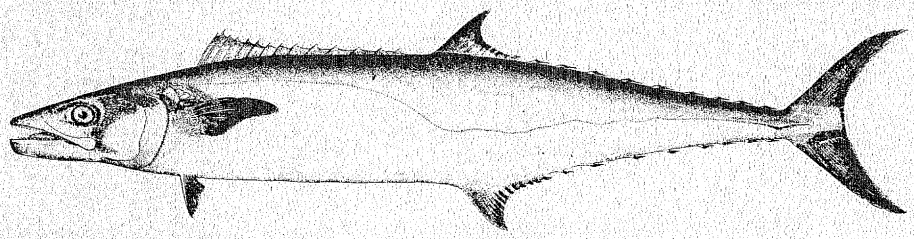

BIOLOGICAL & FISHERIES DATA
ON
KING MACKEREL, *Scomberomorus cavalla* (Cuvier)

NOVEMBER 1977

Biological and Fisheries Data

on

king mackerel, *Scomberomorus cavalla* (Cuvier)

by

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1.e IDENTITYe

1.1 Nomenclaturee

1.1.1 Valid Name

Scomberomorus cavalla (Cuvier) 1829.

First described under the name Guarapucu by Marcgrave, in Hist. Brazil, 1648, p. 178; but this is not recognized under ICZN rules because it was published before 1757.

Present-day taxonomists credit Cuvier with the priority description of this species under the name Cybium cavalla in his Règne Animal, ed. 2, II. 1829, p. 200.

1.1.2 Synonomy

Guarapucu Marcgrave 1648, Hist. Brazil, p. 178, (Brazil).

Cybium cavalla Cuvier 1829, Règne Animal, p. 200 (after Marcgrave; Brazil).

Cybium caballa (Cuvier and Valenciennes 1831, Hist. Nat. Poissons, VIII, p. 19. (no locality).

Scomberomorus caballa Goode and Bean 1882, Proc. U. S. Nat. Mus., p. 237.

Scomberomorus cavalla Jordan 1884, U. S. Nat. Mus., p. 119 (Key West).

1.2 Taxonomye

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; and Bailey et al., 1970).

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

Genotype: Scomberomorus plumierii Lacépède 1802 (=Scomber regalis Block, 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 the 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 National Marine Fisheries Service 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 (plumierii).

Cybium, Cuvier, Règne Animal, ed 2, II, p. 120, 1829 (commersoni).

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 sand-like teeth on 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 (subgenus Cybium) or absent (subgenus Scomberomorus).

Species: Scomberomorus cavalla Cuvier.

The type specimen of S. cavalla was described by Cuvier (1829). Apparently, Cuvier based his description on work by Marcgrave (1648) which the ICZN has not considered available enough to warrant credit for the original description. The type locality for both of these descriptions is Brazil.

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

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

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

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

Two tables from Mago-Leccia (1958) present data on several different characters of the three western North Atlantic species of Scomberomorus (Tables 1 and 2).

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

Table 2. Synopsis of differential characteristics for Scomberomorus cavalla, S. maculatus, and S. regalis. *eindicates that regalis is similar to maculatus (from Mago-Leccia, 1958).e

Character	cavalla	maculatus	regalis
1.e Temporal ridgee	Straight or slightly convex. Not prolonged posteriorly.	Concave. Prolonged posteriorly.	*
2.e Auxiliary ridgee	Low	High	*
3. Vomer	Thick and somewhat pointed.	Thin and spatulate.	*
4.e Frontalse	The slit (pineal window) at the level of alisphenoids. Conspicuous.	The slit (pineal window) inconspicuous and carried a little forward from the level of alisphenoids.	*
5.e Alisphenoidse	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. Parasphenoide	Broad. The median keel not forming a cutting-edge.	Narrow. The median keel forming a cutting-edge.	*
7.e Basisphenoide	Median anterior process broad. Not needle-shaped.	Median anterior process eneedle-shaped.e	*
8.e Hyomandibulare	Lamella broad.	Lamella narrow.e	*
9.e Scapulae	Foramen small.	Foramen small.e	Foramen very large.
10.e Pelvic girdlee	Anterior external portion broad.	Anterior external portione narrow.e	Anterior external portion narrow.
11.e Vertebral columne	First closed haemal arch occurring at vertebra number 10. First haemal spine at vertebra 18th or 19th. Total number of vertebrae 42 or 43.	First closed haemal arche occurring at vertebrae number 13 to 15. Firste haemal spine at vertebrae 22nd to 24th. Total numbere of vertebrae 52 or 53.e	First closed haemal arch occurring at vertebra number 12. First haemal spine at vertebra 20th or 21st. Total number of vertebrae 47 to 49.

1.2.2 and 1.2.3 Taxonomic and Subspecies Status

Of the three species of Scomberomorus found in the western Atlantic, S. cavalla is considered to be the most divergent (Mago-Leccia, 1958). It is considered as a distinct species (Rivas, 1951) possibly closely related to S. chinense of the Pacific Ocean (Mago-Leccia, 1958), or possibly synonymous with that last-named species under the nameeS. cavalla (Fraser-Brunner, 1950). If the two forms are synonymous, S. cavalla of the Atlantic and S. chinense of the Pacific, they are separate populations. Whether or not these two forms are separate species, subspecies, or are the same species is unsettled.

1.2.4 Common Names

King mackerel, kingfish, cavalla, serrucho, sierra, carite, and cero.

1.3 Morphology

1.3.1 External Morphology

The following description is based on several sources: Dresslar and Fesler, 1889; Jordan and Evermann, 1896-1900; Meek and Hildebrand, 1923; Fraser-Brunner, 1950; Rivas, 1951; Bigelow and Schroeder, 1953; Mago-Leccia, 1958; Butz and Mansueti, 1962; Randall, 1968; and Miller and Jorgenson, 1973. Dorsal fin XIV to XVI - I, 14 to 16 + 8 to 11 finlets; anal fin II, 14 to 17 +e8 to 10 finlets (Miller and Jorgenson, 1973 report four anale spines with 13 to 15 soft rays); gill rakers 1 to 3 + 1 + 5 toe 9; and vertebrae 17 to 19 + 23 to 26 = 42 or 43 total. Menezese (1969) noted that king mackerel from Brazil have 0 to 3 + 0e or 1 + 5 to 9 gill rakers (usually 1 or 2 + 1 + 6 to 8) fore a total of 6 to 13 rakers and have 41 or 42 vertebrae.e Figure 1 is from Goode (1884).e

The body is 4.25 to 5.0 times as long as the head and 5.5 to 6.25 times as long as deep. The head is 2.45 to 2.5 times as long as the snout, 5.0 to 5.8 times as long as the eye, 1.65 times as long as the maxillary, and 1.65 to 1.70 times as long as the pectoral fins. The gill rakers are less than one-third the eye diameter.

The color of S. cavalla has been described as bluish or iron gray dorsally, silvery on sides and belly, and having pale to dusky fins. The anterior portion of the spinous dorsal fin is not darker than the remainder of the fin. Several authors report that the young have yellowish spots on their sides but that the adults have only vague markings or none at all. Butz and Mansueti (1962) described the coloration of two S. cavalla,

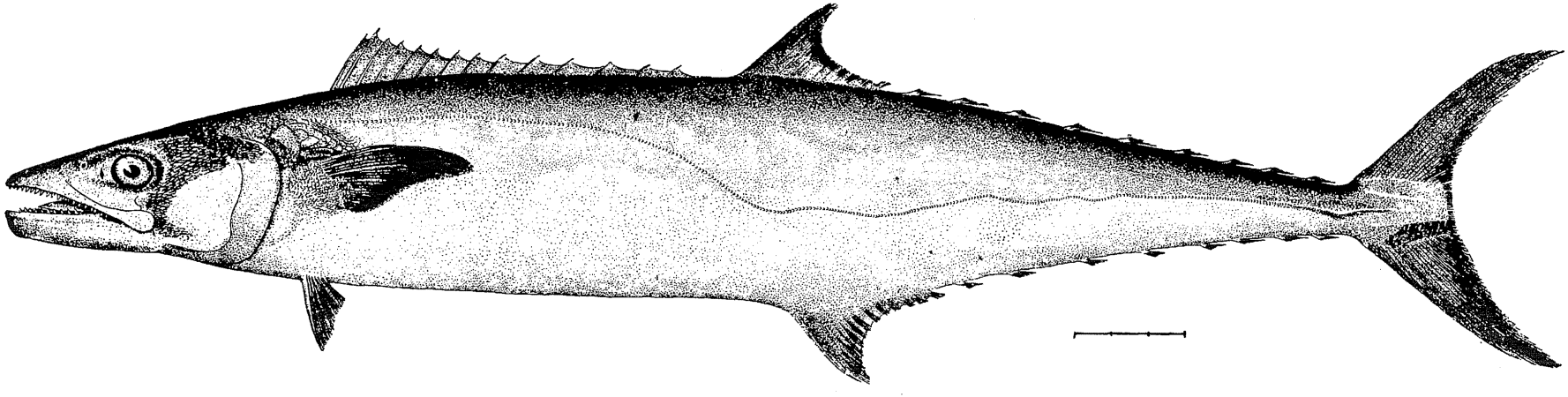

Figure 1. Adult Scomberomorus cavalla (from Goode, 1884).

