Northeast Gulf Science

Volume 4
Number 1 *Number 1*

Article 1

9-1980

Distribution, Seasonality and Abundance of King and Spanish Mackerel Larve in the Northwestern Gulf of Mexico (Pisces: Scombridae)

John D. McEachran
Texas A&M University

John H. Finucane
National Marine Fisheries Service

Leslie S. Hall
Texas A&M University

DOI: 10.18785/negs.0401.01

Northeast Gulf Science Vol. 4, No. 1, p. 1-16 September 1980

DISTRIBUTION, SEASONALITY AND ABUNDANCE OF KING AND SPANISH MACKEREL LARVAE IN THE NORTHWESTERN GULF OF MEXICO (PISCES: SCOMBRIDAE).[1]

John D. McEachran
Department of Wildlife and Fisheries Sciences
Texas A&M University
College Station, TX 77833

John H. Finucane
National Marine Fisheries Service
Southeast Fisheries Center
Panama City, FL 32407

and

Leslie S. Hall
Department of Wildlife and Fisheries Sciences
Texas A&M University
College Station, TX 77833

ABSTRACT: Larvae of king mackerel, *Scomberomorus cavalla,* and Spanish mackerel, *S. maculatus* were collected from 1975 through 1977 off the Texas coast. Both species were captured from May through October. *S. cavalla* was relatively more abundant of the two species and occurred most abundantly over the middle and outer continental shelf (35-183 m). At least 35% of the larvae were captured in September of each year. *S. maculatus* larvae occurred most abundantly over the inner continental shelf (12 to 50 m). *S. cavalla* spawned from May through September to early October, with the greatest spawning intensity occurring over the middle and outer continental shelf during September. *S. maculatus* spawned from May through September to early October over the inner continental shelf, but spawning was less intensive and more irregular than for *S. cavalla.* Comparisons with other larval studies of *S. cavalla* and *S. maculatus* suggest that the northwestern and northeastern Gulf of Mexico and the coast off the southeastern United States are important spawning areas for *S. cavalla* and that the eastern and northeastern Gulf of Mexico are important spawning areas for *S. maculatus.*

Most of the studies of *S. cavalla* and *S. maculatus* off the United States have been limited to Florida and the southeastern United States (Ryder, 1882; Earll, 1883; Hildebrand and Cable, 1938; Klima, 1959; Moe, 1963; Wollam, 1970; Dwinell and Futch, 1973; Beaumariage, 1970, 1973; Powell, 1975; Manooch, 1979; Houde *et al.*, 1979; Powles, ms.) where the species constitute important fisheries resources (Berrien and Finan, 1977a, b). *Scomberomorus* larvae have been reported from off the Texas coast (Pew, 1958; Hoese, 1965; Wollam, 1970) but there have been no published reports of the distribution, seasonality or abundance of *S. cavalla* or *S. maculatus* larvae in this area (Berrien and Finan, *op. cit.*). The objective of the present study is to determine the distribution, seasonal occurrence and abundance of larvae of these species off Texas in order to estimate the importance of the northwestern Gulf of Mexico as spawning and nursery grounds.

Three species of *Scomberomorus* occur along the Atlantic and Gulf of Mexico coasts of the United States. *S. regalis,* cero, ranges from New England to Brazil and throughout the Gulf of Mexico (Böhlke and Chaplin, 1968) but is abun-

[1] Contribution No. 78-50PC. Southeast Fisheries Center, National Marine Fisheries Service, NOAA, Panama City Laboratory, Panama City, Florida

dant in United States waters only off the southern tip of Florida (Manooch, 1979). *S. cavalla* occurs from the Gulf of Maine to Brazil (Beaumariage, 1973). It is abundant along the coasts of North Carolina in spring and fall (Taylor, 1951) and the northeastern and northwestern Gulf of Mexico during the warmer months of the year (Wollam, 1970; Dwinell and Futch, 1973; Beaumariage, 1973). Tagging results indicate that *S. cavalla* found along the east coast of the United States and northern Gulf of Mexico during the spring and summer, winter off southern Florida and the Florida Keys, although large specimens are found around the oil platforms off Louisiana year-round (Williams and Sutherland, 1979). *S. maculatus* occurs from the Gulf of Maine to the Gulf of Mexico (Collette *et al.*, 1978). It is likewise abundant along the east coast of the United States and northern Gulf of Mexico during the spring, summer and fall (Wollam, 1970; Dwinell and Futch, 1973; Powell, 1975) and is found in shallower water in the northwestern Gulf of Mexico than *S. cavalla* (Hoese and Moore, 1977). *S. maculatus* moves westerly in the northern Gulf of Mexico during the spring and summer (Manooch, 1979). However, a winter recapture off Vera Cruz, Mexico of a specimen which had been tagged off Texas (Williams and Sutherland, 1979) suggests that *S. maculatus* may maintain two wintering grounds, one off southern Florida and one off the eastern coast of Mexico.

MATERIAL AND METHODS

Specimens for this study were collected during a special mackerel larval survey of the south Texas coast (SMS) sponsored by the National Marine Fisheries Service, a baseline ichthyoplankton survey of the south Texas outer continental shelf (BSST) sponsored by the Bureau of Land Management and a baseline ichthyoplankton survey of the north central Texas coast and the Buccaneer Oil Field off northeastern Texas (BSNT) sponsored by the National Marine Fisheries Service and by the Environmental Protection Agency, respectively (Fig. 1, Tables 1 and 4). The SMS survey of the south Texas coast consisted of monthly sampling of zooplankton from May through September 1975 at 16 stations located along four transects perpendicular to the coast off south Texas. Depths of stations ranged from 12 to 139 m. The BSST survey was conducted during 1975, 1976 and 1977. During the first year, three seasonal cruises were conducted during December 1974-January 1975, April-May 1975 and August-September 1975 at 12 stations along four transects. Station depths ranged from 18 to 134 m. Each station was sampled twice per cruise, once during daylight and once during night. During 1976, three seasonal cruises were made during January-February, May-June and September on which all transects were sampled. Transects and stations were the same as those sampled in 1975 except that sampling was intensified by adding four additional stations along Transect II. Station depths ranged from 18 to 183 m. Also, the second transect was separately sampled during March, April, July, August, November and December. Each station was sampled once per cruise. The sampling procedure for 1977 was identical to that for 1976. Seasonal cruises were made during January-February, May and September and Transect II was separately surveyed during March, April, July, August, November and December. The BSNT survey was conducted during 1976 and 1977 at 15 to 22 stations during May, August, November-December 1976 and February 1977. Depths of stations ranged from 15 to 92 m.

