvae are caught throughout the summer off Florida (Wollam, 1970; Dwinell, and Futch, 1973) it follows that spawning is prolonged. Earll (1883) reported spawning in any one area to last at least 6 to 10 weeks.

Klima (1959) and Powell (1975) studied this species in Florida waters, both examined S. maculatus ovaries from all months of the year. Ripe females were observed in Florida waters from April (Powell, 1975) and July (Klima, 1959) through September (Klima, 1959; Powell, 1975). This agrees with the larval S. maculatus captures from June through September off the west coast of Florida and Alabama (Wollam, 1970; Dwinell and Futch, 1973) mentioned earlier (see Differential Distribution).

The onset of spawning varies with the latitude, being earlier in the south than in the north. Earll (1883) reported that the gonads do not ripen very rapidly until a temperature of about 72°F has been reached and Beaumariage (1969) claimed spawning is probably limited to water where the temperature is above 78°F. Earll (1883) set the beginning of spawning off the Carolinas as April, with spawning extending from mid June to the end of the summer in Chesapeake Bay and from late August to late September off Sandy Hook, New Jersey and Long Island, New York. Hildebrand and Cable (1938) stated that Earll had placed the start of spawning off North Carolina (in April) as too early and that it actually extended from late June to late August in that location. Both Earll (1883) and Smith (1907) reported that Spanish mackerel spawn at night.

Judging from the dates of capture and sizes of the larvae and juveniles taken, spawning in the eastern Pacific Ocean occurs in July through September off Mexico and approximately December

through April in lower latitudes (Klawe, 1966). Gesteira (1972) reported that Spanish mackerel spawn throughout the year off northeastern Brazil, but most heavily during July to September.

3.1.7 Spawn - Description of the Egg

According to Ryder (1882) Scomberomorus maculatus eggs are round, 1/25" to 1/20" (=1.02 to 1.27 mm) in diameter, the shell is smooth externally and transparent and there is a single oil globule, about 1/100" (=0.25 mm) in diameter. The egg is pelagic, and floats in salt water. The perivitelline space is about 1/250" (=0.1 mm) across. The oil globule is situated in the upper hemisphere and the germinal disc in the lower hemisphere of a free-floating egg. The yolk is clear and the germinal disc, about 1/50" to 1/40" (=0.5 to 0.6 mm) in diameter, has an amber tint.

Smith (1907) cited by Klima (1959) mentions that the eggs are about one millimeter in diameter.

According to Earll (1883, 1884) the eggs measure from 1/30" to 1/22" (=0.85 to 1.15 mm).

3.2 Pre-Adult Phase

3.2.1 Embryonic Development

The embryonic development of Scomberomorus maculatus was studied in detail by Ryder (1882); his illustrations are included here with the accompanying explanations (Figure 2).

For a description of newly laid eggs see the section on spawn, above.

From Ryder's (1882) description: by 7 hr after fertilization the blastoderm covers half of the yolk; by 11 hr the primitive brain, eyes and auditory organs are visible; at about 12 hr the blastopore closes and somites and the notochord are visible; by 14 hr pigment is forming and nasal pits are visible; by 18 hr the heart is beating, the gut is forming and pectoral buds are present; by 24 hr hatching takes place, and the larvae are slightly more than 1/11" long (2.3 mm).

Earll (1883) reported a hatching time of 20 hr at 84°F (29°C) and 24 hr at 78°F (25.5°C).

3.2.2 Larval Development

Yolk-sac larvae reared for six days, until starvation, from eggs of known parentage were described by Ryder (1882). His illustrations are included here (Figure 3).

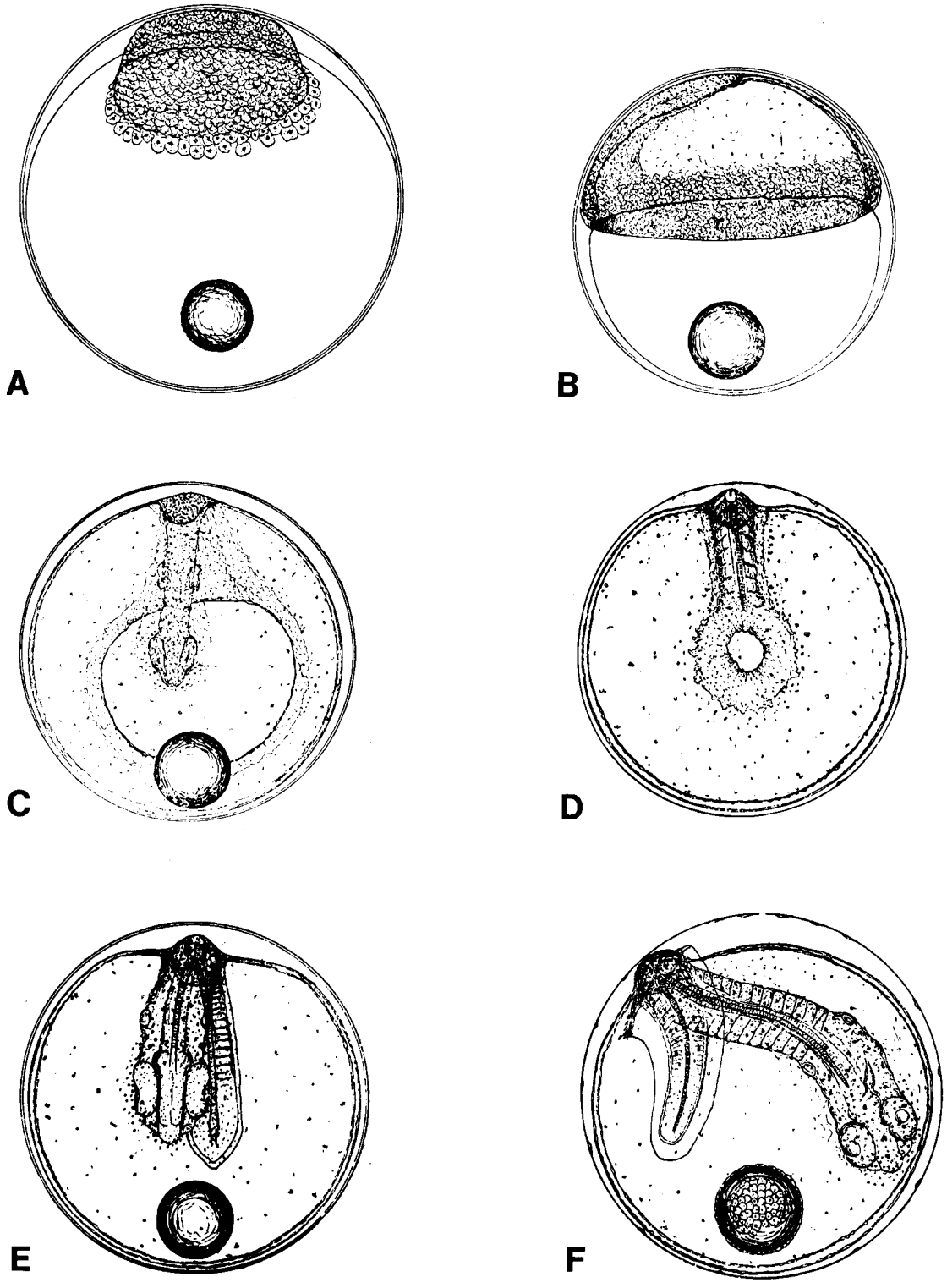

Figure 2. Scomberomorus maculatus eggs: A, 3 hr; B, 7 hr; C, 11 hr; D, 12 hr; E, 14 hr; F, 18 hr after impregnation (from Ryder, 1882).