43.e7 and 43.8 inches long and 26.8 and 27.0 lb. respectively, ase silvery with faint yellow spots over the entire body. Thesee spots faded soon after capture and had disappeared by 2½ days later.e

Scales cover the entire body; a corselet is not developed. The lateral line is abruptly decurved below the origin of the seconde dorsal fin. The gill rakers are short, about ¼ of the eye diameter in adults, and there are fewer gill rakers than in othere species of this genus. The mouth is large and oblique; thee maxillary reaches to slightly beyond the posterior edge of thee eye. The teeth are compressed, triangular and number frome 40 to 60 on each jaw, with large fish having more teeth thane small ones. The pectoral fin is without scales and reachese a vertical from the 8th or 9th dorsal spine. The anal ande second dorsal fins are similar in outline and are scaled;e the origin of the second dorsal is ahead of the anal fin origin. The pelvic fins are longer than the eye but shorter than thee snout. There is a large dermal keel on the caudal peduncle. An air bladder is present.e

1.3.2 Cytomorphology

Engel and Davis (1964) studied the blood composition of seven species of fish. They were trying to relate activity levels (benthic-sluggish vs. pelagic-active) to hemoglobin levels and erythrocyte counts in these species. Engel and Davis' (1964) data included here in Table 3, shows that S. cavalla, a pelagic species, has higher hematocrit,e hemoglobin content, and erythrocyte counts than do thee benthic species investigated.e

1.3.3 Protein Specificity

No information found.

2.e DISTRIBUTIONe

2.1 Total Areae

Scomberomorus cavalla inhabits tropical and subtropical waters of the western Atlantic Ocean from the Gulf of Maine to Rio de Janiero, Brazil, including the Gulf of Mexico and Caribbean Sea (Rivas, 1951; Bigelow and Schroeder, 1953; Briggs, 1958; Randall, 1968; and Beaumariage, 1973). It is a summer and fall visitor along the northeastern United States coast, regularly north to North Carolina

Species	Hematocrit Percent of Volume		Hemoglobin Grams Percent		Erythrocytes X10^4 Cells/ml		Thrombocytes X10^4 Cells/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	32.0-34.0	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

or Virginia, occasionally to southern Massachusetts and rarely, as a stray, to Cape Cod and the southern Gulf of Maine (Bigelow and Schroeder, 1953; Butz and Mansueti, 1962; Beaumariage, 1969).

The mackerel S. sinensis (=S. chinensis) (possibly synonymous with S. cavalla according to Fraser-Brunner (1950) occurs in the Pacific Ocean, off Japan and northern China (Munro, 1943).

2.2 Differential Distribution

2.2.1 Spawn, Larvae and Juveniles

There is no information on distribution of eggs; however, larval and juvenile S. cavalla have been found in the Gulf of Mexico and off the coast of the southeastern United States.

Wollam (1970) reported occurrences on larval and juvenile S. cavalla off southwestern Florida in May, in the Yucatane Channel in June and July, off eastern Florida and in thee northern Gulf of Mexico in September, and off Cape Hatteras,e North Carolina in August, September, and November.e

Dwinell and Futch (1973) found S. cavalla larvae in the northern Gulf of Mexico, off Florida and Alabama, during the months of June, July, August, September, and October (all of the months that sampling was conducted).

Perrett et al. (1971) reported taking two juvenile S. cavalla off Louisiana during the months of June and September.

Nakamura (1976) caught two juveniles, 59.8 and 110.0 mm, in October, in St. Andrew Bay, Florida, on the northeastern border of the Gulf of Mexico.

2.2.2 Adults

Adult S. cavalla occur in the same areas as mentioned for the larvae and juveniles, as well as over a greater known range (see section 2.1 Total Distribution). There are seasonal variations in distribution which are most certainly due to migrations (see section 3.5.1).

2.3 Determinants of Distribution Changes

Temperature and salinity are believed to be important factors in determining the distribution of Scomberomorus cavalla. Munro (1943) stated that all species of the genus Scomberomorus are coastal inhabitants, seldom inhabiting water deeper than 40 fathoms

(73 m), and prefer water of medium salinity, neither low, as in upper parts of estuaries, nor high, as in open ocean waters. All known species of Scomberomorus are tropical or subtropical in distribution. Munro (1943) stated that the range of all species is determined by the 68°F (20°C) summer ocean isotherm, in both hemispheres. Annual spawning migrations are made in order to stay above this temperature. Basing his decision on the 68°F temperature limit, Beaumariage (1969) predicted a northerly range limit in the vicinity of Block Island, Rhode Island.

Butz and Mansueti (1962) reported on the occurrence of three S. cavalla adults in Chesapeake Bay, further north in the bay than previously known. These authors supposed that droughta conditions, with consequent less fresh water runoff, had causeda a greater than normal incursion of salt water and thereby allowed these fish to inhabit an area normally too fresh fora their existence.

2.4 Hybridization

A 621-mm long, possibly 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, anda possibly a female. However, Beaumariage (1973) concluded thata this may have been an unusually large, but still immature,a S.a cavalla.a

3.a BIONOMICS AND LIFE HISTORYa

3.1 Reproductiona

3.1.1 Sexuality

King 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 faster growth rate in females than in males, and a size, and age, difference between the sexes at maturity (see the following section on maturity).

3.1.2 Maturity

Beaumariage (1973) studied gonad development in S. cavalla from Florida waters. He concluded that, although there was some reproductive activity evident from histological examination in age-III females and age-II males, the first major spawning by females occurs at age-IV and by males at age-III. Based on Beaumariage's data, female S. cavalla at age-IV average 819 mm in length (SL) and 5.0 kg in weight; males at age-III average 718 mm in length (SL) and 3.2 kg in weight (Figures 5 and 7).

In contrast to Beaumariage's (1973) study, Ivo (1972) found that female S. cavalla off Brazil obtain sexual maturity between ages V and VI, at approximately 77.0 cm (FL) and 3.5 kg. Some females as young as age-III were mature and some as old as age-VII were immature.

3.1.3 Mating

No information found.

3.1.4 Fertilization

Fertilization is external.

3.1.5 Gonads

Alves and Tome (1967) present a histological description of S. cavalla 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. In a later paper these same authors reported characteristics of semen and described spermatozoa of king mackerel (Alves and Tome, 1968). They found 30% motility after 24 hr. and 10% after 72 hr.

Ivo (1974) derived the following fecundity estimate equations for 39 S. cavalla females from Brazilian waters:

fecundity (F) vs. total length, in cm (TL)

$$F = (-18.763 + 0.321\ TL) \times 10^5$$

fecundity (F) vs. age (A)

$$F = (-6.512 + 2.179\ A) \times 10^5$$

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

$$F = (-4.123 + 0.003\ W) \times 10^5$$

3.d.6 Spawninge

Beaumariage (1973) reported spawning of S. cavalla in Florida is protracted and multiple. His evidence for the protracted spawning was the presence of, in the ovaries, stage IV oocytes (those with yolk) from April through November. He felt that there were several peaks in spawning throughout one season as evidenced by the varying average diameter of stage IV oocytes in his samples throughout the season. An increase in average oocyte diameter he supposed indicated a peak in spawning. Wollam (1970) reported that S. cavalla had ripe gonads from late July through September and that fish with spent gonads were present in increasing numbers from late August until early October.

Further evidence of protracted spawning is the presence of larvae and juveniles over a long season, from May until November within the range of the species along the United States east coast and Gulf of Mexico (see Differential Distribution, section 2.2.).