During the three year study, 375 stations were sampled with sampling occurring in

DOI: 10.18785/negs.0401.01

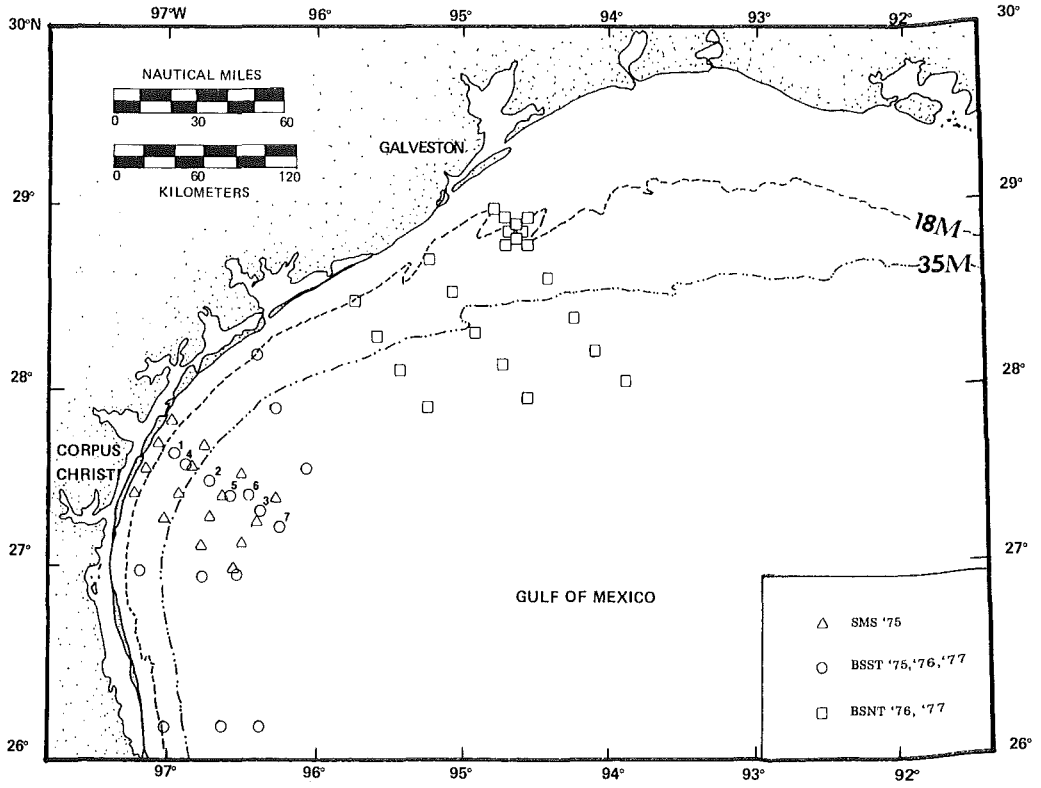

Figure 1. Location of ichthyoplankton surveys and stations during the three studies. SMS = Special mackerel survey of the south Texas coast; BSST = Baseline ichthyoplankton survey of the south Texas outer continental shelf, stations along the second transect numbered: 1-3 were sampled during 1975, 1-7 were sampled during 1976 and 1977. BSNT = Baseline surveys of the north central and northeastern Texas coast.

all months except October. Collections were made either with a pair of 61 cm bongo nets (all surveys except the 1975 BSST survey) or a meter net (the 1975 BSST survey). One of the bongo nets had a 333 μm mesh and the other had a 505 μm mesh. A double oblique tow was made through the water column according to standard MARMAP techniques (Jossi, *et al.*, 1975). The meter net was 250 μm mesh and was towed obliquely through the water column from near the bottom to the surface. A General Oceanics digital flowmeter was mounted inside the frame of each meter and bongo net.

Neuston samples were collected on the 1976 and 1977 BSST surveys and on the BSNT surveys, but are not included in this study because of the difficulty in quantifying them. However, neuston samples collected on the October 1976 BSNT survey are mentioned because these were the only samples collected during this month.

Samples were preserved in a solution of 7% buffered formalin and seawater. *Scomberomorus* larvae were removed from the 505 μm samples in the SMS off the south Texas coast. The meter net samples of the 1975 BSST off the south Texas outer continental shelf were split with a Folsom plankton splitter and mackerel larvae were removed from one of the two aliquots. Both the 333 μm and

TABLE 1. *Scomberomorus cavalla*, summary of larval data collected on surveys of 1975 through 1977 off the Texas coast. SMS 1975 = Special mackerel survey; BSST 1975, 1976, 1977 = Baseline surveys of the south Texas outer continental shelf; BSNT 1976, 1977 = Baseline surveys of the north central and northeastern Texas coast. Positive samples were those containing *S. cavalla* larvae.

Cruise	Dates	Number of Samples	Number of Positive Samples	Mean Number of Larval/10m² All Stations	Mean Number of Larval/10m² Positive Stations	Mean Length of Larvae (mm SL)
SMS 1975	21-22 May	16	5	0.63	0.97	3.5
SMS 1975	23-24 June	16	6	0.83	2.22	3.6
SMS 1975	28-29 July	16	7	1.96	4.47	3.0
SMS 1975	21-22 Aug.	16	11	4.82	7.01	3.3
SMS 1975	14-15 Sept.	16	12	4.26	5.68	3.1
BSST 1975	4 Dec. 1974-25 Jan. 1975	24	0	0	0	—
BSST 1975	16 Apr.-16 May	24	3	0.14	1.1	4.8
BSST 1975	26 Aug.-30 Sept.	24	18	8.22	10.96	3.7
BSST 1976	14 Jan.-3 Feb.	32	0	0	0	—
BSST 1976	18-19 Mar.	14	0	0	0	—
BSST 1976	2-3 Apr.	14	0	0	0	—
BSST 1976	30 May-7 June	32	20	6.79	10.87	3.3
BSST 1976	10-11 July	14	8	7.15	12.51	3.3
BSST 1976	27-28 Aug.	14	10	9.72	13.61	3.7
BSST 1976	10-15 Sept.	32	24	20.73	27.63	3.3
BSST 1976	9-10 Nov.	14	0	0	0	—
BSST 1976	1-2 Dec.	14	0	0	0	—
BSNT 1976	24-29 May	44	1	0.20	8.7	5.0
BSNT 1976	16-21 Aug.	30	17	11.71	20.66	3.7
BSNT 1976	20 Nov.-4 Dec.	38	0	0	0	—
BSNT 1977	18-20 Feb.	42	0	0	0	—
BSST 1977	11 Jan.-21 Feb.	32	0	0	0	—
BSST 1977	14-15 Mar.	14	0	0	0	—
BSST 1977	20-21 Apr.	14	0	0	0	—
BSST 1977	16-20 May	32	7	0.75	3.43	4.1
BSST 1977	6-7 July	14	6	2.24	5.22	3.6
BSST 1977	4 Aug.	14	8	2.84	4.96	3.3
BSST 1977	7-11 Sept.	32	19	23.16	39.01	3.6
BSST 1977	5-6 Nov.	14	0	0	0	—
BSST 1977	2-3 Dec.	14	0	0	0	—

505 μm bongo net samples collected on the baseline (BSST) surveys were examined for *Scomberomorus* larvae. Larvae were identified to species according to Wollam (1970) and measured to the nearest 0.1 mm of Standard Length (SL).