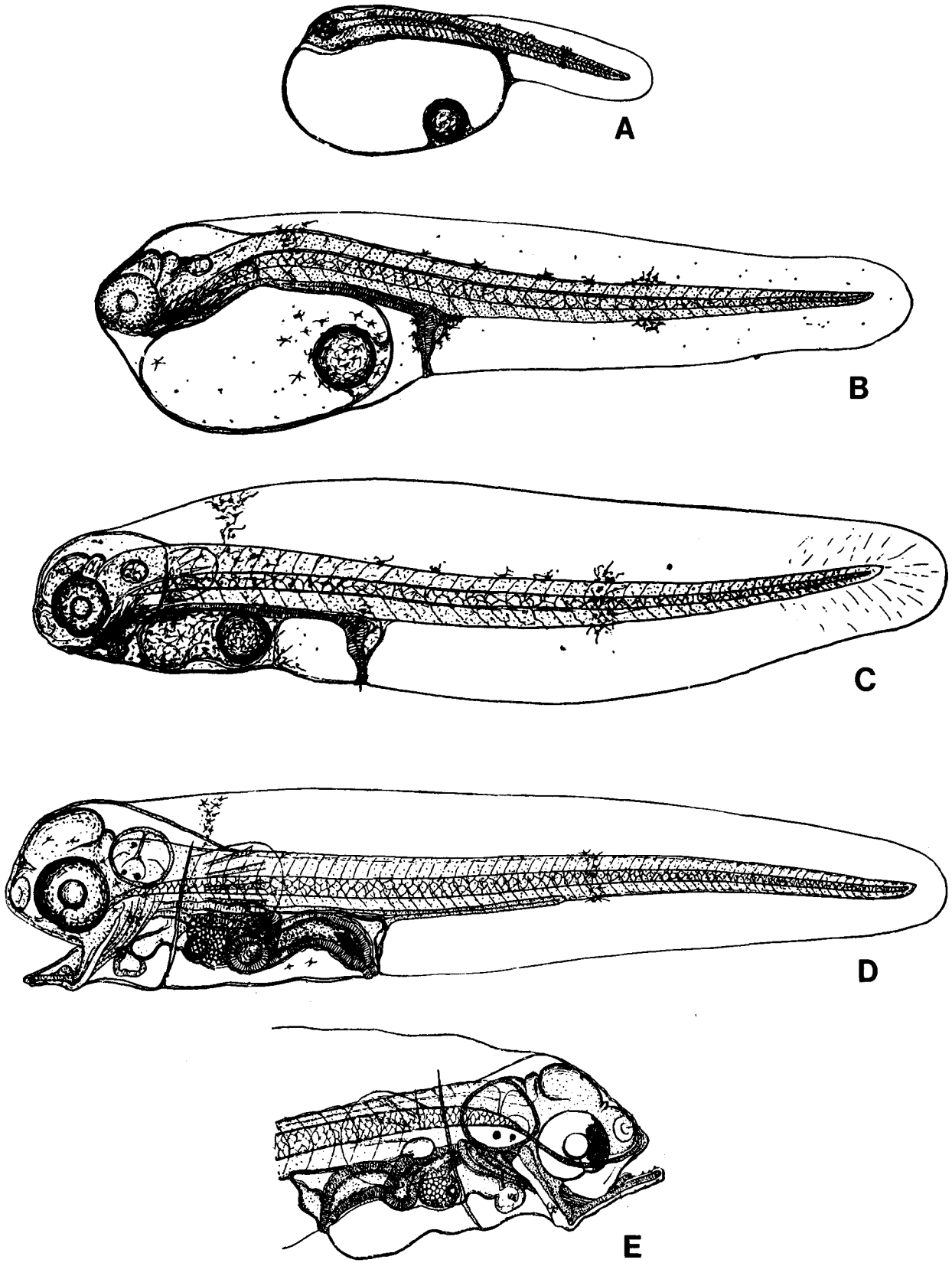

Figure 3. Scomberomorus maculatus larvae: A, 2.3 mm SL, just hatched (24 hr after impregnation); B, 2.7 mm SL, 12 hr; C, 3.0 mm SL, 21 hr; D, 3.2 mm SL, 72 hr; and E, 144 hr after hatching (from Ryder, 1882).

By 24 hr after hatching, although the gill clefts are open, the mouth is still closed; the eyes are pigmented and the pectoral fin buds are expanded and flattened. The head is considerably widened; and the intestine is progressively thickening from posterior to anterior. The yolk and oil globule are much reduced. At two days after hatching the cartilaginous cleithra are forming. By four days the mouth is open and the lower jaw extends almost to the snout. The mouth is observed to open and close frequently and feeding occurs, as food can be seen in the gut. At this time the auditory capsules are enclosed in cartilage. By six days after hatching gill lamellae are developed and there are teeth on the lower jaw. The pectoral girdle (cleithra) has become substantial; and the yolk and oil globule have been almost entirely absorbed.

Older stages of larval and juvenile Scomberomorus maculatus have also been described by Hildebrand and Cable (1938) and by Wollam (1970). Figures 2 to 6 of Hildebrand and Cable (1938), however, are definitely not Scomberomorus maculatus, and their figures 3 to 5 are probably not even scombrids. Also, we question the identity of the 97 mm juvenile illustrated by Hildebrand and Cable (1938) and labeled S. maculatus; the strong bend in the lateral line below the second dorsal fin indicates it may be S. cavalla. Their specimens illustrated which are 14, 17 and 22 mm in length appear to be S. maculatus; these figures are included here (Figure 6). Wollam (1970) illustrated and described S. maculatus 3.1 to 17.4 mm SL. His illustrations are also included here (Figures 4 and 5).

The large number of myomeres (51 to 53), large mouth with well developed teeth, strong preopercular spines, numerous fin elements, and characteristic pigmentation are distinctive in this species. Pigment forms over the brain, on the snout, at the tip of the lower jaw, and between the rami of the lower jaw. A single melanophore develops at the cleithral symphysis. A series of melanophores form post-anally on the ventral edge of the body. Pigmentation forms at the dorsal fin base and in a mid-lateral row. The spinous dorsal fin is the only fin to develop definite pigmentation.

Meristic and morphometric data pertaining to larval and juvenile S. maculatus in Tables 6 and 7 are from Wollam (1970).

3.3 Adult Phase

3.3.1 Longevity

The oldest specimens examined by Klima (1959) and Powell (1975) were five and eight years old respectively.

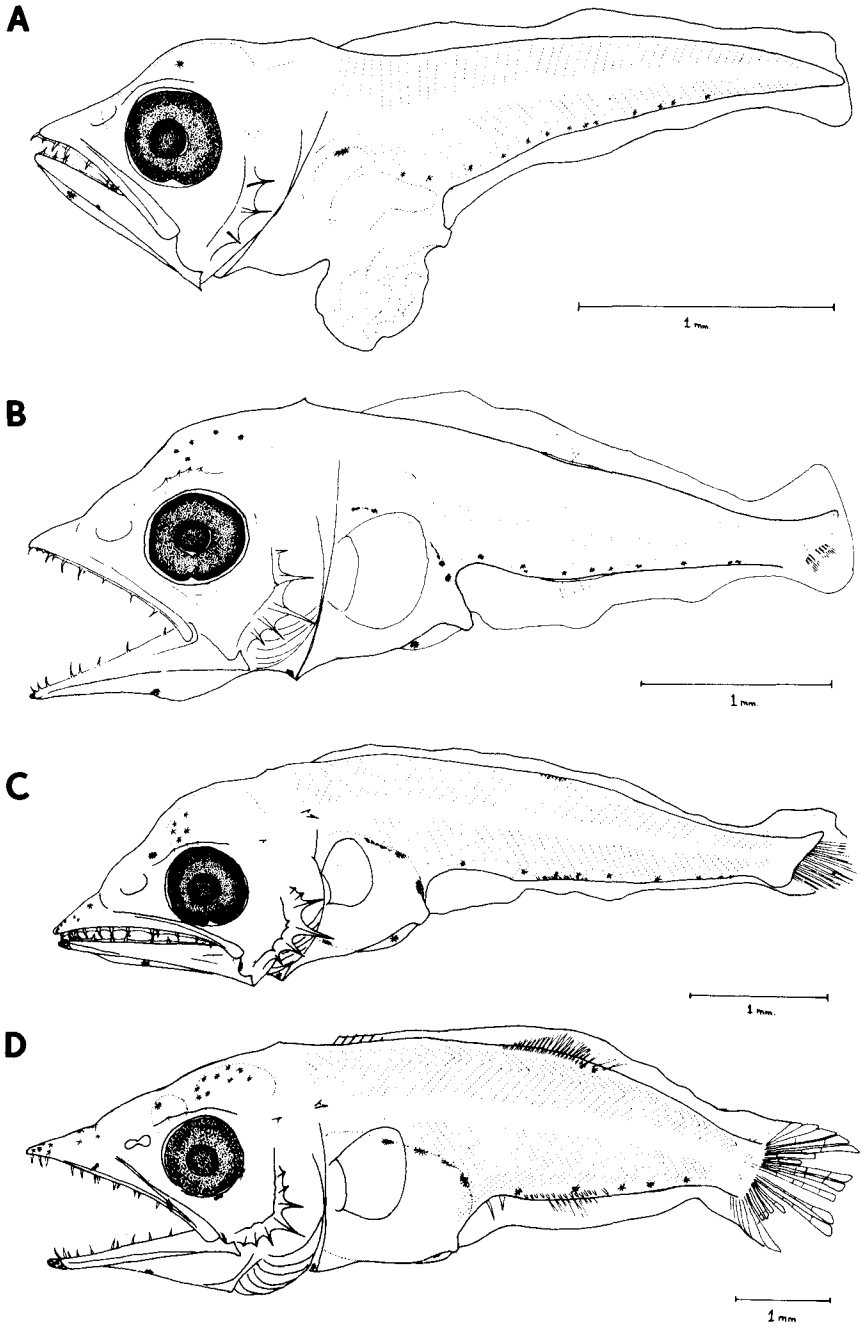

Figure 4. Scomberomorus maculatus larvae: A, 3.1 mm; B, 4.3 mm; C, 5.8 mm; and D, 7.8 mm SL (from Wollam, 1970).