Menezes (1969a), in connection with a feeding study of S. cavalla from Brazilian waters, noted that this species spawns during the fourth and first quarters of the year. However, Ivo (1972) observed spawning-stage gonads in female S. cavalla throughout the year in Brazil.

Beaumariage (1973) correlated gonad development with seasonal changes in photoperiod, and concluded that some environmental cues such as photoperiod or temperature probably influence gonad development and spawning.

3.2 Pre-Adult Phase

3.2.1 Embryonic Phase

No information found.

3.2.2 and 3.2.3 Larval and Adolescent Phase

Wollam (1970) described larval and juvenile Scomberomorus cavalla using specimens from plankton collections. The following summary, illustrations, and two tables of meristic and morphometric data are from Wollam (1970) (Figures 2 and 3, Tables 4 and 5).

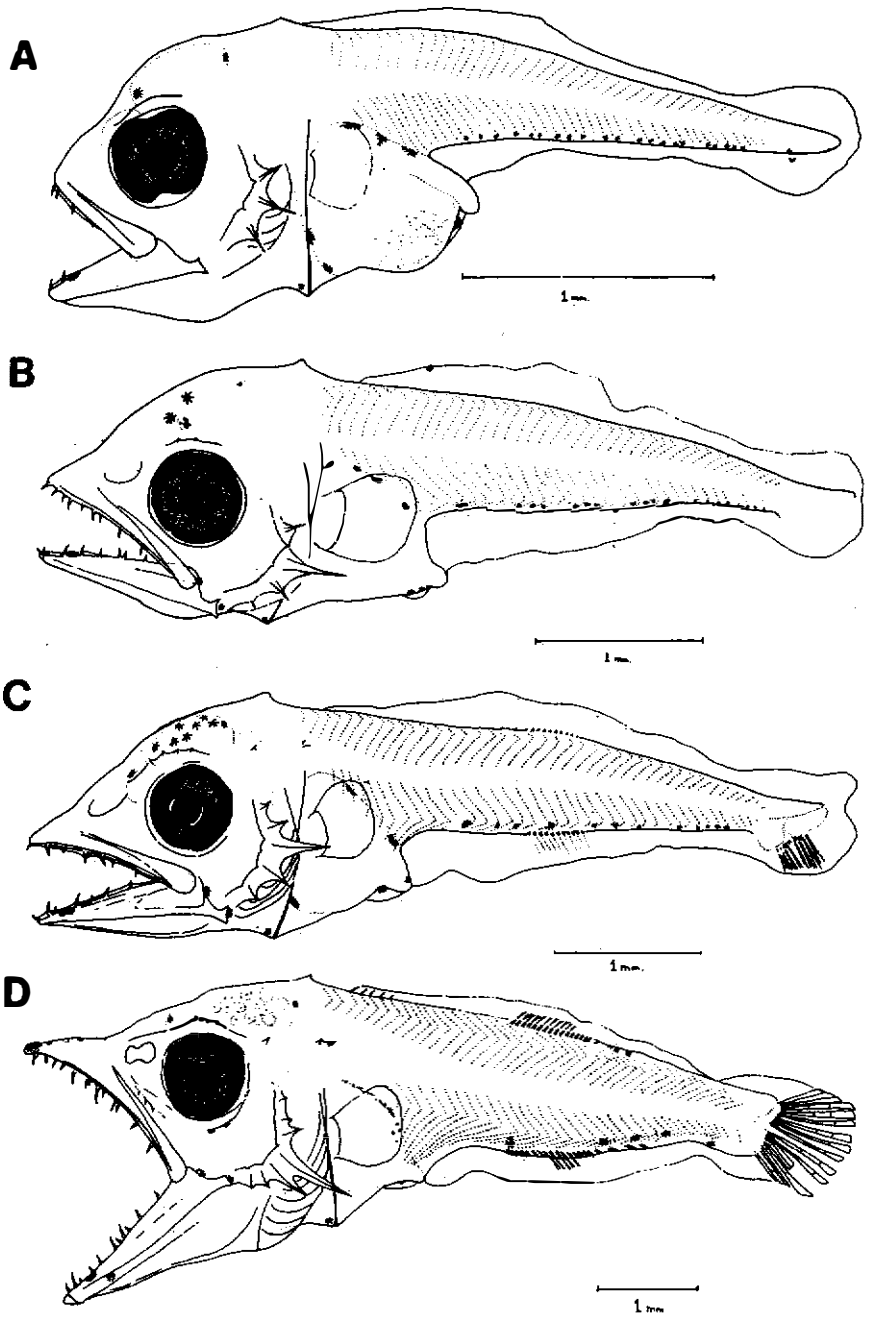

Figure 2. King mackerel larvae: A, 3.3 mm; B, 4.7 mm; C, 5.6 mm; D, 7.6 mm (from Wollam, 1970).

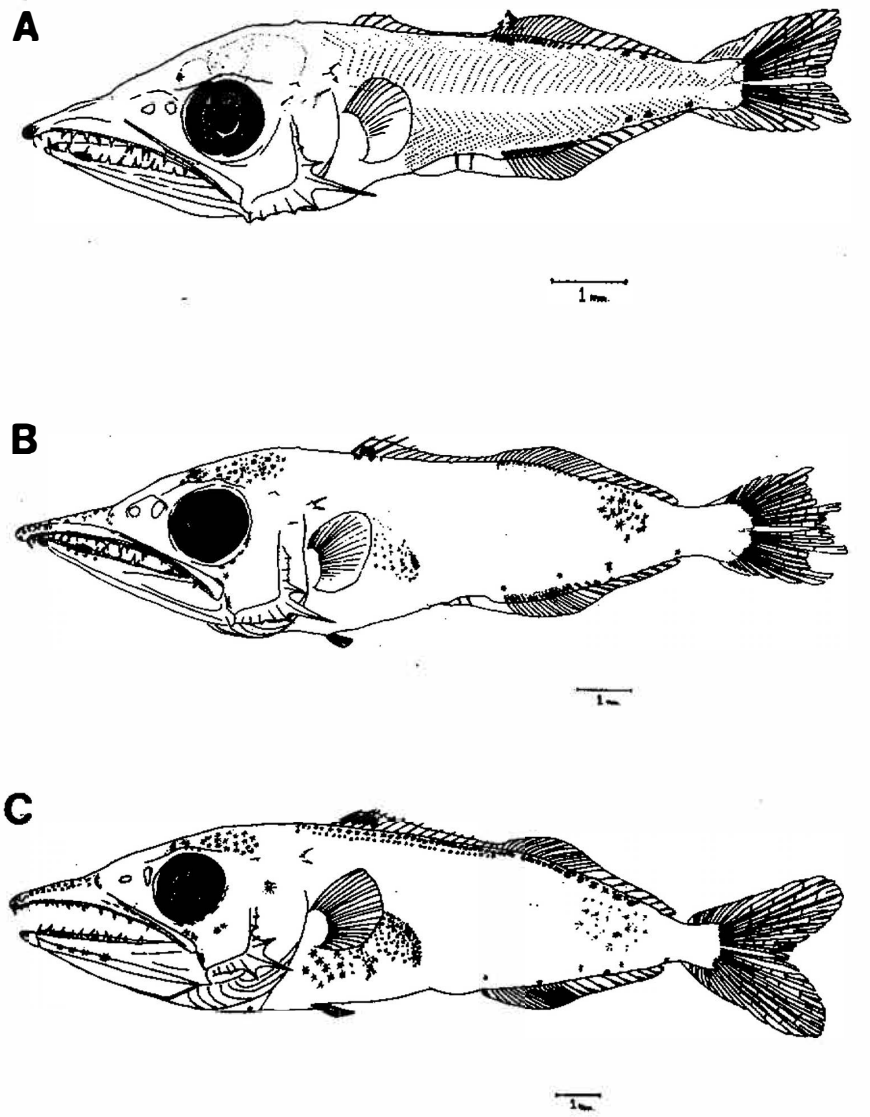

Figure 3. King mackerel larva: A, 10.0 mm; and juveniles: B, 13.1 mm; C, 17.0 mm (from Wollam, 1970).

TABLE 4. Meristic counts of cleared and stained larval and juvenile king mackerel (from Wollam, 1970).