Temperature and salinity data were collected from the entire water column on all surveys but the SMS on which only surface temperatures were measured with a mercury thermometer to the nearest degree. Temperatures and salinities at precise depth intervals were obtained by STD casts on the BSST surveys. Temperature sensing bathythermographs (XBTs) and Goldberg refractometers were used to measure water temperature and salinity on the BSNT survey. On the latter two

DOI: 10.18785/negs.0401.01

surveys water samples for salinity determination were collected with Nansen bottles.

The number of larvae of each species per sample was converted to the number of larvae under 10 m^2 of seawater surface. A Student's t test was used to test for significant differences ($\alpha = 0.05$) in mean number and length of larvae of each species within stations between day and night samples and between 333 μm and 505 μm mesh samples. This test was also used to test for significant differences ($\alpha = 0.05$) in mean length of larvae of each species among stations and transects within each cruise and among monthly cruises. A test of differences was run to determine if the distribution of either species was depth dependent, *i.e.* more abundant at depths <35 m or ≥35 m or depths <50 m or ≥50 m.

RESULTS

No significant differences were found in mean numbers or lengths of larvae of either species within stations between day and night samples or between 333 μm and 505 μm mesh samples, thus these data were pooled to determine the distribution, seasonality and abundance of the larvae.

Scomberomorus cavalla

During the three years of the survey, 1975 through 1977, *S. cavalla* larvae were captured in increasing numbers from May through September (Table 1, Figs. 2-4). At least 35% of the larvae were captured in September of each year. Larvae were captured on all cruises of the SMS survey (off south Texas) and were progressively more abundant and more widely distributed from May through August. During the 1975 BSST survey (off south Texas) larvae were captured on the April-May and August-September cruises but were considerably more abundant on the latter cruise. Larvae were captured on the May-June, July, August and September cruises of the 1976 BSST survey with 46% of the larvae being captured during September. On the BSNT survey (off north central Texas) larvae were captured on the May and August cruises and were of considerably greater abundance on the latter cruise. Also one larva, 5.5 mm SL, was captured in mid-October with a neuston net. Abundance of larvae was much lower on the May BSNT cruise than on the May BSST cruise but slightly higher on the August BSNT cruise than on the comparable 1976 BSST cruise. During the 1977 BSST survey larvae were captured on the May, June, August and September cruises with 80% of the larvae being captured on the September cruise. Abundance of larvae was considerably greater in May-June, July and August 1976 than during these same months in 1977.

S. cavalla larvae were significantly more abundant over the middle and outer continental shelf (≥35 m) than over the inner continental shelf (<35 m) off Texas (Table 2). However, they were not significantly more abundant over the outer shelf (≥50 m) than over the inner shelf (<50 m). Larvae were captured over a temperature range of 19.6 to 29.8 C and a salinity range of 27.3 to 37.4‰ and were most abundant at temperatures from 23.0 to 29.8 C and salinities from 29.6 to 37.4‰ (Table 3).

Larval lengths ranged from 1.8 to 9.3 mm SL with mean lengths ranging from 3.0 to 5.0. However, mean lengths did not increase significantly over any of the yearly surveys (Fig. 5).

Scomberomorus maculatus

S. maculatus larvae were captured from May through September of each year of the survey, but they were much less abundant than *S. cavalla* and abundance did

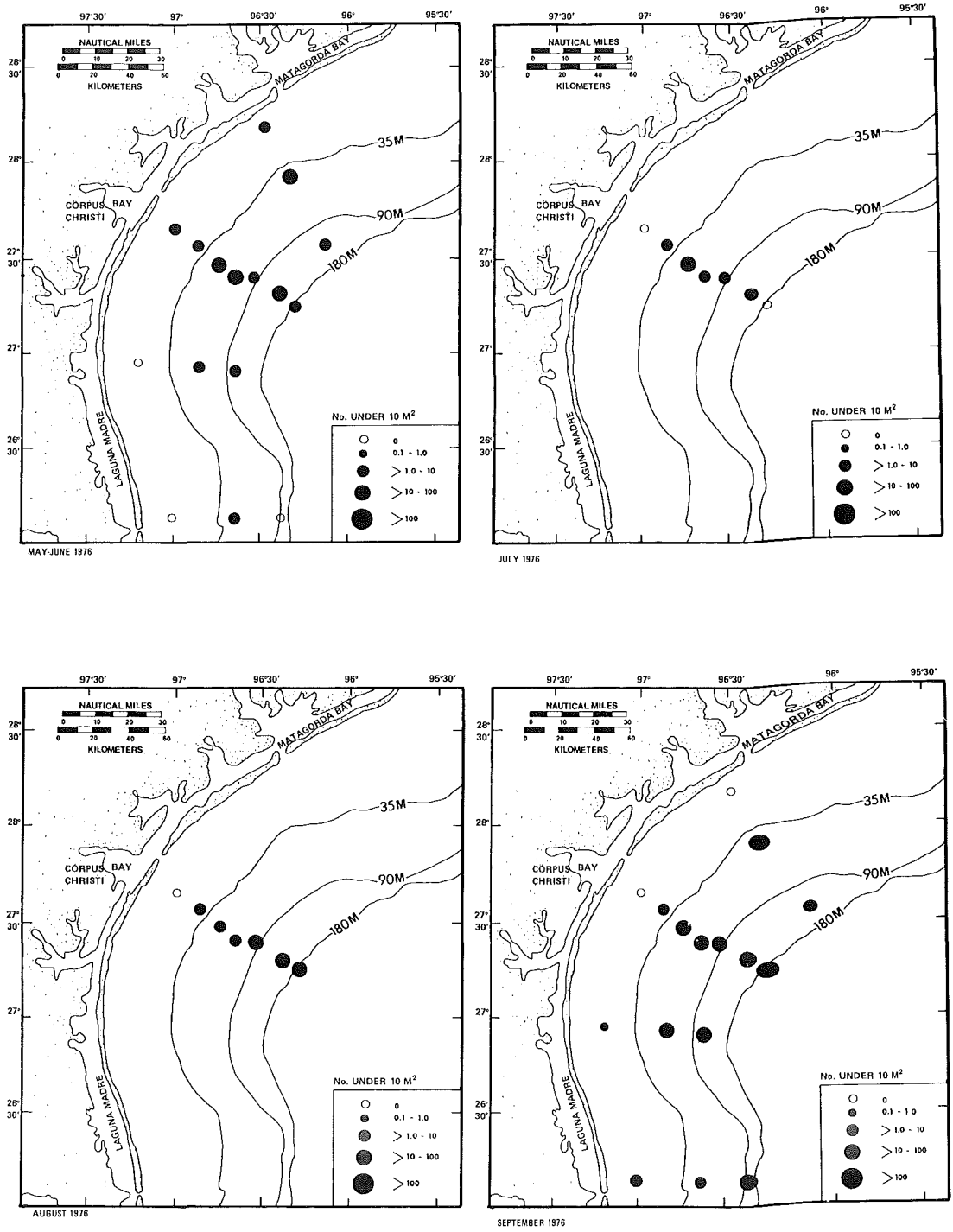

Figure 2. Estimated abundance of *S. cavalla* larvae at each station during the May-June, July, August, and September cruises of the BSST 1976 survey (south Texas).