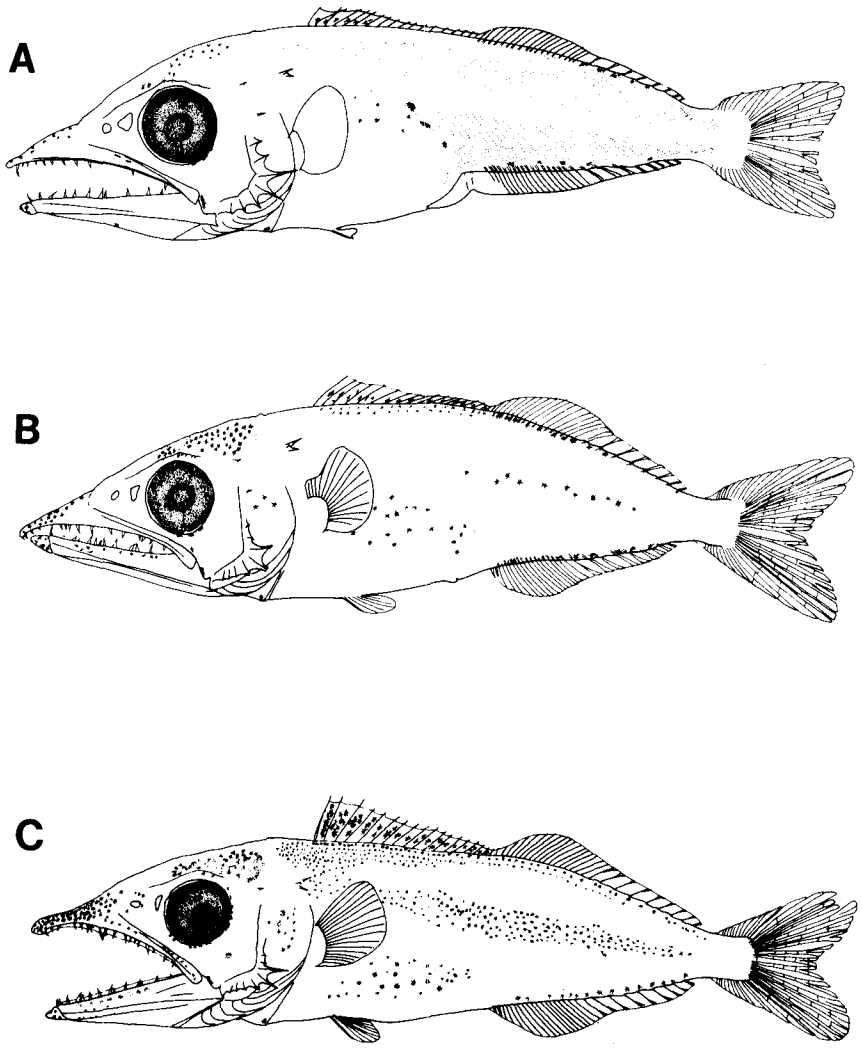

Figure 5. Scomberomorus maculatus: A, larva, 9.5 mm; B, juvenile, 13.5 mm; and C, juvenile, 17.4 mm SL (from Wollam, 1970).

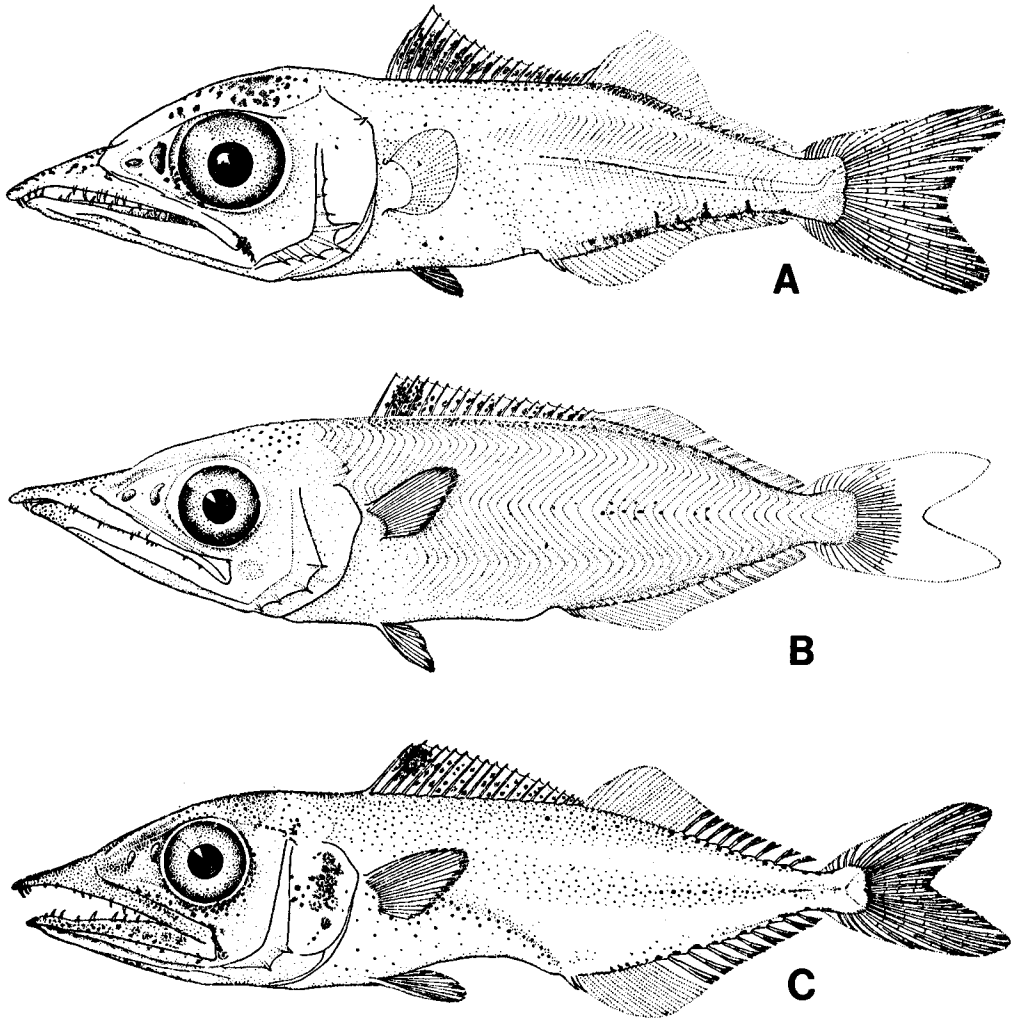

Figure 6. Scomberomorus maculatus juveniles: A, 14 mm TL; B, 17 mm TL; and C, 22 mm TL (from Hildebrand and Cable, 1938).

TABLE 6. Measurements (mm) of body parts of cleared and stained larval and juvenile Spanish mackerel (from Wollam, 1970).

Collection Number	Standard Length	Head Length	Snout Length	Orbit Diameter	Premaxillary Length	Upper Jaw Length	Lower Jaw Length	Body Depth	Snout-to-Anus Distance	Snout-to-First Dorsal Distance	Snout-to-Second Dorsal Distance	Preopercular Spine Length
FBC-5835L	3.1	1.14	0.36	0.44	0.09	0.78	0.75	0.48	1.61	--	--	0.14
FBC-5835L	4.3	1.50	0.55	0.50	0.28	1.14	1.01	0.61	2.18	--	--	0.30
FBC-5835L	5.2	1.90	0.78	0.62	0.39	1.40	1.29	0.82	2.90	--	--	0.26
FBC-5835L	5.7	2.50	1.09	0.78	0.55	1.67	1.56	1.06	3.40	--	--	0.39
FBC-5842L	7.6	3.18	1.40	0.91	0.81	2.09	1.81	1.59	4.60	3.43	--	0.49
FBC-5842L	9.7	4.15	1.91	1.12	1.19	2.68	2.18	2.00	6.42	4.46	--	0.53
FBC-5842L	10.8	4.25	1.93	1.15	1.22	2.72	2.30	2.14	6.50	4.73	7.05	0.53
FBC-5842L	13.0	5.30	2.52	1.36	1.55	3.37	2.72	2.68	8.60	5.57	8.55	0.65
FBC-5844L	17.0	6.55	2.95	1.75	1.78	4.02	3.37	3.30	10.75	7.20	11.30	0.62
FBC-5843L	20.0	7.20	3.20	1.85	1.91	4.02	3.62	4.08	13.00	7.95	13.12	0.78
FBC-5845L	23.5	8.16	3.68	2.06	2.00	4.27	4.34	4.86	15.91	8.75	15.00	0.75
FBC-5847L	29.0	9.80	4.03	2.65	2.33	5.18	5.00	5.63	19.20	10.06	18.70	0.87

TABLE 7. Meristic counts of cleared and stained larval and juvenile Spanish mackerel (from Wollam, 1970).