Collection Number	Standard Length (mm)	Teeth Upper Jaw	Teeth Lower Jaw	Branchiostegal Rays[2]	Myomeres	Vertebrae Trunk	Vertebrae Caudal	Preopercular Spines	First Dorsal Fin Spines	Anal Fin Spines	Second Dorsal Fin-rays and finlets	Anal Finrays and Finlets	Pectoral Finrays	Pectoral Fin Spines and Rays	Caudal Finrays-Dorsal (principal and secondary)	Caudal Finrays-Ventral (principal and secondary)
FBC-5834L	3.3	3	2	2	42	-	-	3	-	-	-	-	-	-	-	-
FBC-5834L	3.7	6	5	5	43	-	-	5	-	-	-	-	-	-	-	-
FBC-5834L	4.3	7	6	5	43	-	-	6	-	-	-	-	-	-	-	-
FBC-5834L	4.7	10	9	5	42	-	-	5	-	-	-	-	-	-	-	-
FBC-5832L	5.3	12	10	6	43	-	-	6	-	-	-	-	-	-	2 + 0	2 + 0
FBC-5832L	5.6	10	8	6	42	-	-	6	-	-	-	-	-	-	5 + 0	4 + 0
FBC-5832L	5.8	9	10	6	43	-	-	6	-	-	-	-	-	-	3 + 0	2 + 0
FBC-5830L	6.5	11	14	7	42	-	-	7	-	-	-	-	-	-	5 + 0	5 + 0
FBC-5832L	7.2	12	13	7	43	-	-	8	-	-	-	-	-	-	8 + 0	8 + 0
FBC-5833L	7.6	14	11	7	43	-	-	8	3	-	6	3	4	-	9 + 0	8 + 2
FBC-5829L	10.0	17	13	7	43	32	total	9	16	1	22	21	8	1,2	9 + 5	8 + 5
FBC-5828L	13.1	16	14	7	-	17	25	10	16	2	25	24	14	1,5	9 + 8	8 + 8
L-32	16.5	23	20	7	42	17	25	10	16	2	25	24	17	1,5	9 + 12	8 + 12
FBC-5827L2	23.0	24	19	7	-	17	25	8	16	2	26	25	21	1,5	9 + 13	8 + 12
FBC-5827L2	31.0	29	25	7	-	18	24	5	16	2	25	25	21	1,5	9 + 14	8 + 13

TABLE 5. Measurements (mm) of body parts of cleared and stained larval and juvenile king 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-5834L	3.3	1.00	0.21	0.39	0.10	0.42	0.48	0.44	1.62	--	--	0.27
FBC-5834L	3.7	1.33	0.46	0.48	0.14	0.68	0.72	0.55	1.83	--	--	0.28
FBC-5834L	4.3	1.20	0.32	0.46	0.16	0.70	0.64	0.60	1.96	--	--	0.32
FBC-5834L	4.7	1.35	0.42	0.46	0.20	0.88	0.68	0.58	2.10	--	--	0.42
FBC-5832L	5.3	1.748	0.42	0.60	0.28	1.08	1.22	0.768	2.68	--	--	0.48
FBC-5834L	5.6	1.888	0.70	0.62	0.30	1.24	1.14	0.688	2.52	--	--	broken
FBC-5832L	5.8	1.608	0.66	0.64	0.30	1.20	0.92	0.788	2.64	--	--	0.53
FBC-5830L	6.5	2.308	0.96	0.74	0.46	1.588	1.43	0.928	3.08	--	--	0.74
FBC-5832L	7.2	2.688	1.32	0.84	0.64	1.938	1.81	1.048	3.64	--	--	0.94
FBC-5833L	7.6	2.968	1.47	0.94	0.87	2.188	2.09	1.378	4.28	--	--	0.99
FBC-5829L	10.0	4.288	2.08	1.16	1.29	3.028	2.62	1.808	5.25	4.66	6.74	1.26
FBC-5828L	13.1	5.588	2.66	1.48	1.81	3.768	3.18	2.408	7.46	6.15	8.75	1.34
L-38	16.5	7.158	3.58	1.88	2.46	5.12	4.27	3.578	11.00	7.75	11.10	1.50
FBC-5827L8	23.0	8.818	4.14	2.14	2.76	5.708	4.98	4.798	14.30	9.55	15.60	1.18
FBC-5827L8	31.0	10.708	4.72	2.46	2.96	6.618	5.96	6.618	19.30	12.00	19.60	1.12

The number of myomeres (42 or 43), large mouth with well developed teeth, strong preopercular spines, numerous fin elements, and characteristic pigmentation are distinctive in this species.

Melanophores develop over the brain, on the snout, below the eye, and between the maxilla and premaxilla. A very conspicuous melanophore forms on each dentary in early larvae as small as 3.3 mm SL, about one-third of the distance back from the mandibular symphysis. A melanophore is present at the cleithral symphysis at all sizes in Wollam's series; and one melanophore is found just before the vent while the preanal finfold persists. A series of melanophores is found on the ventral midline, postanally, which decreases in number from about 29 in early larvae to only 4 or 5 melanophores by a size of 7.6 mm SL. Pigmentation occurs over the gut in all sizes. Dorsal pigmentation is found on larvae at sizes from 7.6 mm and larger. This pigment first forms near the developing dorsal finlets; then by 12.4 mm it is found near the base of the first dorsal fin, and by 17.0 mm these two areas of dorsal pigment have increased and merged. Between 12.4 and 17.0 mm melanophores near the dorsal finlets have proliferated and formed a saddle-shape patch. At larger sizes, between 17.0 and 31.0 mm, midlateral pigment forms, connecting the saddle-shape patch with an expanding area of pigmentation beneath the origin of the first dorsal fin.

The only fin to become pigmented is the spinous, first, dorsal fin. The anterior interradial membranes of the first dorsal become pigmented starting at about 13.0 mm; the first five or six spines are pigmented by 17.0 mm and there are scattered melanophores on the rest of this fin by a length of 31.0 mm.

3.3 Adult Phase

3.3.1 Longevity

Scomberomorus cavalla live as long as 13 years (Beaumariage, 1973)

3.3.2 Hardiness

No information found.

3.3.3 Competitors

No information found.

3.3.4 Predators

Man is a predator of S. cavalla, certainly of large fish.

3.3.5 Parasites, Diseases and Abnormalities

The following lists the parasites reported as occurring on Scomberomorus cavalla; no information on diseases or abnormalities was found.

Copepoda - Order Caligoidae, Family Caligidae

Caligus pelamydis Kroyer 1863; on gills; Veracruz, Texas, and Grand Isle, Louisiana (Causey, 1960; Silas and Ummerkutty, 1964).

Caligus productus Dana 1852; on gills; Gulf of Mexico (Silas and Ummerkutty, 1964).

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

- Order Caligoida, Family Dichelesthiidaea

Pseudocyncus buccatus Wilson; Veracruz, Mexico (Causey, 1960).

- Order Lernaeopodoida, Family Lernaepodidaea

Charopinus quarternius Wilson 1915; on gills; Grand Isle, Louisiana (Silas and Ummerkutty, 1964).

Brachielle thynni Cuvier 1817; on gills; Texas (Silas and Ummerkutty, 1964).

Cestoda -

Synbothrium filicolle Linton; in elongate cysts on viscera (Linton, 1897; Linton, 1901).

- Order Trypanorhyncha, Family Tentacularidae

Tentacularia coryphaenae (Bosc, 1802); in body cavity (Ward, 1954).

Trematoda - Order Monogenea, Family Gastrocotylidae

Scomberocotyle scomberomori (Koranth, 1955); on gills; Alligator Harbor, Florida, Tampa Bay, Florida, Port Aransas, Texas (Hargis, 1956).

Pseudaxine mexicana Meserve, 1938; on gills; Alligator Harbor, Florida, Grand Isle, Louisiana (Hargis, 1956; McMahon, 1964).

Lithidocotyle acanthophallus MacCallum and MacCallum, 1913; on gills; Alligator Harbore Florida, Tampa Bay, Florida, Grand Isle, Louisiana (Hargis, 1956; McMahon, 1964).

Thoracocotyle crocea MacCallum, 1913; on gills; Beaufort, North Carolina (Pearsee 1949; McMahon, 1964), Alligator Harbor, Florida (Hargis, 1956; McMahon, 1964).

Thoracocotyle paradoxica Meserve; on gills; Beaufort, North Carolina (Pearse, 1949).

- Family Bucephalidaee

Bucephalopsis arcuatus (Lintone 1900); on caeca and intestine (Ward, 1954).