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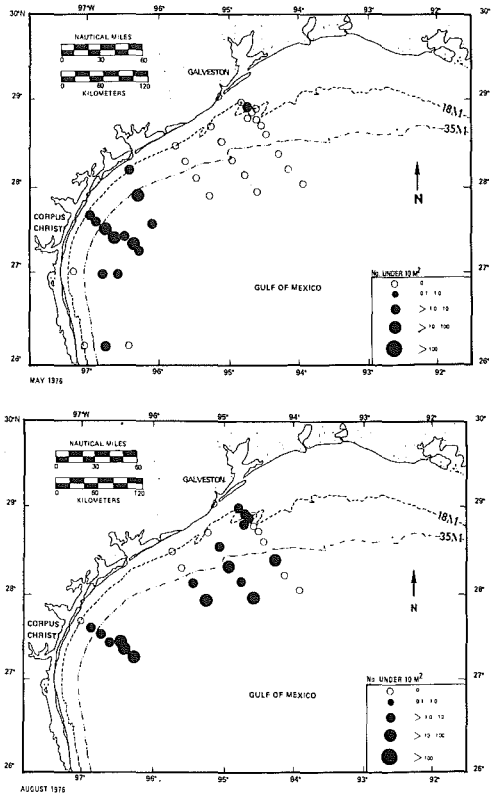

Figure 3. Estimated abundance of *S. cavalla* larvae at each station during May and August 1976. Three northeastern most transects represent BSNT surveys and the other transects represent the May-June and August BSST surveys.

not increase with progression of the spawning season (Table 4, Figs. 6-8). Larvae were captured on all but the May cruise of the SMS survey and were slightly more abundant and widespread in June than in the succeeding months. During the 1975 BSST survey larvae were captured on the April-May and August-September cruises with abundance being higher for the latter cruise. Larvae were captured on the May-June, July, August and September cruises of the 1976 BSST survey and abundance was higher in August and September than in May-June and July. On the BSNT survey (off north central Texas) larvae were captured only on the August cruise and were more abundant on this cruise than on the August cruise of the BSST survey. Also one larva, 4.2 mm SL, was captured in mid-October with a neuston net. During the 1977 BSST survey larvae were captured on the May, July, August and September cruises and were most abundant in May, most widely distributed in September.

S. maculatus larvae were significantly more abundant over the inner and middle

TABLE 2. Mean number of *S. cavalla* larvae per 10 m² per cruise captured in water < 35 m and ≥ 35 m.

Cruise		Dates	Mean No. of Larvae/10 m³ < 35 m	≥ 35 m	d
SMS	1975	21-22 May	0.18	0.44	0.26
SMS	1975	23-24 June	0	0.83	0.83
SMS	1975	28-29 July	1.39	0.56	-0.83
SMS	1975	21-22 Aug.	1.23	3.59	2.36
SMS	1975	14-15 Sept.	1.35	2.91	1.56
BSST	1975	16 Apr.-16 May	0	0.14	0.14
BSST	1975	26 Aug.-30 Sept.	0.07	8.15	8.08
BSST	1976	30 May-7 June	0.57	6.22	5.65
BSST	1976	10-11 July	0.76	6.39	5.63
BSST	1976	27-28 Aug.	0.04	9.32	9.28
BSST	1976	10-15 Sept.	0.59	20.14	19.55
BSNT	1976	24-29 May	0.20	0	-0.20
BSNT	1976	16-21 Aug.	1.60	10.09	8.49
BSST	1977	16-20 May	0.08	0.67	0.59
BSST	1977	6-7 July	0.44	1.80	1.36
BSST	1977	4 Aug.	0.36	2.47	2.11
BSST	1977	7-11 Sept.	0	23.16	23.16
					d = 5.30 Sd^2 = 43.80 Sd = 8.73* t = 2.50 *P<0.05

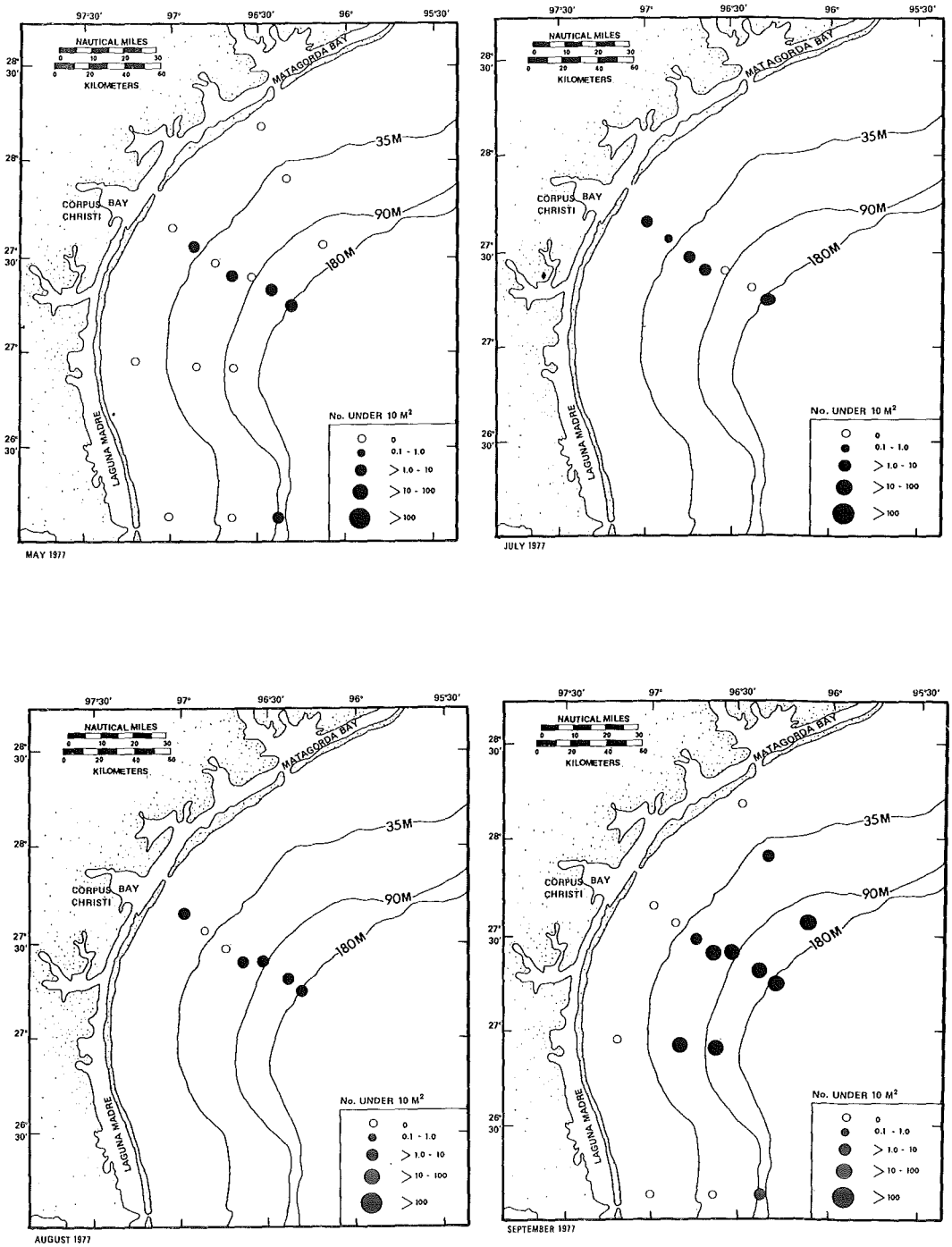

Figure 4. Estimated abundance of *S. cavalla* larvae at each station during the May, July, August, and September cruises of the BSST 1977 survey (south Texas).