Collection Number	Standard Length (mm)	Teeth Upper Jaw	Teeth Lower Jaw	Branchiostegal Rays	Myomeres	Vertebrae Trunk	Vertebrae Caudal	Preopercular Spines	First Dorsal Fin Spines	Anal Fin Spines	Second Dorsal Fin-rays & Finlets	Anal Finrays & Finlets	Pectoral Finrays	Pelvic Fin Spines & Rays	Caudal Finrays-Dorsal (principal and secondary)	Caudal Finrays-ventral (principal and secondary)
FBC-5835L	3.1	5	4	1	51	--	--	3	--	-	--	--	--	--	--	--
FBC-5835L	4.3	9	8	2	52	--	--	5	--	-	--	--	--	--	--	--
FBC-5835L	5.2	10	9	5	53	--	--	5	--	-	--	--	--	--	4+0	3+0
FBC-5837L	5.7	11	10	7	53	--	--	6	--	-	--	--	--	--	7+0	5+0
FBC-5842L	7.6	11	13	7	52	--	--	7	6	-	7	6	2	--	9+1	8+1
FBC-5842L	9.7	14	12	7	52	--	--	7	18	-	21	18	11	I,3	9+3	8+3
FBC-5842L	10.8	18	17	7	52	22	30	7	18	-	23	20	11	I,4	9+4	8+4
FBC-5842L	13.0	20	14	7	--	22	29	7	19	2	26	25	14	I,4	9+9	8+9
FBC-5844L	17.0	22	18	7	52	22	30	7	19	2	26	25	18	I,5	9+11	8+11
FBC-5843L	20.0	23	22	7	--	23	29	7	20	2	26	26	20	I,5	9+12	8+12
FBC-5845L	23.5	24	20	7	--	22	30	7	20	3	25	25	20	I,5	9+11	8+11
FBC-5847L	29.0	24	21	-	--	22	30	7	19	3	25	25	20	I,5	9+12	8+12

3.3.2 Hardiness

No information found.

3.3.3 Competitors

No information found.

3.3.4 Predators

Apparently this has not been studied; although man is probably a major predator, certainly of the larger-size Spanish mackerel.

3.3.5 Parasites, Diseases and Abnormalities

The following lists the parasites reported as occurring on Scomberomorus maculatus; no diseases or abnormalities reported.

Sporozoa -

Kudoa crumena n. sp., cysts in musculature, south Florida (Iverson and Van Meter, 1967).

Copepoda - Family Caligidae

Caligus rapax Milne-Edwards; external on body; Texas (Silas and Ummerkutty, 1964).

Caligus bonito Wilson; in mouth; Gulf of Mexico (Bere, 1936).

- Family Pseudocycnidae

Pseudocycnus buccatus Wilson; on gills; Gulf of Mexico (Bere, 1936; Causey, 1960).

Cybicola elongata n. sp.; on gills; Bimini (Pearse, 1951).

- Family Lernaeidae

Lernaeenicus longiventris n. sp.; Woods Hole (Wilson, 1917).

- Family Shiinoidae

Shiinoa inauris n. sp.; from nasal laminae; Aransas Pass, Texas; Key West, Florida; Placida, Florida; and off Argentina (Cressey, 1975).

Nemtoda -

Ascaris incurva Rudolphi; from intestine; Woods Hole region (Linton, 1901).

Ascaris clavata Rudolphi, immature; from stomach; Fulton Market, New York (Linton, 1901).

Contracaecum fortalezae Klein; in stomach, larvae and small intestine; Rio de Janeiro (Klein, 1973).

Ichthyonema globiceps Rudolphi; from ovary; New Jersey coast (Linton, 1901).

Cestoda -

Synbothrium filicolle Linton; cysts on viscera; Woods Hole region (Linton, 1897 and Linton, 1901); same species from Beaufort, North Carolina (Linton, 1905).

Rhynchobothrium bulbifer Linton; cysts on viscera; Woods Hole (Linton, 1901).

R. speciosum Linton; cysts on viscera; Woods Hole (Linton, 1901).

Rhynchobothrium sp.; from Beaufort, North Carolina (Linton, 1905).

Tetrarhynchus bisulcatus Linton; on viscera; Beaufort, North Carolina (Linton, 1905).

- Family Dasyrhynchidae

Callitetrarhynchus gracilis (Rudolphi); larvae encysted on viscera (Silas, 1964).

- Family Lacistorhynchidae

Lacistorhynchus tenus (Van Beneden, 1858); cysts in stomach and back muscles (Silas, 1964).

Trematoda -

Gasterostomum sp.; from intestine; Woods Hole Region (Linton, 1901).

Gasterostomum baculum n. sp.; Beaufort, North Carolina (Linton, 1905).

Koellikeria scomberomori n. sp.; in stomach, 4 out of 5 were loose and one was encysted (MacCallum and MacCallum, 1916).

Family Gastrocotylidae

Scomberocotyle scomberomori (Karantha, 1955); on gills; from Alligator Harbor, Florida, Tampa Bay, Florida, and Port Aransas, Texas (Hargis, 1956); and from lower Chesapeake Bay (McMahon, 1964).

Thoracocotyle crocea MacCallum, 1913; on gills; (MacCallum, 1913); from Alligator Harbor, Florida (Hargis, 1956); Chesapeake Bay (McMahon, 1964).

Pseudaxine mexicana (Meserve, 1938); on gills; from Alligator Harbor, Florida and Grand Isle, Louisiana (Hargis, 1964); from Chesapeake Bay (McMahon, 1964).

Lithidocotyle acanthophallus (MacCallum and MacCallum, 1913); on gills; from Alligator Harbor, Florida (Hargis, 1964) and Chesapeake Bay (McMahon, 1964).

3.4 Nutrition and Growth

3.4.1 Feeding

Little is known of the manner of feeding of Scomberomorus maculatus. Earll (1883) cited a fishing manual by Scott (1875), and reported that Spanish mackerel feed by surrounding shoals of smaller fishes forcing them to the surface where the mackerel feed by chasing their prey, and in doing so often jump clear of the water.

Menezes (1970) reported that female S. maculatus reduce feeding during the spawning season (October to April off Brazil) and that they compensate for this with a post-spawning (July to September) period of higher voracity. She also noted that females eat more than males. Various organs of the digestive system in S. maculatus, including the esophagus, stomach, intestine, liver, gall bladder, and pyloric caeca were studied histologically and described by Alves (1969) and Alves and Tome (1970).

3.4.2 Food

Earll (1883) reported S. maculatus to feed almost exclusively on small fishes, chiefly menhaden and alewives, and to feed seldomly, if ever, on bottom invertebrates.

The following reports on food of S. maculatus are from Klima (1959) who cited several previous authors in his paper. Goode (1887) reported S. maculatus does great damage to menhaden schools. Carson (1944) reported menhaden is the principal food but that S. maculatus feeds on any available species. In examining the stomachs of 3,428 S. maculatus from the Texas coast, Miles and Simmons (1951) found 2,274 containing food and 30% containing menhaden. In another

study, Kemp (who worked with Miles and Simmons) examined 611 mackerel stomachs with food and found 82 containing shrimp, 30 squid, 53 ribbonfish, 6 menhaden, 4 with other species, and the rest were unidentified.

Klima (1959) examined 292 stomachs, of which 111 were empty. Of the 181 fish with food, 76% contained herring-like fishes. Table 8 summarizes his results.

Menezes (1970) studied food habits among 1,020 S. maculatus taken throughout the year off Brazil. She found that fishes constitute the primary food, with decapod crustaceans and cephalopod molluscs also consumed. Clupeids (especially Opisthonema oglinum) were the most abundant of the fishes eaten, followed in importance by engraulids, hemirhamphids, and carangids, among others. Panaeid shrimps were the most common crustaceans and loliginid cephalopods the most common molluscs consumed.

3.4.3 Growth Rate

Hildebrand and Cable (1938) collected 4-mm larvae as early as June off North Carolina. By October some larvae had grown to 80 mm long.

Klima (1959) and Powell (1975) studied age and growth of S. maculatus from Florida using otoliths as indicators of age. Yearly variations in growth are reflected as distinct growth rings, or annuli, on the otoliths. Figure 7 (from Powell, 1975) illustrates observed and calculated growth of males and females. The sexes were presented separately because they differ in growth rate; females grow faster than males. Only ages I to V are shown because Powell did not have a sufficient number of samples from older fish to warrant analysis.

Powell (1975) presented information which indicates that Klima's (1959) and Nomura's (1967) age designations are in error by one year in excess of the correct age. These earlier authors were apparently ascribing first annulus status to a mark on the otoliths which was not a true annulus, and which Klima, in fact, described as appearing different from all other annuli on the otoliths of this species.

Nomura (1967) reported an average condition factor (K) of 10.34 for 109 S. maculatus 16 to 36 cm (FL) taken off Brazil during March to July.