Nematoda - Order Ascariodoidae, Family Ascaridae

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

3.4 Nutrition and Growth

3.4.1 Feedinge

Menezes (1969) studied feeding habits of 798 Scomberomorus cavalla (in Brazil); her conclusions follow: 1) females are more voracious than males, as evidenced by the greater average volume of food in female stomachs than in males; 2)e although the differences are not great, females showe a greater preference for clupeid fishes and loliginid mollusca than do males; 3) there is a reduction in feeding during October through December caused by the onset ofe spawning, and there is a marked increase in feeding during January through March, after most S. cavalla havee finished spawning.e

Various organs of the digestive system in S. cavalla, including the esophagus, stomach, intestine, pyloric caeca, liver and gall bladder, were studied histologically and described by Alves and Tome (1966, 1967b, 1970).

3.4.2 Food

In a study of food items among 798 S. cavalla from Brazil, Menezes (1969) found that this species is a carnivore; fishes, crustaceans, and molluscs are the foods eaten, in that order of decreasing abundance. Among the fishes eaten, clupeids, chiefly the thread herring, Opisthonema oglinum, are the most important. Among crustaceans, shrimp (Penalidae) are eaten most often. And among molluscs, squids (Loliginidae) are the most important.

Menezes' (1969) study agrees with work in Texas by Knapp (1950) and in Florida by Beaumariage (1973). Knapp (1950) found fish and shrimp most prominent in stomach contents of 327 S. cavalla. Beaumariage (1973) reported that only 39% of the 306 S. cavalla stomachs examined contained food. Food items included: clupeid fishes (59% of stomachs with food), largely Opisthonema oglinum and Harengula pensacolae; other fishes (8% of stomachs with food) of the families Carangidae, Lutjanidae, Pomadasyidae, Sparidae, or Triglidae; and invertebrates (33% of stomachs with food) including shrimp, squid, and a scallop.

3.4.3 Growth Ratea

Dwinell and Futch (1973) estimated that their smallest S.a cavalla (2.8 mm SL) was probably not much over threea days old and their largest (28.8 mm SL) was probably onlya about one month old.a

Beaumariage (1973) studied age and growth of S. cavalla in Florida. He found that females grow faster than males; Figure 4 is included here to illustrate that relation. S.a cavalla growth rate data by Beaumariage (1973) compareda to that from Brazil by Nomura and Rodrigues (1967), is alsoa included here (Figure 5). Results of the two studies doa not agree except in that females grow faster and attaina a larger size than males.a

Nomura and Rodrigues (1967) reported an average condition factor (K) of 8.07 for 1,504 S. cavalla 36 to 120 cm FL taken off Brazil throughout the year.

3.5 Behaviora

3.5.1 Migrations and Movements

It is believed that Scomberomorus cavalla in United States coastal waters perform annual migrations. General statements

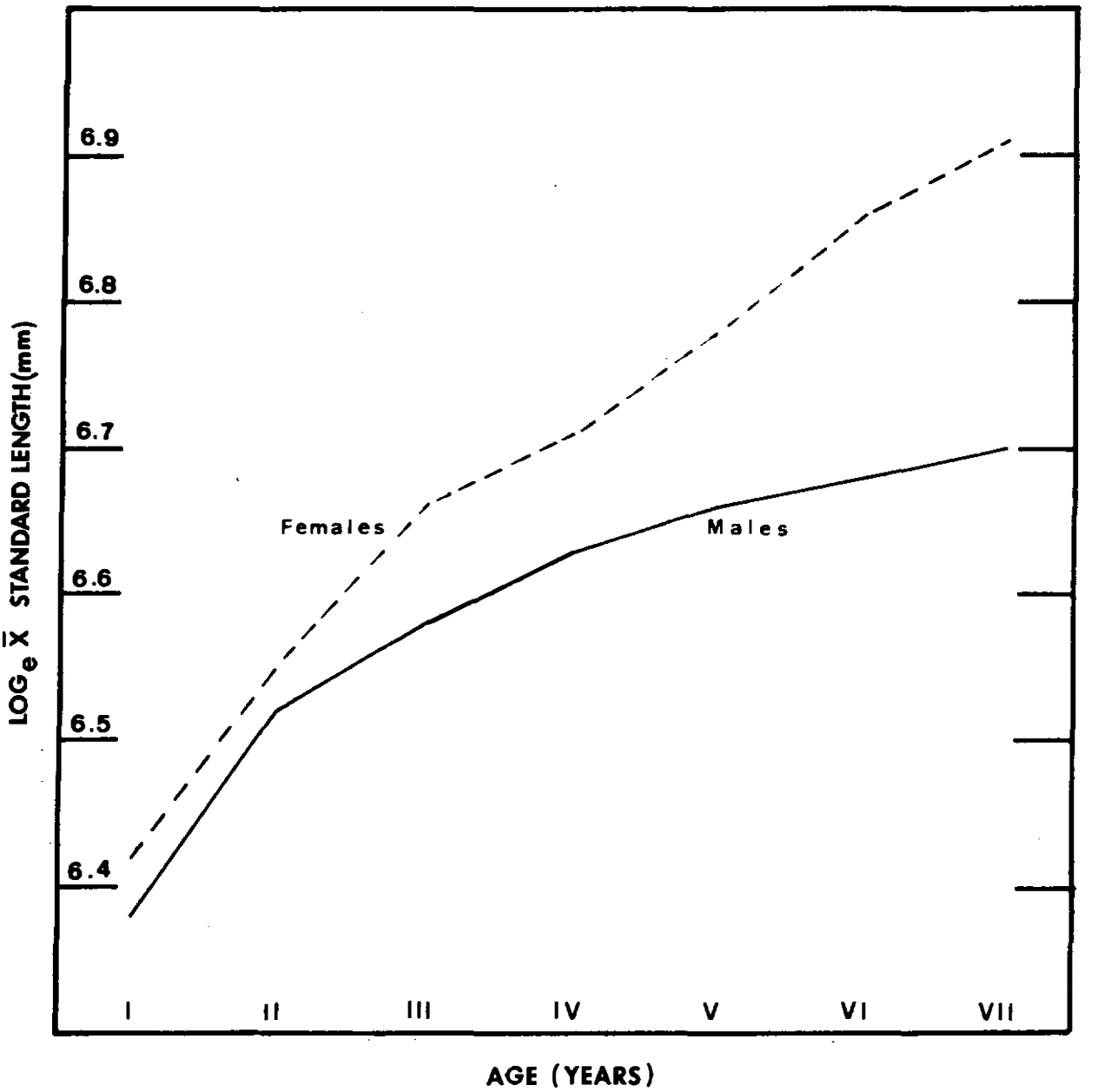

Figure 4. Relative annual growth of each sex of S. cavalla throughout Florida (from Beaumariage, 1973).