DOI: 10.18785/negs.0401.01

continental shelf (<50 m) than over the outer continental shelf (≥50 m) (Table 5). However, they were not significantly more abundant over the inner shelf (<35 m) than over the middle and outer shelf (≥35 m). Larvae were captured over a temperature range of 19.6 to 29.8 C and a salinity range of 28.3 to 37.4‰, and were most abundant at temperatures from 20.2 to 29.8 C and salinities from 28.3 to 34.4‰.

Larval lengths ranged from 1.8 to 11.5 mm SL with mean lengths per cruise ranging from 2.1 to 7.0 mm. However, mean lengths did not increase significantly over any of the yearly surveys (Fig. 9).

DISCUSSION

Findings of the present study largely agree with those of previous authors. In the northeastern Gulf of Mexico (Mobile, Alabama to Apalachee Bay, Florida) Dwinell and Futch (1973) caught *S. cavalla* larvae from May through October with the greatest abundance occurring in September. Houde *et al.* (1979) captured *S. cavalla* larvae during the summer and fall on the west Florida continental shelf, while Powles (ms.) reported larvae abundant from May through mid-September off the Southeastern United States (Cape Fear, North Carolina to Cape Canaveral, Florida). Dwinell and Futch (1973) reported higher abundance of larvae over the middle and outer continental shelf than over the inner shelf in the northeastern Gulf of Mexico. Houde *et al.* (1979) caught five of six larvae in depths of less than 50 m off the west Florida coast, while Powles (ms.) reported highest abundance of *S. cavalla* near or outside the continental shelf break (200 m contour). Depths

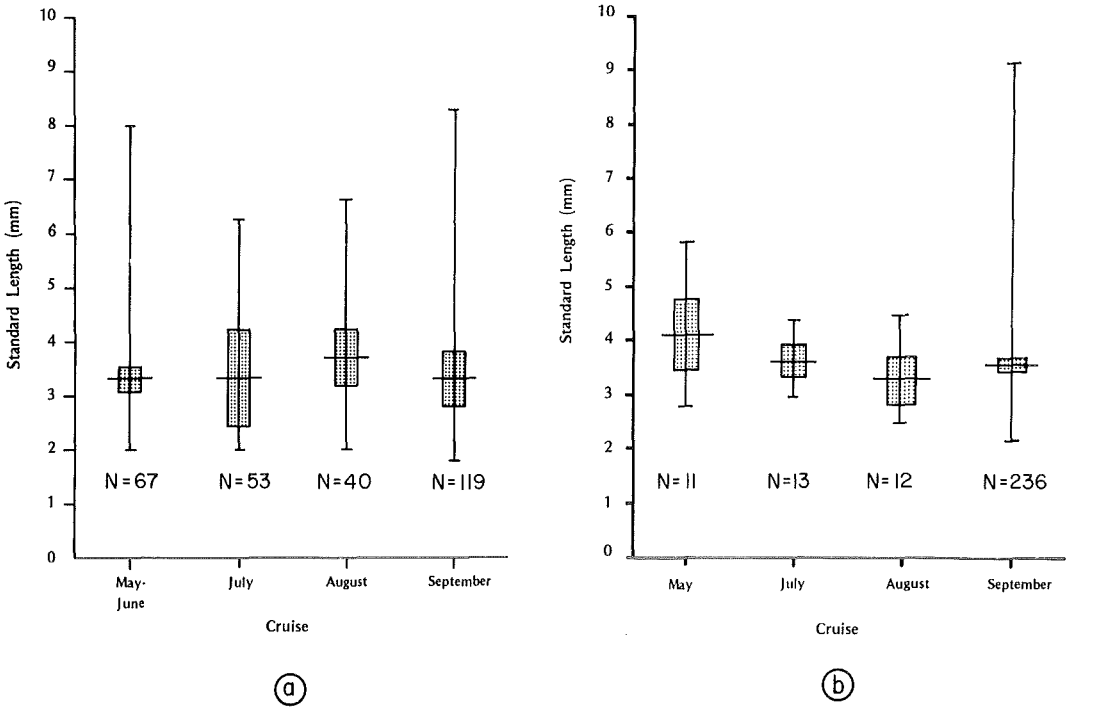

Figure 5. Distribution of standard lengths of *S. cavalla* larvae captured on the BSST 1976 and 1977 surveys (south Texas). Horizontal line = mean, vertical line = range, stippled bar = 95% confidence interval.

TABLE 3. Summary of plankton tow characteristics and temperature and salinity data collected on surveys off the Texas Coast.

Cruise			Number of Samples	Mean Volume Filtered (m^3)	Range of Temperatures of Water Column	Range of Salinities of Water Column
SMS	May	1975	16	497.5	24.0-27.0	—
SMS	June	1975	16	396.9	28.5-29.8	—
SMS	July	1975	16	496.1	27.0-30.2	—
SMS	Aug.	1975	16	408.6	28.0-29.7	—
SMS	Sept.	1975	16	682.1	28.4-28.7	—
BSST	Dec.-Jan.	1975	24	669.7	16.4-22.4	31.1-36.1
BSST	Apr.-May	1975	24	641.9	19.6-24.2	30.7-36.1
BSST	Aug.-Sept.	1975	24	491.2	24.2-29.8	29.6-36.3
BSST	Jan.-Feb.	1976	32	214.8	15.0-20.9	32.6-36.3
BSST	Mar.	1976	14	247.6	17.8-20.7	29.7-36.1
BSST	Apr.	1976	14	245.9	18.6-20.6	30.2-36.0
BSST	May-June	1976	32	221.7	22.4-27.4	30.4-35.9
BSST	July	1976	14	258.3	23.4-27.8	34.2-36.0
BSST	Aug.	1976	14	235.7	25.6-28.1	35.5-37.4
BSST	Sept.	1976	32	221.8	23.2-29.2	33.5-36.7
BSST	Nov.	1976	14	229.5	18.9-25.4	3.24-36.3
BSST	Dec.	1976	14	248.9	14.9-21.1	33.5-36.3
BSNT	May	1976	44	51.0	23.8-26.0	27.3-33.0
BSNT	Aug.	1976	30	41.4	24.6-29.4	32.0-35.0
BSNT	Nov.-Dec.	1976	38	57.3	13.1-20.8	31.9-36.3
BSNT	Feb.	1976	42	85.0	12.3-19.2	32.0-37.8
BSST	Jan.-Feb.	1977	32	190.4	11.0-19.1	32.6-36.4
BSST	Mar.	1977	14	228.9	15.2-17.9	33.1-36.4
BSST	Apr.	1977	14	206.1	19.6-21.1	31.5-36.3
BSST	May	1977	32	236.0	20.2-25.5	28.3-36.2
BSST	July	1977	14	339.1	20.6-25.4	36.1-36.3
BSST	Aug.	1977	14	237.4	21.9-28.0	36.2-36.3
BSST	Sept.	1977	32	226.7	23.7-29.8	34.2-36.3
BSST	Nov.	1977	14	292.7	22.4-26.1	35.2-36.5
BSST	Dec.	1977	14	266.1	21.3-23.8	33.4-36.4

greater than 183 m were not sampled in the present study, thus availability of larvae seaward of the continental shelf in the northwestern Gulf of Mexico is unknown.