TABLE 8. List of food items* found in stomachs of 181 Spanish mackerel samples from the Florida hook and line fishery, October-March (from Klima, 1959).

Common Name	Scientific Name	Number
Herrings	Clupeidae	125
Pilchard	Harengula pensacolae and related species	17
Thread herring	Opisthonema oglinum	2
Shrimp	Penaeus sp.	11
Mullet	Mugil sp.	8
Needlefish	Strongylura sp.	1
Anchovy	Eugraulidae	1
Unidentified fish		15

* One fishing lure was found in the stomach of a fish.

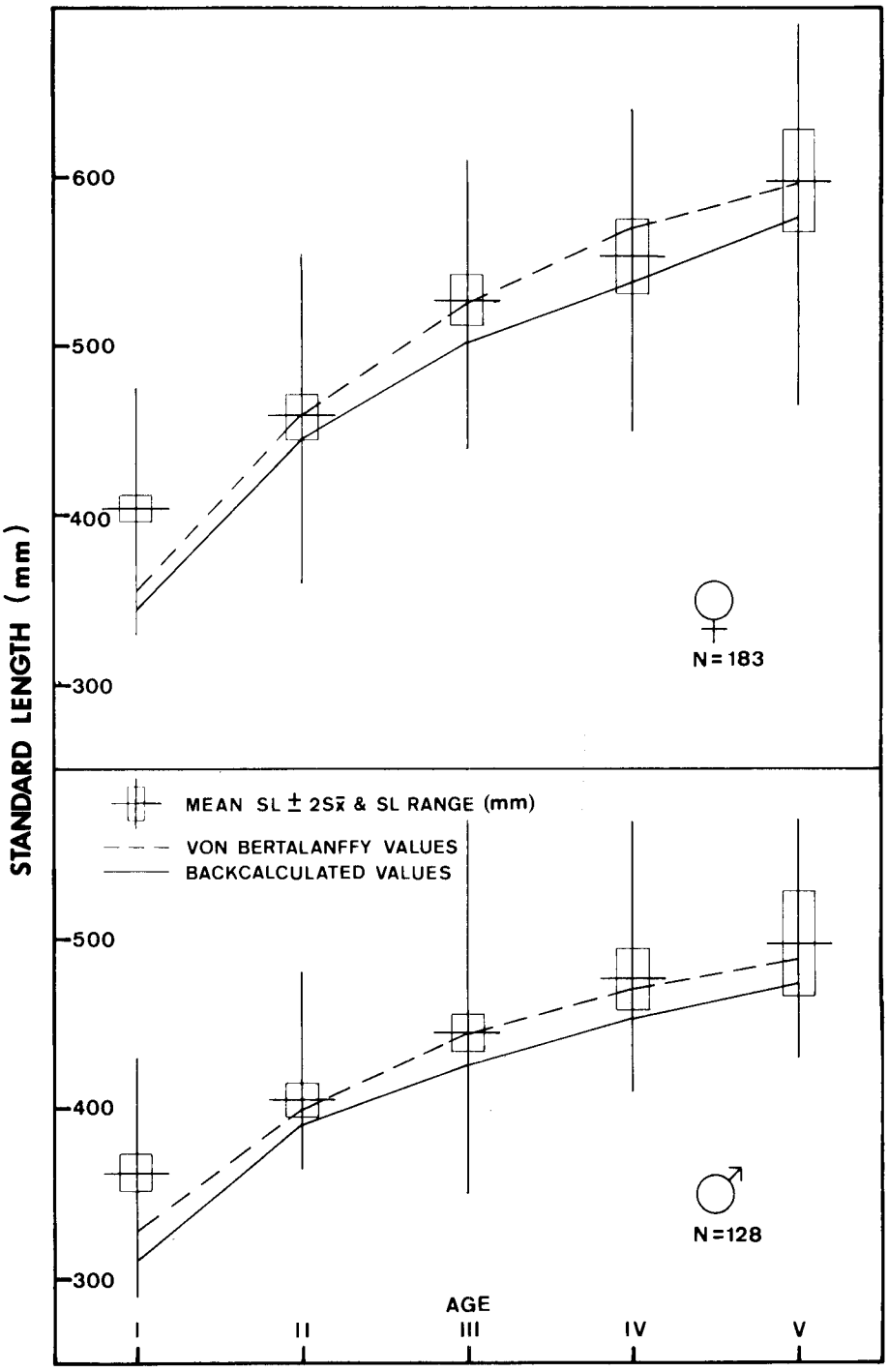

Figure 7. Plots of mean empirical, backcalculated and theoretical standard length for male and female Spanish mackerel (from Powell, 1975).

3.5 Behavior

3.5.1 Migrations and Local Movements

During winter there are large concentrations of Scomberomorus maculatus off Florida and around the Florida Keys; they move northward each spring to occur off the Carolinas by April, off Chesapeake Bay by May and in some years occur as far north as Narragansett Bay by July. In the Gulf of Mexico they migrate to the west of Cape San Blas. They remain in the north until September and migrate south in the fall (Beaumariage, 1970; Wollam, 1970). As mentioned in the section on distribution, the northernmost extent of migration along the Atlantic coast in summer is normally New York or southern New England, with infrequent strays occurring as far north as the Gulf of Maine.

Earll (1883) noted that water temperature of 70 to 80°F (21 to 27°C) are normally associated with this species and that it is seldom found in water colder than 65°F (18°C).

3.5.2 Schooling

Scomberomorus maculatus tends to occur in schools (Earll, 1883; Randall, 1968) which, according to Earll (1883), may be large enough to cover several square miles and are found near the water surface. Schools freely enter tidal estuaries, bays and lagoons when following bait schools (Migdalski, 1958).

3.5.3 Response to Stimuli

No information found on environmental stimuli other than the thermal limits already mentioned (see sections on determinants of distribution and migrations).

4. POPULATION

4.1 Population Structure

4.1.1 Sex Ratio

While no information was found on the sex ratio of the Scomberomorus maculatus population, Klima (1959) presents some data on the sex ratio caught by two different types of gear, hook and line and gill net (see section on selectivity of fishing gear).

4.1.2 and 4.1.3 Age and Size Composition of the Catch

Klima (1959) presented length frequency data on the sport and commercial fishery for S. maculatus in Florida (Figure 8). Those caught by hook and line (sport fishery) ranged from 21 to 69 cm FL while 28% were 33 to 35 cm in length. Those taken by gill nets (commercial fishery) ranged from 30 to 65 cm with over 52% from 36 to 41 cm.

Most S. maculatus taken in the fishery are reported to be 1½ to 2 feet in length and to weigh 1 to 4 lb with only a few attaining the maximum length of 3 to 4 feet and a weight of 8 to 10 lb (Dresslar and Fesler, 1889; Hildebrand and Schroeder, 1928; Nichols, 1929; Beebe and Tee-Van, 1933; Bigelow and Schroeder, 1953; Randall, 1958).

Length-weight relationships of male and female S. maculatus from Florida were reported by Powell (1975) (Figure 9) and Beardsley and Richards (1970). Length-weight data for this species from Brazil were reported by Nomura and Costa (1966), Nomura (1967), and Nomura and Costa (1968).

4.2 Abundance and Density

4.2.1 Average Abundance

No information found.

4.2.2 Changes in Abundance

Apparently this species fluctuates in abundance over time. Earll (1883) discussed an apparent decline and absence of this species in the Sandy Hook, New York and southern New England area in the 1700's and early 1800's. At the time of his writing (1883), Spanish mackerel were abundant in summer in the area mentioned. Earll felt that the fluctuations were due to natural causes.

4.2.3 Average Density

No information found.

4.2.4 Changes In Density

No information found.

4.3 Natality and Recruitment

No information found.