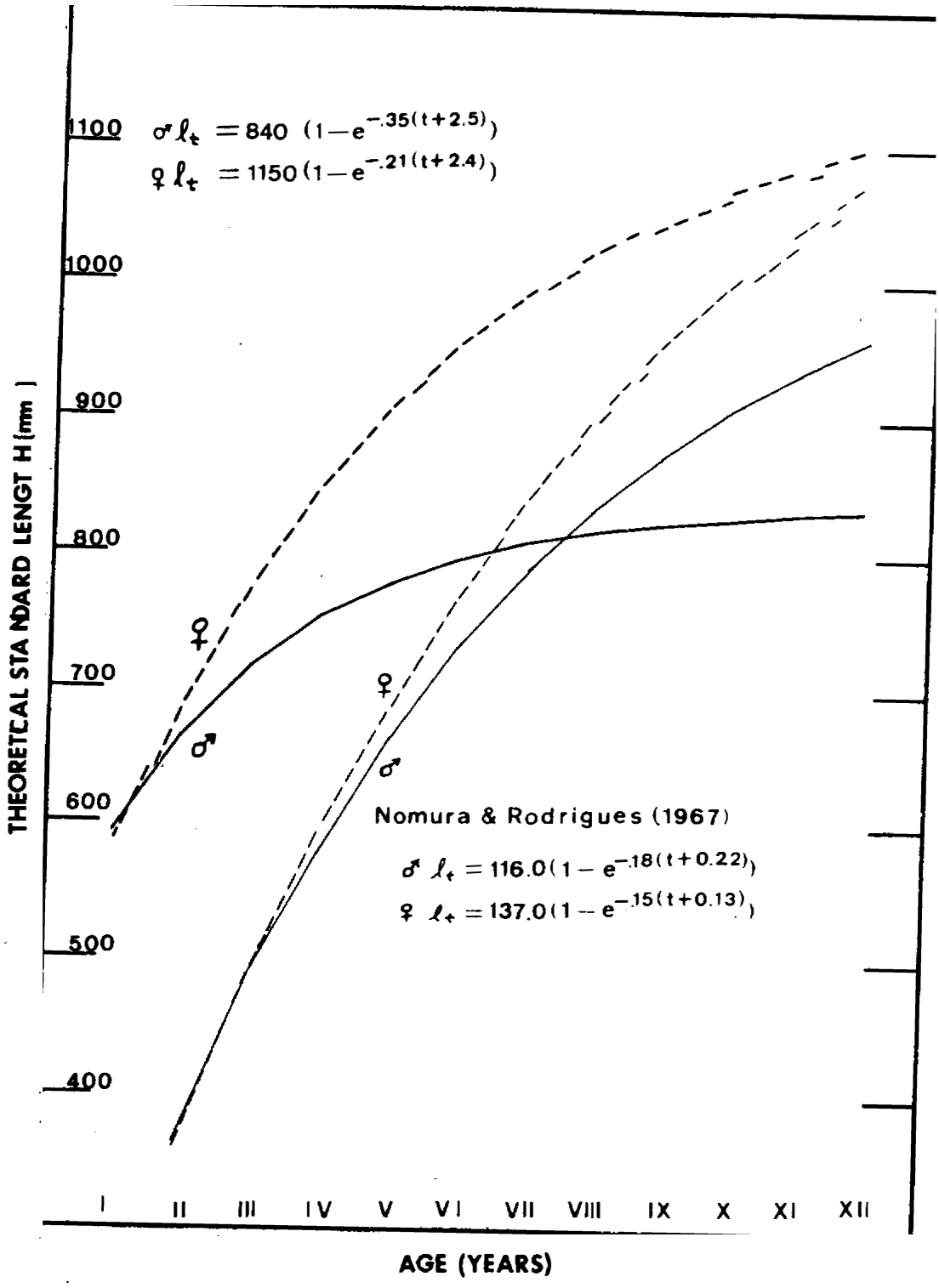

Figure 5. Theoretical growth curves of king mackerel from Brazil compared with those from Florida waters. Nomura and Rodrigues' equation measurements (FL cm) were converted after deriving the size at each age to SL mm (SLa= $\frac{\text{FLa}+ 17.143}{1.096}$ to facilitate comparison with Beaumariage's theoretical growth rates, the uppermost curves (from Beaumariage, 1973).

about such migrations imply: a southern Florida and Florida Keys wintering area; northerly movement away from the wintering area on the west coast of Florida and the United States Atlantic coast in the late spring and summer; a summer and early fall spawning area in the northern Gulf of Mexico, and on the Atlantic coast anywhere from northern Florida and South Carolina to Cape Hatteras, with strays to southern New England; and a fall, southerly migration to Florida waters (Smith, 1907; LaMonte, 1951; Migdalski, 1958; Dwinell and Futch, 1973).

3.5.2 Schooling

Small S. cavalla (no sizes given) tend to travel in schools while larger fish occur in small groups or as individuals (Migdalski, 1958; Beaumariage, 1973).

3.5.3 Response to Stimuli

Wickham et al. (1973) found that catches of king mackerel, among other pelagic fishes, were enhanced in the vicinity of midwater artificial structures. The king mackerel were not attracted to the structures per se, rather by the presence of structure-attracted bait fish schools.

4.e POPULATIONe

4.1 Structuree

4.1.1 Sex Ratio

No information found.

4.1.2 and 4.1.3 Age and Size Composition

Florida is the only geographic area for which the age and size composition of the catch of Scomberomorus cavalla (in United States waters) was found; Beaumariage (1973) presented this data for troll-and-gill-net catches (Figure 6). The age and size of first-capture S. cavalla falls within the one year age class and between 500 and 600 mm FL.

For the age and size at maturity, see the section on maturity, section 3.1.2.

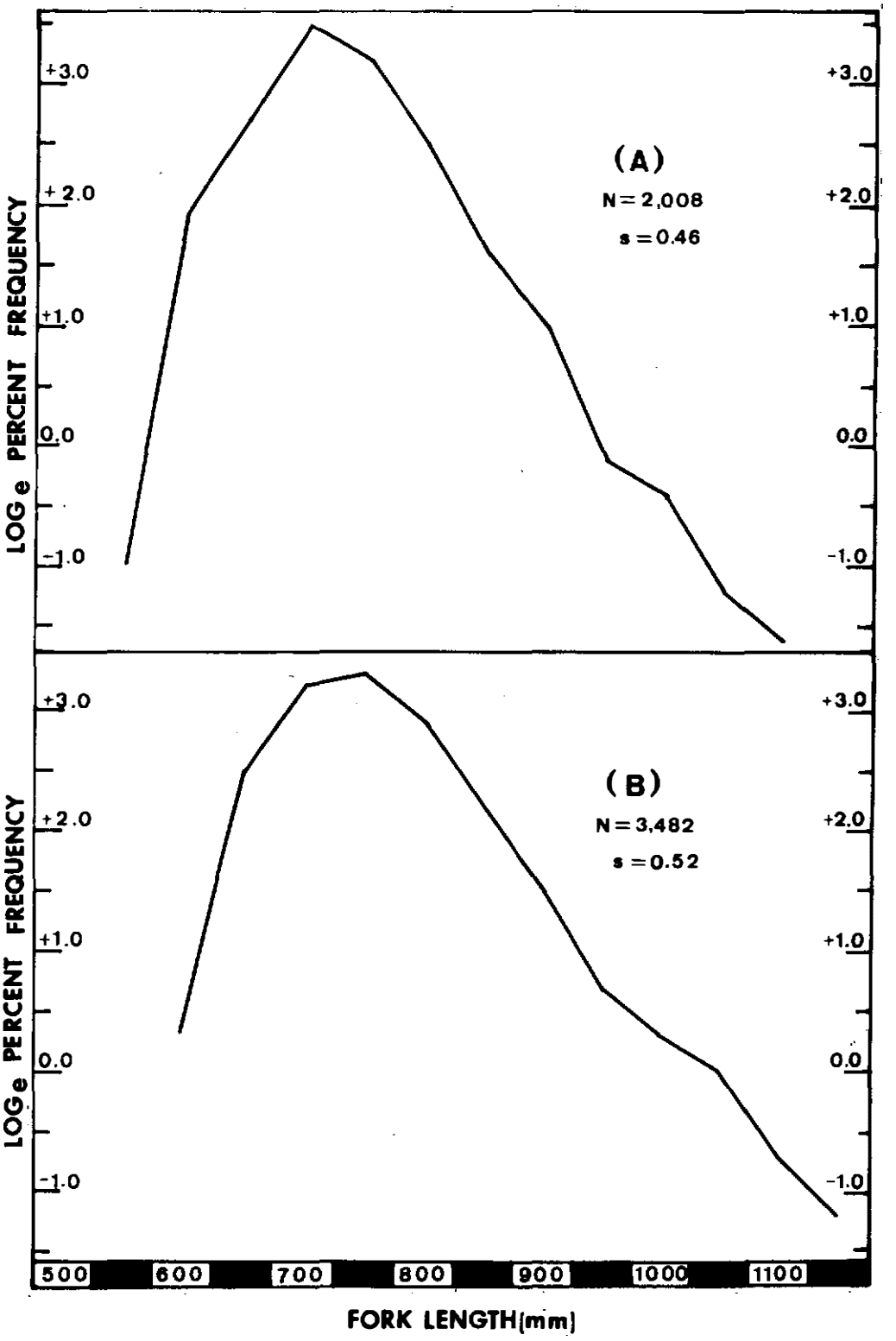

Figure 6. Comparison of Florida catch curves for king mackerel (sexes combined) taken commercially by trolling (A) and with gill nets (B), s represents annual survival estimate (from Beaumariage, 1973).

Scomberomorus cavalla live at least as long as 13 years (Beaumariage, 1973) and attain a maximum of 90 to 100 lb and a length of 5.0 to 5.5 ft (Dresslar and Fesler, 1889; Bigelow and Schroeder, 1953; Migdalski, 1958).

The length-weight relation of S. cavalla from Florida was presented by Beaumariage (1973) (Figure 7), and by Beardsley and Richards (1970) and that from Brazil by Nomura and Costa (1966), Nomura and Rodrigues (1967), and Nomura and Costa (1968).

4.2 Abundance and Density of Populations

No information found.

4.3 Natality and Recruitment

4.3.1 Reproduction Rates

No information found.