Previous authors have likewise found *S. maculatus* larvae in inshore waters during the summer months. Baughman (1950) stated that young specimens less than 50 mm SL occurred in surf zone off Texas during most of the summer. Hoese (1965) captured 159 larvae (2.0 to 8.5 mm SL) in inshore waters off Port Aransas, Texas from May through September. In the northeastern Gulf of Mexico *S. maculatus* larvae were captured in June, August and September but not in May, July and October and the greatest number were captured in June (Dwinell and Futch, 1973). Dwinell and Futch also reported that larvae were most abundant over the inner continental shelf. Houde *et al.* (1979) reported that *S. maculatus* larvae were relatively common along the entire west Florida coast during the spring and summer and were most abundant at depths less than 20 m. Hildebrand and Cable (1938) reported that *S. maculatus* but not *S. cavalla* juveniles occurred in estuaries of the southeastern United States. Powles (ms.) captured *S. maculatus* larvae from May through Mid-September off the southeastern United States, mainly over the inner continental shelf, within 20 km of the coast (≤18 to 29

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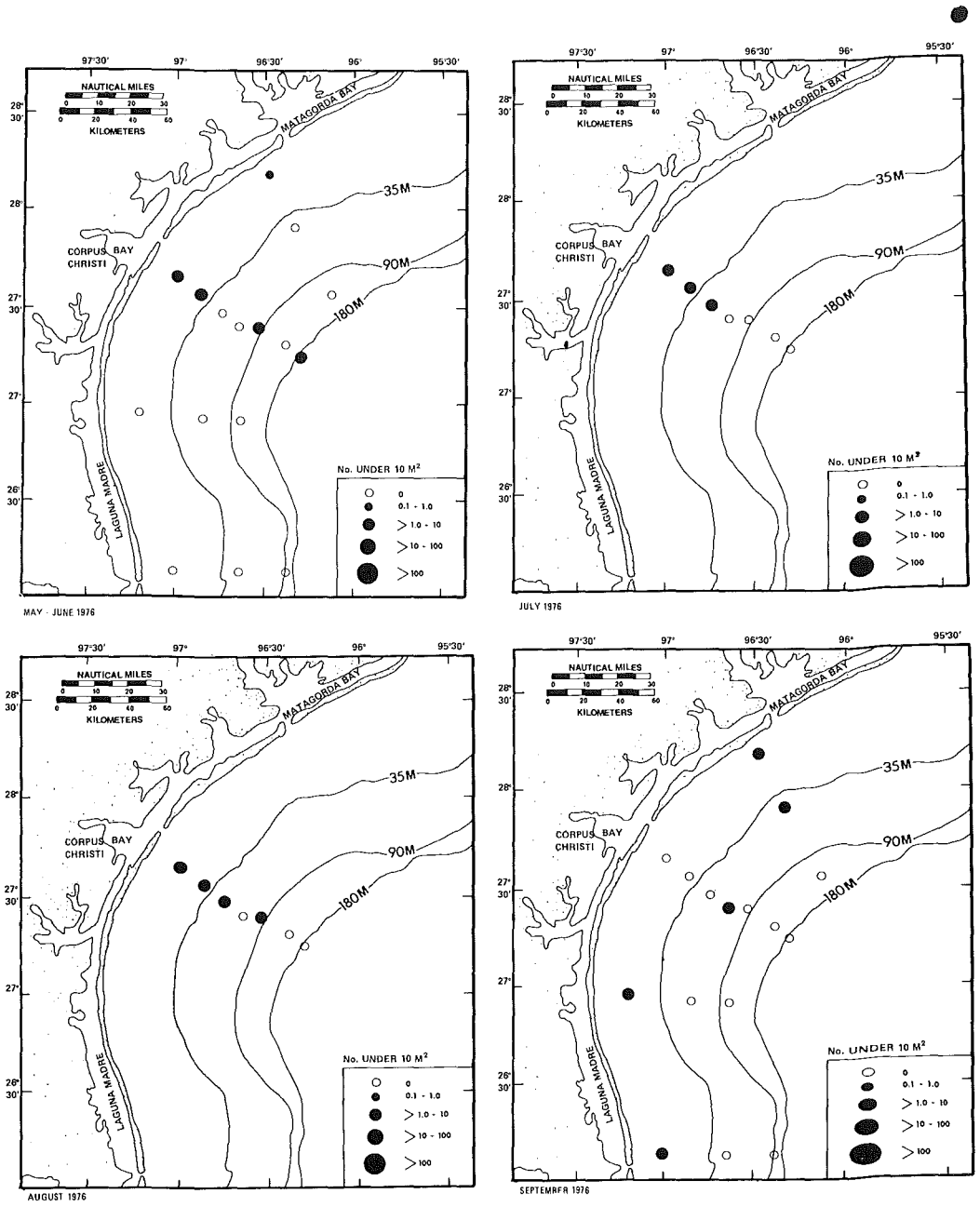

Figure 6. Estimated abundance of *S. maculatus* larvae at each station during the May-June, July, August, and September cruises of the BSST 1976 survey (south Texas).

m). Hoese (1965) stated that spawning of *S. maculatus* occurs at temperatures greater than 25 C and at salinities between 30.5 and 35.5‰ and Beaumariage (1970) claimed that spawning of this species is probably limited to temperatures above 25.6 C. In the present study larvae were found at stations with mean water column temperatures from 19.6 to 29.8 C and salinities from 28.3 to 37.4‰, suggesting that spawning can take place at cooler and less saline waters than previously thought. However, because temperature and salinity measurements on the 1976 BSST

TABLE 4. *Scomberomorus maculatus*, summary of larval data collected on surveys of 1975 through 1977 off the Texas coast. SMS 1975 = Special mackerel survey for 1975; BSST 1975, 1976, 1977 = Baseline surveys of the south Texas outer continental shelf for 1975, 1976, 1977; BSNT 1976, 1977 = Baseline surveys of the north central and northeastern Texas coast for 1976, 1977. Positive samples were those containing *S. maculatus* larvae.