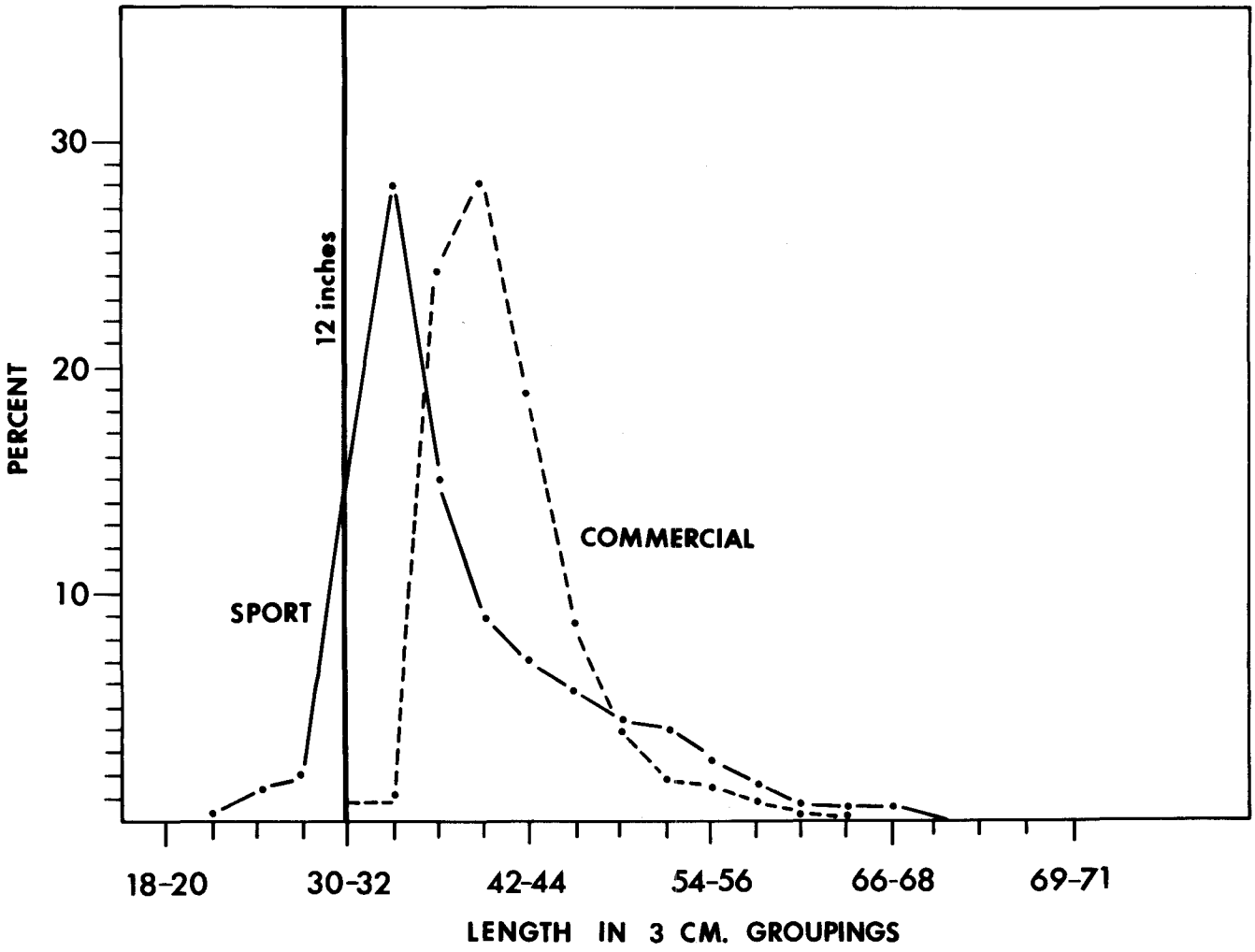

Figure 8. Length frequency distribution of Spanish mackerel from the commercial and sport fisheries of Florida; October 1956 - April 1958 (from Klima, 1959).

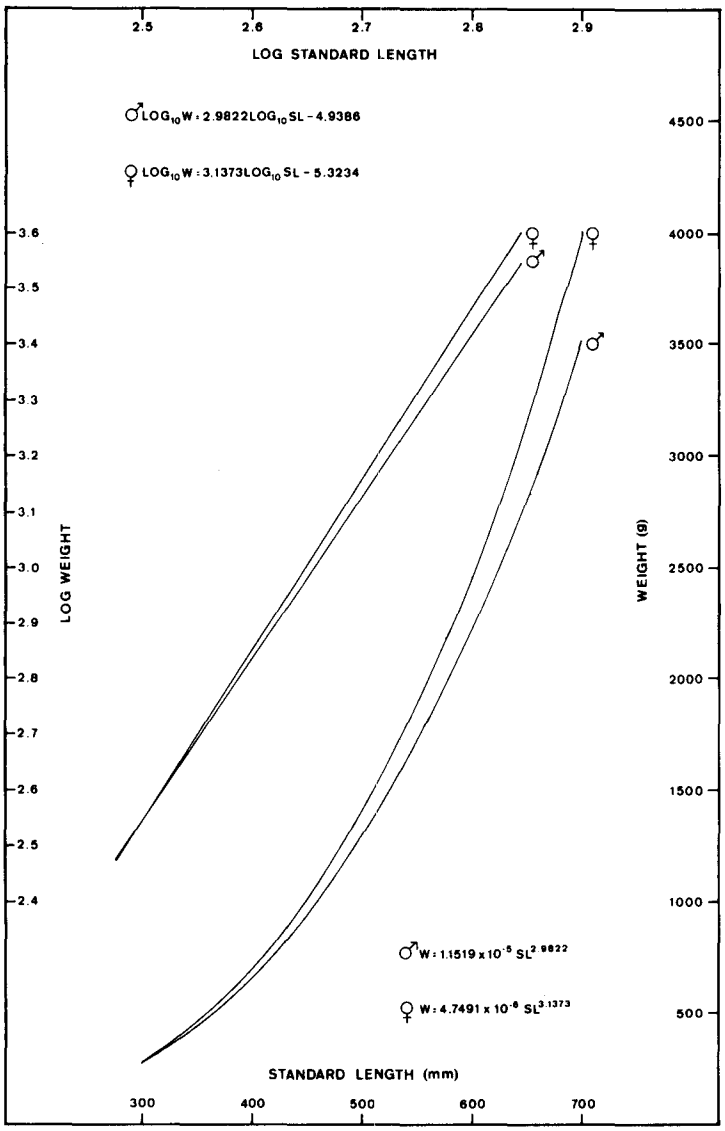

Figure 9. Logarithmic and exponential length-weight relationships of male and female Spanish mackerel (from Powell, 1975).

4.4 Mortality and Morbidity

No information found.

4.5 Dynamics of the Population

No information found.

4.6 The Population in the Community and the Ecosystem

No information found.

5. EXPLOITATION

5.1 Fishing Equipment

5.1.1 and 5.1.2 Gear and Boats

In the vicinity of Sandy Hook, New Jersey, Spanish mackerel were first taken around 1850 by trolling artificial lures behind sloops travelling at about 2 to 4 mph. Gill nets came into use in the 1860's; these nets were about 100 fathoms long and 100 meshes deep, the meshes measured 3½ to 4 inches, stretch mesh. Gill nets were introduced into the Chesapeake Bay fishery in 1877. Pound nets were first used in New Jersey in 1855 and by the 1880's were the principal means of taking Spanish mackerel in that area. The large, ocean pound nets were more successful in taking Spanish mackerel than were the pound nets in Sandy Hook Bay (Earll, 1883).

According to the United States Fishery Statistical Digests the types of fishing gear employed in this fishery include gill nets (anchored, staked, drifting, and runaround), haul seines, pound nets, trammel nets, hand lines, trolled lines, and otter trawls.

The fishing gear used for S. maculatus in Florida is the gill net and trolled hook and line (Klima, 1959). The boats used in the commercial fishery are generally 25 to 35 feet long, 8 or 9 feet wide, and are equipped with high speed gasoline engines. At the time of Klima's (1959) writing, the boats were wooden, usually lapstrake or clinker construction. These boats had large sealed beam lights for night fishing. Commonly the boats were company owned. The fishermen would supply the nets, fuel and

labor. Twelve to 15% of the catch belonged to the company, which would also buy the remainder. Independent boat operators could sell their catch to any company.

The nets vary from 250 to 900 yards long and are made of No. 6 or 9 cotton twine, as nylon and linen are expensive and are cut as readily as the cotton by the mackerel's teeth. Nets used in the bay fishery are 80 to 100 meshes deep while those used offshore are about 140 meshes deep. The mesh size is $3\frac{1}{4}$ to $3\frac{3}{4}$ inch, stretch mesh (Klima, 1959).

Night fishing is conducted in south and north Florida, with day-time fishing also occurring in north Florida. At night boats cruise and search for tell-tale bioluminescence, which is most visible on nights with no moon (Klima, 1959).

Commercial fishing takes place along the beach and in bays with water depths of 6 to 35 feet. The gill nets are sunk or floated, depending on the depth of the fish. The gill nets are usually set surrounding a school; then either slowly retrieved, making the encirclement smaller, or (in turbid water) the boat is run around in such a way as to frighten the fish into the net so that they gill themselves (Klima, 1959).

Sport fishing for Spanish mackerel in Florida is conducted from boats, jetties and piers using spinning gear with herring-like bait fishes (pilchard, thread herring and Spanish sardine) as well as mojarras, mullet and shrimp. Artificial lures, such as spoons and feathers, are also used. Catches of Spanish mackerel are good when bait fishes are plentiful. Bait is often caught with lift nets, with bait rings, and by hook and line (Klima, 1959).

A hook and line fishery for Spanish mackerel and king mackerel off northeastern Brazil is described in the series of papers by Costa and Paiva (1963 et seq.) and by Costa and Almeida (1974). This is a year-round fishery, operating from both moving (trolling) and stationary boats. Bait fishes commonly used include thread herring, tomtate, and sardines. A gill net fishery for Spanish mackerel in this same area was described by Filho (1972). The nets are made of No. 50 or 60 monofilament nylon, measure about 78.5 by 2.3 m (258 by 7.5 ft), and have 3.5 to 4.5-cm ($1\frac{3}{8}$ by $1\frac{3}{4}$ in) bar measure mesh. Usually four such nets are joined and fished together for about 3 hr at a time.

