THE DISTRIBUTION, ABUNDANCE, AND TRANSPORT OF LARVAL SCIAENIDS COLLECTED DURING WINTER AND EARLY SPRING FROM THE CONTINENTAL SHELF WATERS OFF WEST LOUISIANA[1]

JAMES H. COWAN, JR.[2] AND RICHARD F. SHAW[3]

ABSTRACT

The larvae of six species of Sciaenidae were collected in continental shelf waters off west Louisiana on five midmonthly ichthyoplankton cruises from December 1981 to April 1982. Ranked in order of abundance these species were sand seatrout, *Cynoscion arenarius*; Atlantic croaker, *Micropogonias undulatus*; spot, *Leiostomus xanthurus*; black drum, *Pogonias cromis*; southern kingfish, *Menticirrhus americanus*; and banded drum, *Larimus fasciatus*. Total larva density was highest in April, and the high densities were associated with the coastal boundary layer, a horizontal density front caused by an intrusion of fresher water onto the inner shelf that probably issued from the Atchafalaya River east of the study area. Spawning by sand seatrout began in January, two months earlier than previously reported, and first occurred offshore of midshelf but moved shoreward as the season progressed. Analysis of length-frequency data suggest that spot probably began to spawn in November, one month earlier than once thought. Both sand seatrout and Atlantic croaker larvae were captured at higher rates at night than during the daytime. Sand seatrout larvae appear to be somewhat surface oriented while spot may undergo vertical migration. Interpretation of the sciaenid data support a previously developed transport hypothesis involving gulf menhaden larvae and west-northwest alongshore advection within and just outside of a horizontally stratified coastal boundary layer.

Members of the perciform family Sciaenidae are an important sport and commercial fishery resource along the United States coast of the Gulf of Mexico and are perhaps the most prominent group of northern Gulf inshore fishes. Sciaenids exceed all other families in numbers of species (18) and in numbers of individuals or biomass; they are among the top four families with Mugilidae, Engraulidae, and Clupeidae (Gunter 1938, 1945; Moore et al. 1970; Franks et al. 1972; Hoese and Moore 1977). Of the six species of sciaenids captured during this study, only the banded drum, *Larimus fasciatus*, is not commonly sought by both sport and commercial fishermen.

Many of Louisiana's sciaenids spawn in coastal or offshore waters. They have pelagic eggs and young which are then transported into estuaries (Johnson 1978 for review). The seasonal importance of Louisiana's estuaries as nursery grounds for postlarval and juvenile sciaenids is well documented (Cowan 1985 for review), and several summary works are available which contain taxonomic and biological information on adult sciaenids (Pearson 1929; Suttkus 1955; Guest and Gunter 1958; Hoese and Moore 1977; Johnson 1978; Powles and Stender 1978; Barger and Johnson 1980; Barger and Williams 1980; Mercer 1984a, b). In contrast, there is little information about sciaenid ichthyoplankton assemblages in Gulf continental shelf waters, their offshore and coastal distribution, or the oceanic current systems which influence their estuarine recruitment.

This study provides such early life history information by determining larva distribution, abundance, and length frequency; by documenting spawning location (depth and distance from shore) of winter and early spring-spawned sciaenids off west Louisiana; and by analyzing larval sciaenid distribution with respect to known water circulation patterns and a larval gulf menhaden, *Brevoortia patronus*, transport hypothesis in the shelf waters of the northwestern Gulf of Mexico (Shaw et al. 1985b). Recruitment implications of the observed distribution, larva age structure, and transport of sciaenids in Louisiana waters are also discussed.

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[2]Center for Wetland Resources, Louisiana State University, Baton Rouge, LA 70803-7503; present address: Center for Environmental and Estuarine Studies, University of Maryland, Chesapeake Biological Laboratory, Box 38, Solomons, MD 20688-0038.

[3]Center for Wetland Resources, Louisiana State University, Baton Rouge, LA 70803-7503.