Cruise		Dates	Number of Samples	Number of Positive Samples	Mean Number of Larvae/10m²		Mean Length of Larvae (mm SL)
					All Stations	Positive Stations	
SMS	1975	21-11 May	16	0	0	0	—
SMS	1975	23-24 June	16	8	0.51	1.03	2.6
SMS	1975	28-29 July	16	6	0.46	1.23	2.2
SMS	1975	21-22 Aug.	16	5	0.36	1.16	2.1
SMS	1975	14-15 Sept.	16	6	0.37	0.98	5.0
BSST	1975	4 Dec. 1974-25 Jan. 1975	24	0	0	0	0
BSST	1975	16 Apr.-16 May	24	1	0.03	0.60	7.0
BSST	1975	26 Aug.-30 Sept.	24	9	1.62	4.32	4.1
BSST	1976	14 Jan.-3 Feb.	32	0	0	0	—
BSST	1976	18-19 Mar.	14	0	0	0	—
BSST	1976	2-3 Apr.	14	0	0	0	—
BSST	1976	30 May-7 June	32	6	0.62	3.3	2.9
BSST	1976	10-11 July	14	5	1.25	3.5	2.8
BSST	1976	27-28 Aug.	14	5	2.03	5.68	3.6
BSST	1976	10-15 Sept.	32	6	1.07	5.7	3.8
BSST	1976	9-10 Nov.	14	0	0	0	—
BSST	1976	1-2 Dec.	14	0	0	0	—
BSNT	1976	24-29 May	44	0	0	0	—
BSNT	1976	16-21 Aug.	30	9	3.42	11.39	3.3
BSNT	1976	30 Nov.-4 Dec.	38	0	0	0	—
BSNT	1976	18-20 Feb.	42	0	0	0	—
BSST	1977	11 Jan.-21 Feb.	32	0	0	0	—
BSST	1977	14-15 Mar.	14	0	0	0	—
BSST	1977	20-21 Apr.	14	0	0	0	—
BSST	1977	16-20 May	32	6	1.88	10.00	2.8
BSST	1977	6-7 July	14	3	0.69	3.20	2.5
BSST	1977	4 Aug.	14	2	0.47	3.30	3.3
BSST	1977	7-11 Sept.	32	12	2.55	6.81	3.3
BSST	1977	5-6 Nov.	14	0	0	0	—
BSST	1977	2-3 Dec.	14	0	0	0	—

survey were taken on separate cruises, as much as two weeks from the time that the larval samples were made, and temperatures and salinities at depth of capture are not known for any of the samples, precise hydrographic conditions required for larvae and for spawning cannot be determined.

Distribution and relative abundance of larvae of both *Scomberomorus* species provided information on the distribution and seasonality of spawning of these species off the Texas coast. Larvae of both species ranged from about 2 to 10 mm SL and a large portion of the larvae were less than 3.0 mm SL. Dwinell and Futch (1973),

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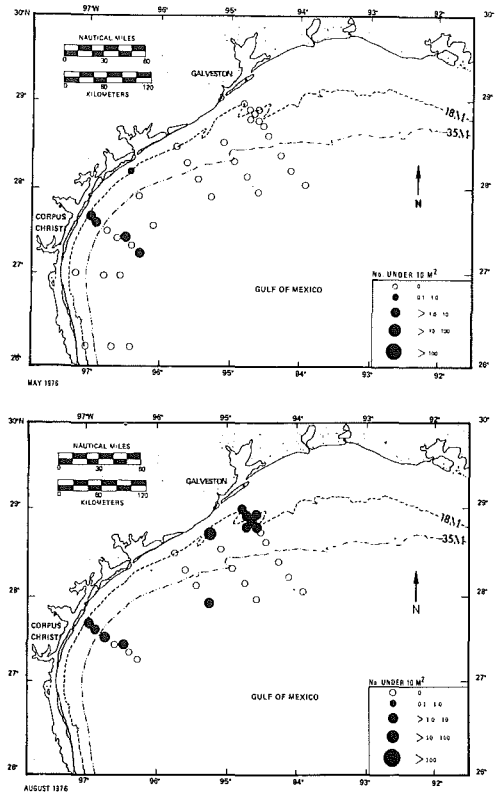

Figure 7. Estimated abundance of *S. maculatus* larvae at each station during May and August 1976. Three northeastern most transects represent BSNT surveys and the other transects represent the May-June and August BSST 1976 surveys.

based on figures of Ryder (1882), estimated that *S. maculatus* larvae hatch at about 2.0 mm SL and attain a length of 2.8 mm SL within three days. *S. cavalla* larvae are very similar to *S. maculatus* larvae (Wollam, 1970) and probably have a similar growth rate. Thus distribution of larvae less than 3.0 mm SL should fairly accurately reflect spawning location and time of the adult stocks. It follows, therefore that *S. cavalla* spawns from May through late September to early October, with greatest intensity of spawning occurring in September over the middle and outer continental shelf (35 to 183 m) and that *S. maculatus* spawns during the same period over the inner continental shelf (<50 m). However, *S. maculatus* appears either to spawn less intensively off Texas than *S. cavalla* or the major spawning locations of *S. maculatus* were not sampled. The inshore waters where *S. maculatus* spawns were sampled less intensively than the offshore waters. However, it is unlikely that sampling error alone could explain the lower abundance of *S. maculatus* larvae over the three years

TABLE 5. Mean number of *S. maculatus* larvae per 10 m² per cruise captured in water < 50 m and ≥ 50 m.

Cruise		Rates	Mean No. of Larvae/10 m² < 50 m	≥ 50 m	d
SMS	1975	21-22 May	0	0	0
SMS	1975	23-24 June	0.33	0.18	0.15
SMS	1975	28-29 July	0.46	0	0.46
SMS	1975	21-22 Aug.	0.29	0.08	0.21
SMS	1975	14-15 Sept.	0.37	0	0.37
BSST	1975	16 Apr.-16 May	0.03	0	0.03
BSST	1975	26 Aug.-30 Sept.	1.62	0	1.62
BSST	1976	30 May-7 June	0.43	0.19	0.24
BSST	1976	10-11 July	1.25	0	1.25
BSST	1976	27-28 Aug.	1.54	0.49	1.05
BSST	1976	10-15 Sept.	0.98	0.09	0.89
BSNT	1976	24-29 May	0	0	0
BSNT	1976	16-21 Aug.	3.25	0.16	3.09
BSST	1977	16-20 May	1.47	0.41	1.06
BSST	1977	6-7 July	0.53	0.16	0.37
BSST	1977	4 Aug.	0.47	0	0.47
BSST	1977	7-11 Sept.	1.01	1.55	-0.54
					$\bar{x} = 0.69$ $S^2 = 0.57$ $S = 0.78$ $t = 3.68^*$ *P<0.05