5.2 and 5.3 Fishing Areas and Seasons

The more important fishing areas for Scomberomorus maculatus in United States waters are in the Gulf of Mexico, off Florida, and north along the Atlantic coast to Chesapeake Bay. In some years sizeable catches are made as far north as New Jersey and Long Island. During late March or early April this species occurs off Charleston, South Carolina and by late April it is in the sounds of North Carolina. By the middle of May, S. maculatus schools are in Chesapeake Bay, and by late July they are off Sandy Hook and possibly as far north as Narragansett Bay. Schools of S. maculatus remain north until September or October when they return in the fall; few remain in the Beaufort area during the summer (Klima, 1959).

There is a similar spring northward and fall southward migration of Spanish mackerel along the Gulf Coast of Florida as reflected by the landings. Klima (1959) noted the catches in Galveston in July and August and that Spanish mackerel remain in the northern Gulf area in November and few are caught there in winter.

On the southwest and southeast coasts of Florida there are large, commercial catches from November through March. Over 90% of Florida's annual commercial landings are taken between Tampa Bay and Key West during these months (Beaumariage, 1970). There is a seasonal movement northward during spring so that by June in this area the production drops off. Along the northwest coast of Florida there is a March-April peak and an October to January low catch. This indicates a seasonal movement along the northwest Florida coast, northward in spring and southward in fall (Klima, 1959).

Off the northeastern coast of Brazil, S. maculatus are fished year-round, with the greatest catches usually occurring in the 4th and 1st quarters of the year. The gill net fishery is centered around water about 15 m deep, about 8 km from the coast. The distance from shore for the hook-and-line fishery varies seasonally, being farther offshore during the 4th and 1st quarters of the year, when the weather and sea conditions are most favorable (Costa and Paiva, 1963 et seq.; Filho, 1972; Costa and Almeida, 1974).

5.4 Fishing Operations and Results

5.4.1 Effort and Intensity

No information found (see section on fishing equipment for the types of gear used in this fishery).

5.4.2 Selectivity

Klima (1959) reported on the different sizes of Spanish mackerel taken by various mesh sizes in gill nets. Klima's illustration is included here to summarize his findings (Figure 10). Nets with $3\frac{1}{8}$-inch mesh caught 30 to 55 cm FL fish, with many fish in the 36 to 40 cm length group. The Spanish mackerel caught by $3\frac{1}{2}$-inch gill nets were from 36 to 65 cm, generally larger than those taken by the smaller mesh nets.

Klima showed that there is differential size selectivity between commercial (gill net) and sport fishery (hook and line) catches of Spanish mackerel in Florida waters. Those taken by hook and line were 21 to 69 cm FL long, with 28% at 33 to 35 cm long. Those taken by gill nets were 30 to 65 cm long, with 52% at 36 to 41 cm long. Figure 8, presented in section 4.1.2-4.1.3, illustrates the different size compositions of the sport and commercial catches.

Klima (1959) found a difference in catch rates between the sexes of Spanish mackerel taken by sport (hook and line) and commercial (gill net) fisheries (Figure 11). In his total sample (1,156 fish) from the sport fishery only 20% (232 fish) were male, while 49% (218 fish) were male in the total commercial fishery sample (441 fish). Klima suggested that there may be a difference in behavior, i.e., the females being more aggressive in taking bait, which may account for the difference experienced.

Sizes and ages of S. maculatus reportedly taken by the Brazilian hook and line fishery tend to be greater than those from the gill net fishery. The trolling fishery takes fish at ages II to X, mostly III to VI, with a mode at age IV, while the gill net fishery catches fish at ages I to X, mostly II to IV, with a mode at age III (Filho, 1972). Because this species reaches sexual maturity in Brazil at age III or IV, Filho (1972) recommends a larger mesh size than that used (3.5 to 4.5-cm bar measure) so as to take less fish from the potential spawning stock.

5.4.3 Catches

Table 9 summarizes Spanish mackerel landings. The data were found in the United States Fishery Statistical Digests (1948 to 1974) and in the Salt Water Angling Surveys (Clark [1962?], Deuel and Clark, 1968, Deuel, 1973).

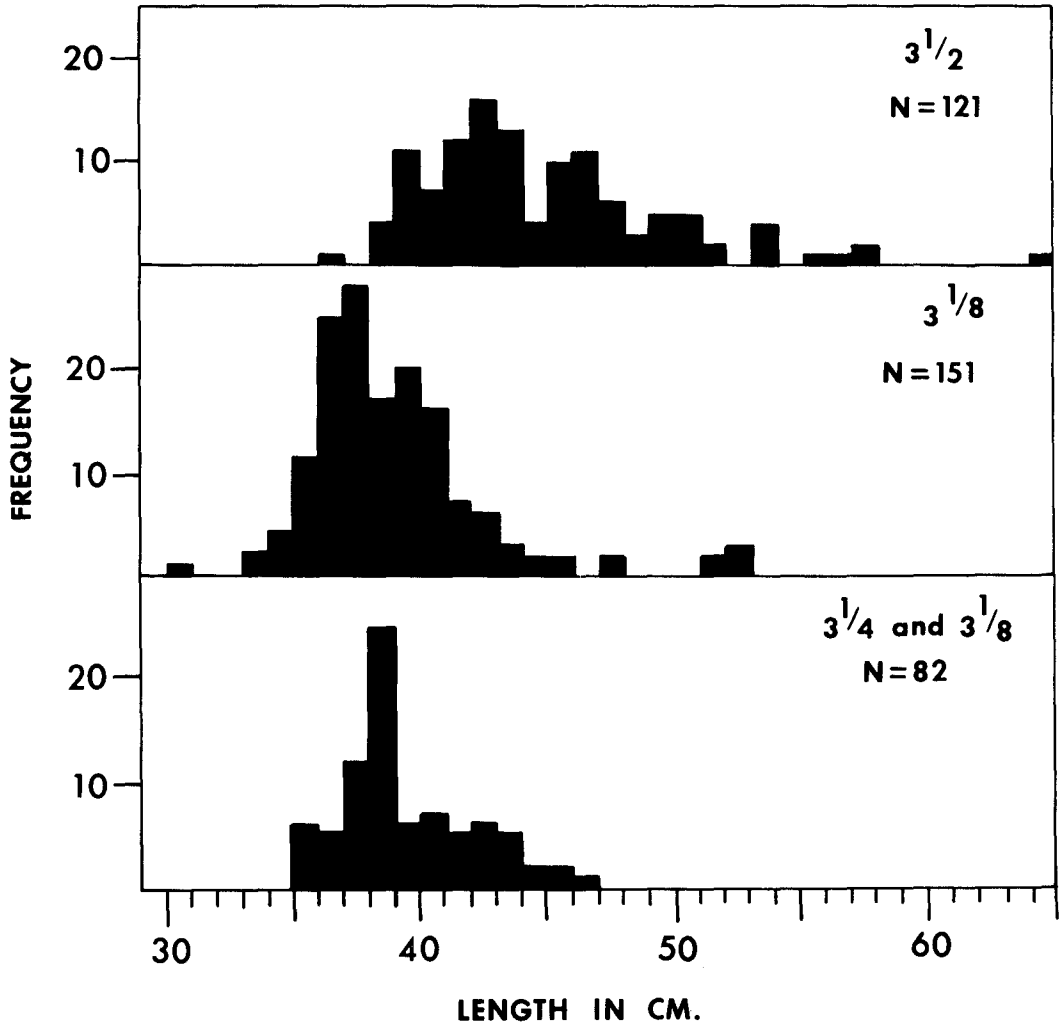

Figure 10. Length frequency distribution of Spanish mackerel sampled from various size gill nets used in southeast Florida (from Klima, 1959).