4.3.2 Factors Affecting Reproduction

No information found.

4.3.3 Recruitment

Beaumariage (1973) examined catch curves of S. cavalla taken by both commercial trolling and by gill-netting operations. He observed that complete recruitment of males and females, considered together, occurred at sizes of 750 to 799 mm FL (age II females and age III males) in the trolling fishery and at 800 to 849 mm FL (age III females and age IV or V males) in the gill-net fishery. His estimates were based on the methods of Robson and Chapman (1961).

4.4 Mortality and Morbidity

4.4.1 Mortality Rates

Beaumariage (1973) made two estimates of the survival rate for S. cavalla, based upon catch curves of the commercial trolling fishery and gill-net fishery. His estimates of annual survival were: 46% from the trolling fishery and 52% from the gill-net fishery. The difference between the two estimates probably was caused by the two fisheries operating in different areas, and therefore probably sampling differently age-structured groups of S. cavalla.

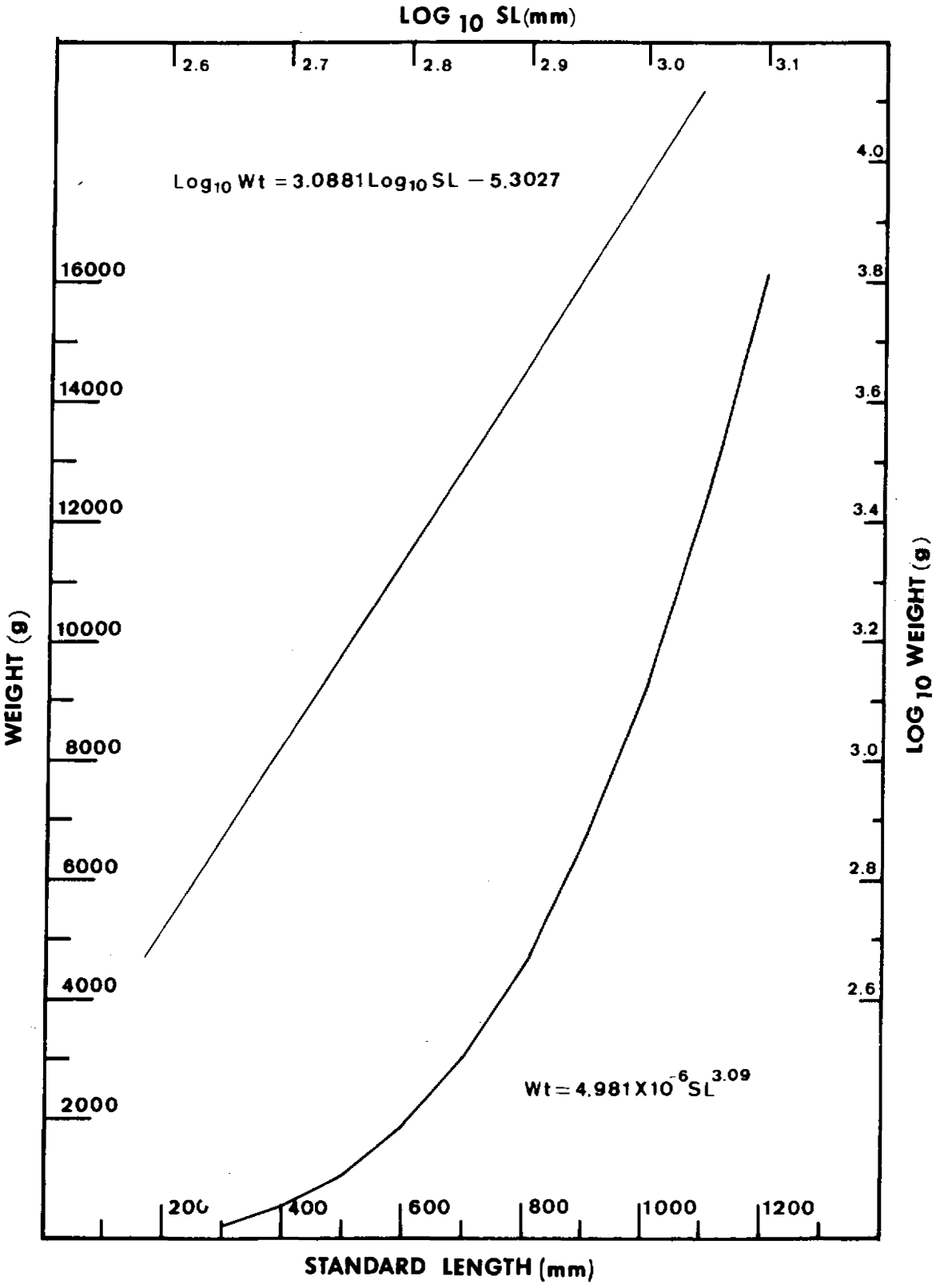

Figure 7. Length-weight relationship for king mackerel, sexes combined (from Beaumariage, 1973).

4.5 Dynamics of Population as a Whole

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 Gear

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

The most important present-day fishing methods for this species are gill-netting and trolling. Gill nets used in southwestern Florida are typically made of No. 18 nylon, 600 to 650 yards long, and 200 meshes deep ($4\frac{3}{4}$ inch stretch mesh). These nets are capable of fishing in water 70 feet deep. They have been in use since power blocks became available in 1963. Trolled lines, on commercial boats, are usually 200 ft of No. 9 wire, with spoons or hand-made jigs attached. Electronic sounders facilitate school location and electric reels enable boats to land up to 2000 lb of fish on a good day (Beaumariage, 1973).

Some purse-seining for king mackerel is done. During Beaumariage's (1973) study only one vessel, 70 feet long, and capable of carrying 70,000 lb of fish, was using this gear in Florida. The seine on this boat was 600 yards long with the wings ($2\frac{1}{2}$ inch stretch mesh) and bunt ($1\frac{5}{16}$ inch stretch mesh) made of No. 24 nylon, and the 10 mesh skirt (5 inch stretch mesh) made of No. 72 nylon (Beaumariage, 1973).

Sport fishermen troll rigged halfbeaks, strip bait, or mullet, often with a double-hook rig, such that the second hook is in the tail of the bait. Although chumming will attract king mackerel, the larger fish are usually taken while trolling (Migdalski, 1958).

A hook-and-line fishery for king mackerel and Spanish 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, which also takes king mackerel, in this same area was described by Filho (1974). 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.

5.1.2 Boats

Commercial fishing for king mackerel in Florida during 1968-1969 was conducted by trolling from boats 24 to 44 ft long, capable of carrying 1,000 to 5,000 lbs of fish; by gill-netting from boats 38 to 80 ft long, capable of carrying 18,000 to 50,000 lbs of fish; and by purse seining from one boat 70 ft long, capable of carrying 70,000 lbs of fish (Beaumariage, 1973).

5.2 and 5.3 Fishing Areas and Seasons

Fishing areas for king mackerel in United States waters change with the season; south in winter and north in summer. In the state of Florida alone, this seasonal differential is well illustrated by Beaumariage's (1973) data (Figure 8). His figure shows peak landings in south Florida in winter and spring, and peak landings in northwest Florida in summer and fall. On the Atlantic coast during summer, king mackerel migrate north to about Cape Hatteras, with only a few specimens caught farther north.

On the east coast of Florida, fishing effort during December to March is concentrated between Jupiter Inlet (25°55'N) and Palm Beach Inlet (26°45'N), and shifts northward during the remainder of the year to include Fort Pierce Inlet (27°30'N) to Port Canaveral (28°30'N).

Off the northeastern coast of Brazil, S. cavalla are fished year-round. The largest catches and largest fish tend to be taken during the 4th and 1st quarters of the year, at the season when fishermen work farther offshore under more favorable weather and sea conditions than exist at other times (Costa and Paiva, 1963 et seq.; Costa and Almeida, 1974).