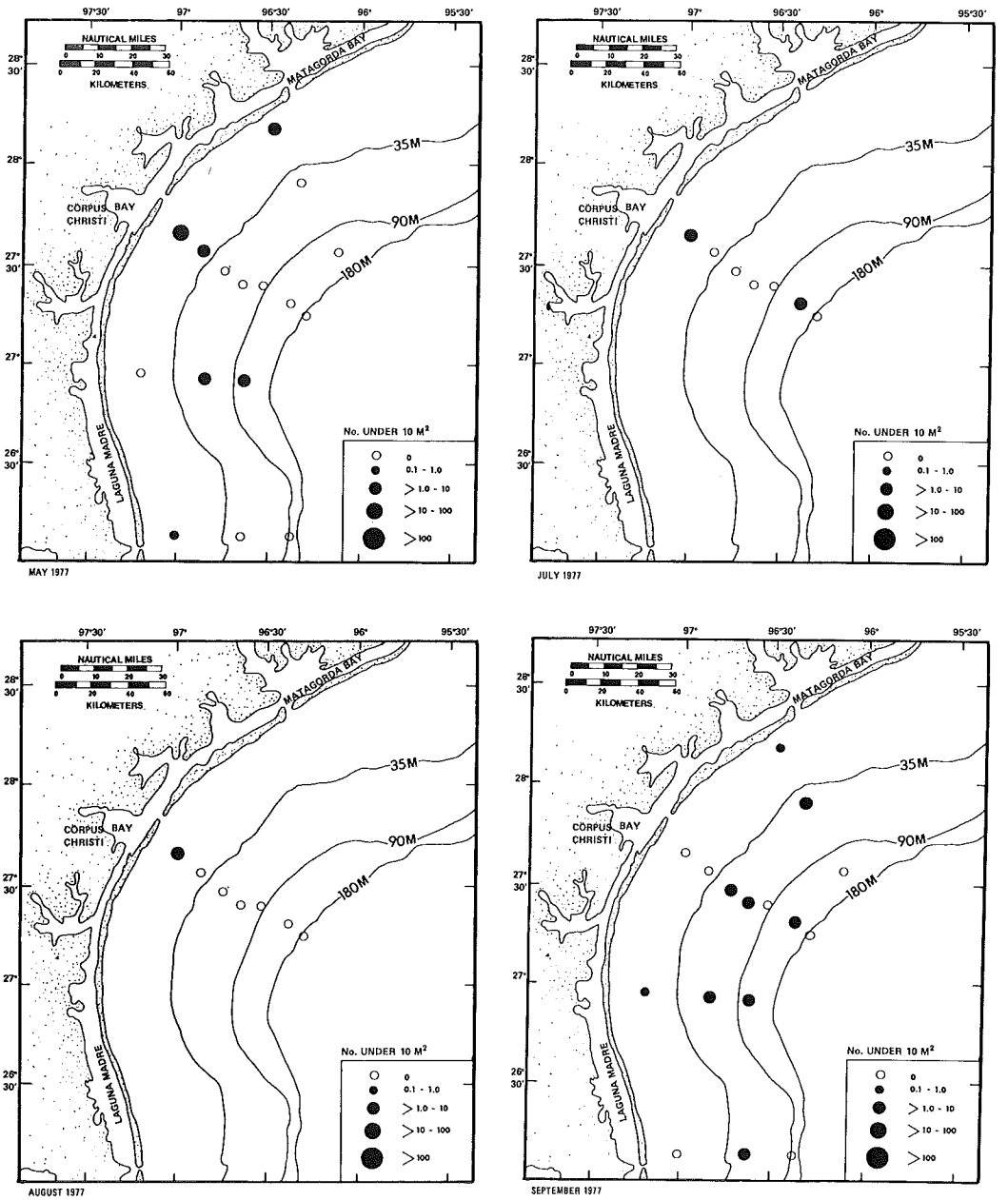

Figure 8. Estimated abundance of *S. maculatus* larvae at each station during the May, July, August, and September cruises of the BSST 1977 (south Texas).

of the survey. According to Hoese (1965) spawning of *S. maculatus* is limited to clear, "blue" water, thus it is unlikely that the majority of the spawning occurred inshore of the area sampled in this study. Also Hoese (1965) recorded larvae from over the same depth range sampled in this study.

Comparison of the results of the present study with those of Dwinell and Futch (1973), Houde *et al.* (1979) and Powles (ms.) suggests that the northwestern and

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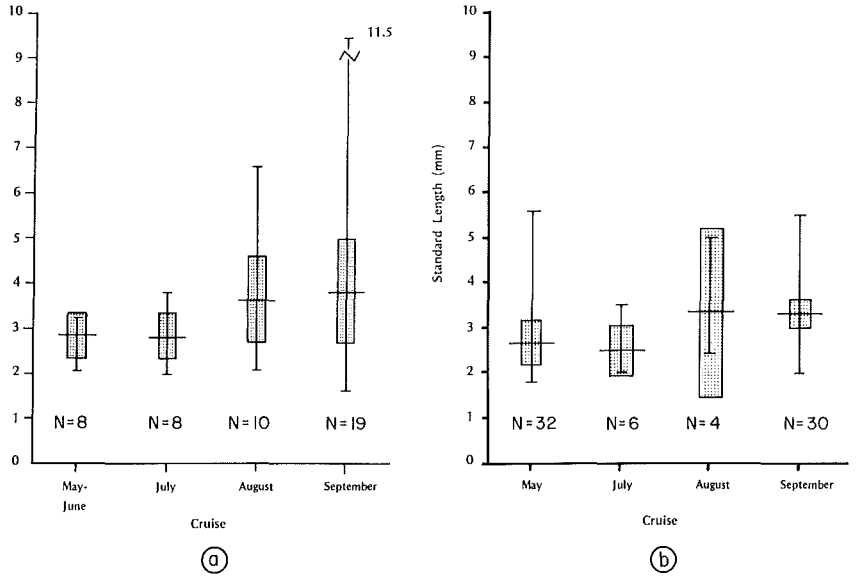

Figure 9. Distribution of standard lengths of *S. maculatus* larvae captured on the BSST 1976 and 1977 surveys (south Texas). Horizontal line = mean, vertical line = range, stippled bar = 95% confidence interval.

northeastern Gulf of Mexico and coast off the southeastern United States are important spawning areas for *S. cavalla* and that the eastern and northeastern Gulf of Mexico are important spawning areas for *S. maculatus*. These studies collected 139 *S. cavalla* and 188 *S. maculatus* from the northeastern Gulf, (Dwinell and Futch, 1973) 6 *S. cavalla* and 97 *S. maculatus* from the eastern Gulf (Houde *et al.*, 1979) and 213 *S. cavalla* and 16 *S. maculatus* from off the southeastern United States (Powles, ms.). However, these findings are preliminary and suggest that more intensive and geographically extensive larval surveys are needed to furnish reliable data on spawning of *S. cavalla* and *S. maculatus*.

ACKNOWLEDGMENTS

This research was supported in part by the Texas A&M University Sea Grant Program, Project number 53533. We thank Lyman E. Barger, L. Alan Collins, Allen Dixon and William Slingerland for sorting out the mackerel larvae from the plankton samples. Figures were prepared by Beth Brueker. Sally L. Richardson offered valuable suggestions on improving the manuscript.

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DOI: 10.18785/negs.0401.01