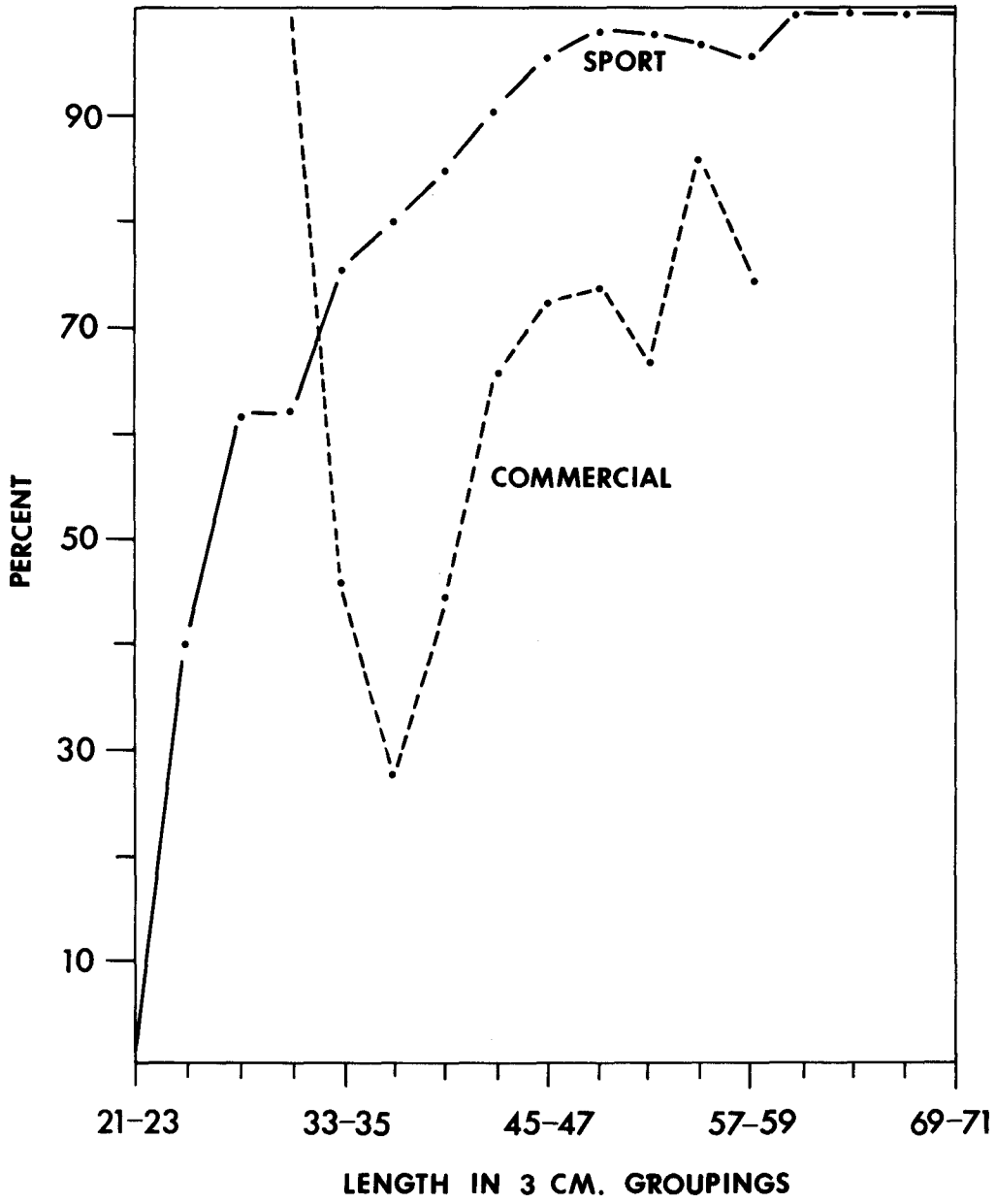

Figure 11. Percentages of Spanish mackerel females by size in commercial and sport fisheries (from Klima, 1959).

TABLE 9. Spanish mackerel landings (in thousands of pounds) by region and by fishery (commercial and sport); - = no data available, <1 indicates less than 500 lb landed.

	Commercial Fishery						Sport Fishery				
Year	New England	Middle Atlantic	Chesapeake	South Atlantic	Gulf Coast	Total	North Atlantic	Middle Atlantic	South Atlantic	Gulf Coast	Total
1888	-	-	-	-	312	-	-	-	-	-	-
1889	-	-	-	-	598	-	-	-	-	-	-
1890	-	-	-	-	693	-	-	-	-	-	-
1897	-	-	-	362	751	-	-	-	-	-	-
1902	-	-	-	1,013	1,584	-	-	-	-	-	-
1908	-	-	-	-	1,486	-	-	-	-	-	-
1918	-	-	-	3,211	3,522	-	-	-	-	-	-
1920	-	-	14	-	-	-	-	-	-	-	-
1923	-	-	-	2,652	3,865	-	-	-	-	-	-
1927	-	-	-	2,122	4,771	-	-	-	-	-	-
1928	-	-	-	2,250	3,351	-	-	-	-	-	-
1929	-	-	-	2,640	3,575	-	-	-	-	-	-
1930	-	-	-	2,159	4,195	-	-	-	-	-	-
1931	-	-	-	2,617	2,380	-	-	-	-	-	-
1932	-	-	-	3,531	2,934	-	-	-	-	-	-
1934	-	-	-	3,434	3,536	-	-	-	-	-	-
1936	-	-	-	4,193	5,266	-	-	-	-	-	-
1937	-	-	-	2,449	3,985	-	-	-	-	-	-
1938	-	-	-	2,916	4,309	-	-	-	-	-	-
1939	-	-	-	3,075	4,291	-	-	-	-	-	-
1940	-	-	-	2,756	3,695	-	-	-	-	-	-
1945	-	-	-	5,979	5,259	-	-	-	-	-	-
1948	0	0	33	5,979	6,064	12,076	-	-	-	-	-
1949	0	0	15	5,979	3,876	9,870	-	-	-	-	-
1950	0	0	14	3,724	2,593	6,331	-	-	-	-	-
1951	0	0	7	2,183	6,511	8,701	-	-	-	-	-
1952	0	0	3	3,609	4,517	8,129	-	-	-	-	-
1953	0	<1	3	3,775	3,015	6,793	-	-	-	-	-
1954	0	0	4	2,431	2,887	5,322	-	-	-	-	-
1955	0	0	0	3,403	1,627	5,030	-	-	-	-	-
1956	0	<1	16	4,925	2,919	7,860	-	-	-	-	-
1957	0	0	24	4,469	3,649	8,142	-	-	-	-	-
1958	0	<1	8	7,524	3,870	11,402	-	-	-	-	-
1959	<1	1	18	2,508	4,691	7,218	-	-	-	-	-
1960	0	0	20	2,406	5,468	7,974	0	0	24,830	11,330	36,160**
1961	<1	0	123	3,296	4,014	7,433	-	-	-	-	-
1962	0	0	15	2,674	6,912	9,601	-	-	-	-	-
1963	0	0	79	2,267	5,447	7,793	-	-	-	-	-
1964	0	<1	33	2,083	3,957	6,073	-	-	-	-	-
1965	<1	0	74	3,032	4,905	8,011	0	167	18,186	4,283	22,636*
1966	0	<1	142	2,261	7,066	9,469	-	-	-	-	-
1967	0	0	30	1,879	5,976	7,885	-	-	-	-	-
1968	0	<1	60	4,484	7,232	11,776	-	-	-	-	-
1969	<1	0	124	2,452	8,342	10,918	-	-	-	-	-
1970	<1	<1	201	3,639	8,269	12,109	0	946	14,623	7,808	23,377*
1971	0	<1	52	2,681	7,728	10,461	-	-	-	-	-
1972	0	<1	23	3,475	7,134	10,632	-	-	-	-	-
1973	0	<1	0	3,303	6,376	9,679	-	-	-	-	-
1974	0	2	24	2,422	8,553	11,001	-	-	-	-	-
1975	1	5	62	5,209	6,138	11,414	-	-	-	-	-

* Sport fishery statistics for 1965 and 1970 include data on Scomberomorus regalis and S. maculatus.
** Sport fishery statistics for 1960 include data on Scomberomorus cavalla, S. regalis and S. maculatus.

6. PROTECTION AND MANAGEMENT

6.1 Regulatory Measures

6.1.1 Limitation of Total Catch

During times of Spanish mackerel abundance company-owned boats in Florida are subject to maximum landing quotas, as set by the fish companies. This prevents flooding the market and enables most fishermen to earn a living. The quotas usually range from two to six thousand pounds per boat. The lowering of landings is affected by shortening nets (Klima, 1959).

6.1.2 Protection of Portions of Populations

In the state of Florida it is illegal to retain fish less than 12 inches (30 cm) long (FL).

6.2 Control or Alteration of Physical Features of the Environment

6.3 Control or Alteration of Chemical Features of the Environment

6.4 Control or Alteration of Biological Features of the Environment

No information found for sections 6.2, 6.3, and 6.4.

6.5 Artificial Stocking

Earll (1883) reported an attempt to artifically propagate Spanish mackerel. He was trying to determine the feasibility of hatching large quantities of eggs so that the young could be stocked at various places on the Atlantic coast. By carrying out such propagation and subsequent stocking, the United States Commission of Fish and Fisheries hoped to increase the supply of food fish. Earll (1883) succeeded in rearing a small number of *S. maculatus* to the end of their yolk-sac stage. He concluded that, because: 1) the spawning season lasts for several months; 2) eggs are available in abundance; and 3) the hatching time is short; the Commission could produce a large number of young Spanish mackerel in a short time and with a small work force.

7. POND FISH CULTURE

No information found.

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