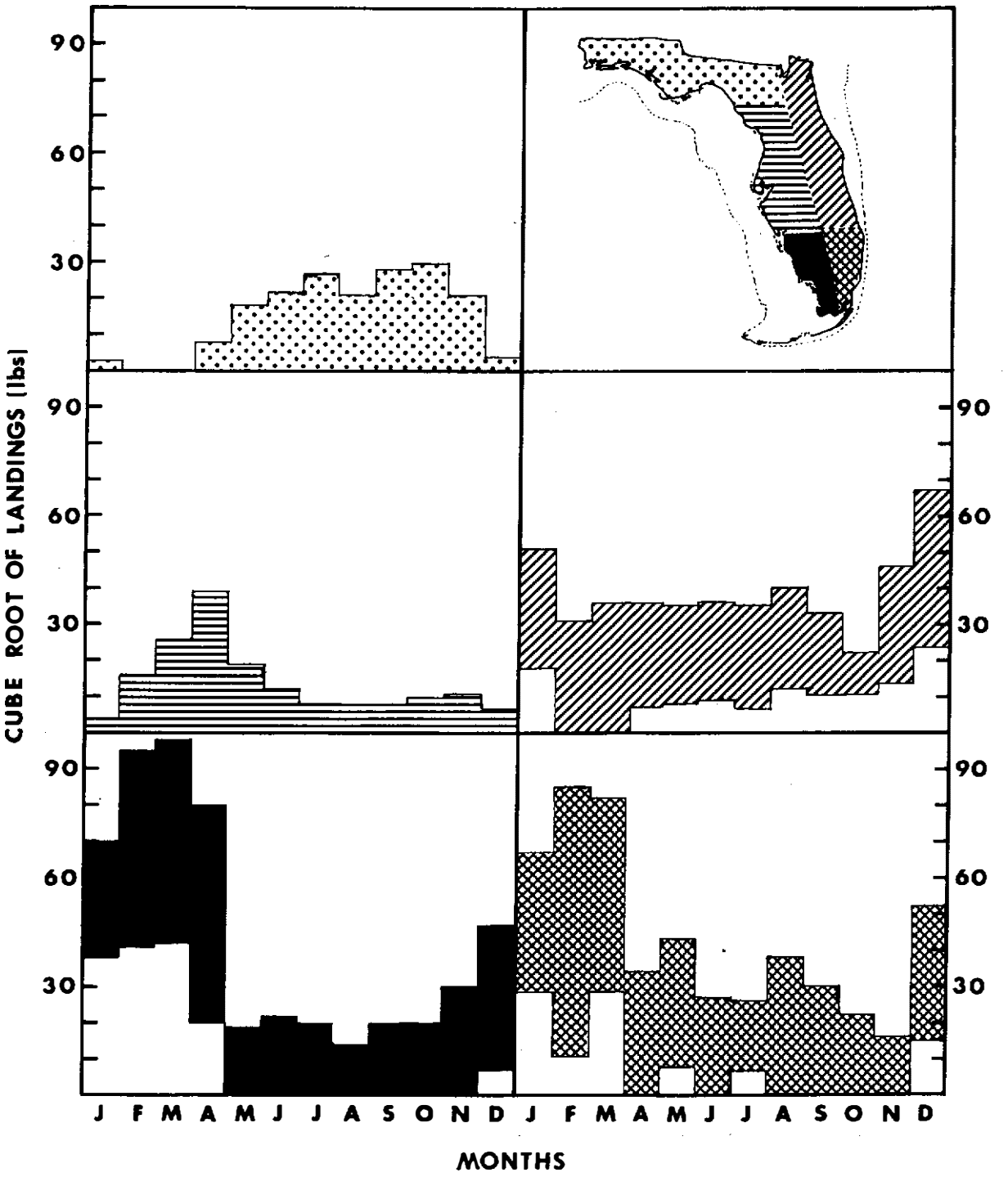

Figure 8. Average seasonal distribution of king mackerel from 1967-1969 landings throughout Florida. Clear area indicates landings sampled during 1968 (from Beaumariage, 1973).

5.4 Fishing Operations and Results

5.4.1 Effort and Intensity

No information found (see section on gear, 5.1.1).

5.4.2 Selectivity

Slight differences in length-frequency distribution of S. cavalla taken off Florida by commercial gill netso and by the commercial hook-and-line fishery are showno in Figure 6.o

Scomberomorus cavalla taken in the hook-and-line fishery off Brazil usually measure within 35 to 140 cm FL, with a modal length between 65 and 75 cm; their ages are from II to XII years with a mode at IV or V years (Costa and Paiva, 1963 et seq.; Costa and Almeida, 1974).

5.4.3 Catches

Table 6 summarizes king mackerel landings found in United States Fishery Statistical Digests (1948 to 1974) and from the Salt Water Angling Surveys (Clark [1962?]; Deuel and Clark, 1968; Deuel, 1973).

6.o PROTECTION AND MANAGEMENTo

6.1 Regulatory Measureso

6.1.1 Limitation or Reduction of Total Catch

No information found.

6.1.2 Limitation on Efficiency of Gear

The state of Florida established a quota for the total purseo seine production of S. cavalla. This quota was set as 9% of the average Florida landings for all commercial gear for the previous five years (Beaumariage, 1973).

6.2 Control or Alteration of Physical Features of the Environment

No information found except for that already described under response to stimuli, section 3.5.3.

TABLE 6. King mackerel landings (in thousands of pounds) by region and by fishery (commercial and sport); - = no data available, <1 indicates less than 500 pounds landed.

	Commercial Fishery						Sport Fishery			
Year	New England	Middle Atlantic	Chesapeake	South Atlantic	Gulf Coast	Total Commercial	Middle Atlantic	South Atlantic	Gulf Coast	Total Sport
1902	-	-	-	77	-	-	-	-	-	-
1918	-	-	-	2,487	466	-	-	-	-	-
1923	-	-	-	1,966	564	-	-	-	-	-
1927	-	-	-	3,356	1,263	-	-	-	-	-
1928	-	-	-	2,653	1,327	-	-	-	-	-
1929	-	-	-	2,400	1,973	-	-	-	-	-
1930	-	-	-	2,282	1,406	-	-	-	-	-
1931	-	-	-	2,671	749	-	-	-	-	-
1932	-	-	-	2,706	595	-	-	-	-	-
1934	-	-	-	1,977	684	-	-	-	-	-
1936	-	-	-	2,942	1,005	-	-	-	-	-
1937	-	-	-	1,983	1,376	-	-	-	-	-
1938	-	-	-	2,803	864	-	-	-	-	-
1939	-	-	-	2,442	1,571	-	-	-	-	-
1940	-	-	-	1,506	1,972	-	-	-	-	-
1945	-	-	-	2,781	1,138	-	-	-	-	-
1948	0	19	0	2,780	1,119	3,918	-	-	-	-
1949	0	34	0	2,782	1,419	4,235	-	-	-	-
1950	0	59	0	1,160	418	1,637	-	-	-	-
1951	0	17	0	1,973	1,151	3,141	-	-	-	-
1952	0	12	0	1,526	810	2,348	-	-	-	-
1953	0	11	0	1,304	1,279	2,594	-	-	-	-
1954	0	1	0	921	1,083	2,005	-	-	-	-
1955	0	7	0	1,404	1,188	2,599	-	-	-	-
1956	0	0	0	2,434	1,204	3,638	-	-	-	-
1957	0	0	0	2,503	891	3,394	-	-	-	-
1958	0	0	8	1,860	1,406	3,274	-	-	-	-
1959	0	0	5	2,228	1,239	3,472	-	-	-	-
1960	0	0	5	1,857	1,785	3,647	0	24,830	11,330	36,160**
1961	2	0	18	2,120	1,683	3,823	-	-	-	-
1962	0	0	8	2,129	2,021	4,158	-	-	-	-
1963	0	0	10	2,231	2,817	5,058	-	-	-	-
1964	0	0	37	2,108	1,314	3,459	-	-	-	-
1965	0	0	6	2,688	1,898	4,592	247	74,132	16,299	90,678
1966	0	0	7	1,881	2,633	4,521	-	-	-	-
1967	0	0	3	3,012	3,084	6,099	-	-	-	-
1968	0	0	3	2,594	3,604	6,201	-	-	-	-
1969	0	0	2	2,961	3,242	6,205	-	-	-	-
1970	0	0	5	4,351	2,372	6,728	225	34,942	27,459	62,626
1971	0	0	7	2,922	2,738	5,667	-	-	-	-
1972	0	<1	2	3,500	1,378	4,880	-	-	-	-
1973	0	1	0	3,350	2,224	5,575	-	-	-	-
1974	0	<1	15	4,318	6,134	10,467	-	-	-	-
1975	0	1	13	3,806	2,622	6,442	-	-	-	-

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

6.3 Control or Alteration of Chemical Features of the Environment

6.4 Control or Alteration of Biological Features of the Environment

6.5 Artificial Stocking

No information found for sections 6.3, 6.4, and 6.5.

7. POND FISH CULTURE

No information found.

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