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METHODS AND MATERIALS

Detailed sampling methodology has been presented elsewhere (Shaw et al. 1985 a, b). Briefly, larval sciaenids were collected off west Louisiana on a sampling grid consisting of 37 stations on 5 transects (Fig. 1) during 5 midmonthly cruises from December 1981 to April 1982. Ichthyoplankton samples were analyzed from the 335 μm mesh net side of an opening and closing, 60 cm, paired "bongo type" plankton sampler fitted with General Oceanics[4] flowmeters (model no. 2030). Most plankton collections (125 of 187 total) consisted of 10-min stepped oblique tows from near bottom to surface. Nets were set closed and opened just prior to the stepped ascent. Each tow had five steps with a retrieval rate between steps of 20 m/minute; towing speed was about 1 m/second (2 knots). The object of the 10-min tow was to filter approximately 100 m^3 of water. This process increased the water volume filtered per unit depth at the shallow stations relative to deeper stations. This discrepancy is acceptable since the alternative would be to compare 17-s shallow-station oblique tows with 9-min deep-station tows at a uniform retrieval rate (Houde 1977). At selected stations (A-3, 6, 9; B-1; C-6; D-1; E-3, 6, 9; Fig. 1), only 10-min simultaneous surface and near-bottom horizontal tows (31 surface and 31 near-bottom) were made to determine if sciaenid larvae were vertically stratified. Larva total length (TL) was measured to the nearest 0.1 mm. Larva densities are reported as standardized catch rates at a station (density = larvae/100 m^3).

A four-way analysis of variance (ANOVA) was performed on $\log_{10}$ transformed [(no. larvae/100 m^3) + 1] data to determine the spatial (vertical and horizontal), temporal, and diel patterns of species density and distribution. The four main effects tested were month (January–April); station depth group (d.g.) (d.g. 1 $\leq$ 10 m, 10 m $<$ d.g. 2 $\leq$ 14 m, 14 m $<$ d.g. 3 $<$ 24 m and d.g. 4 $\geq$ 24 m); day-night (2000 hours $\leq$ night $\leq$ 0500 hours); and horizontal tow type (surface vs. near-bottom). Data from the December cruise were not included as only the A transect was completed due to adverse weather conditions.

Two methods of current estimates were utilized (following Shaw et al. 1985b): 1) instantaneous current profiles taken at each station and 2) continuous surface and near-bottom current meter measurements at two sites (H and S; Fig. 1). The instantaneous number of larvae transported on each transect was calculated by using the equation $D \times \overline{U} \times M$ = number of larvae per meter per second where D = larva density (larvae/m^3) from either oblique tows or from the mean of the horizontal tows (i.e., average of surface and near-bottom catch rates), $\overline{U}$ = depth-averaged water velocity (m/s) determined from instantaneous current meter profiles at each station, and M = water depth (m) at each station.

Distribution diagrams and length-frequency histograms were generated for each cruise for the three most abundant sciaenid species. Inspection of these data along with current measurements allowed a comparison with the previously mentioned transport hypothesis.

[4]Reference to trade names does not imply endorsement by the National Marine Fisheries Services, NOAA.

RESULTS AND DISCUSSION

Total Sciaenids

A total of 5,225 larval sciaenids accounted for 9.1% of the fish larvae collected. In December through February, samples were dominated by Atlantic croaker, *Micropogonias undulatus*, and spot, *Leiostomus xanthurus*. In March and April samples contained mostly sand seatrout, *Cynoscion arenarius*. In all, six species of sciaenid larvae were collected: sand seatrout (N = 4,100); Atlantic croaker (N = 567); spot (N = 264); black drum, *Pogonias cromis* (N = 68); southern kingfish, *Menticirrhus americanus* (N = 53); and banded drum (N = 13). Additional *Menticirrhus*, not identifiable to species, accounted for 160 more specimens (Table 1). A more detailed examination of the data on the three most abundant sciaenid species follows.

Sand seatrout, *Cynoscion arenarius*

A total of 4,100 sand seatrout larvae was collected making it the most abundant sciaenid taken during the study. Larval sand seatrout densities were highest in April (Table 1) with a mean of 46.1 larvae/100 m^3; mean density in February and March was 0.3 and 2.9/100 m^3, respectively, and 1 larva was collected in January. Larvae were distributed mostly over the midshelf in February but highest concentrations were later found inshore and towards the east (Fig. 1). Over the course of study, larvae were found in temperatures and salinities ranging from 14° to 21°C and

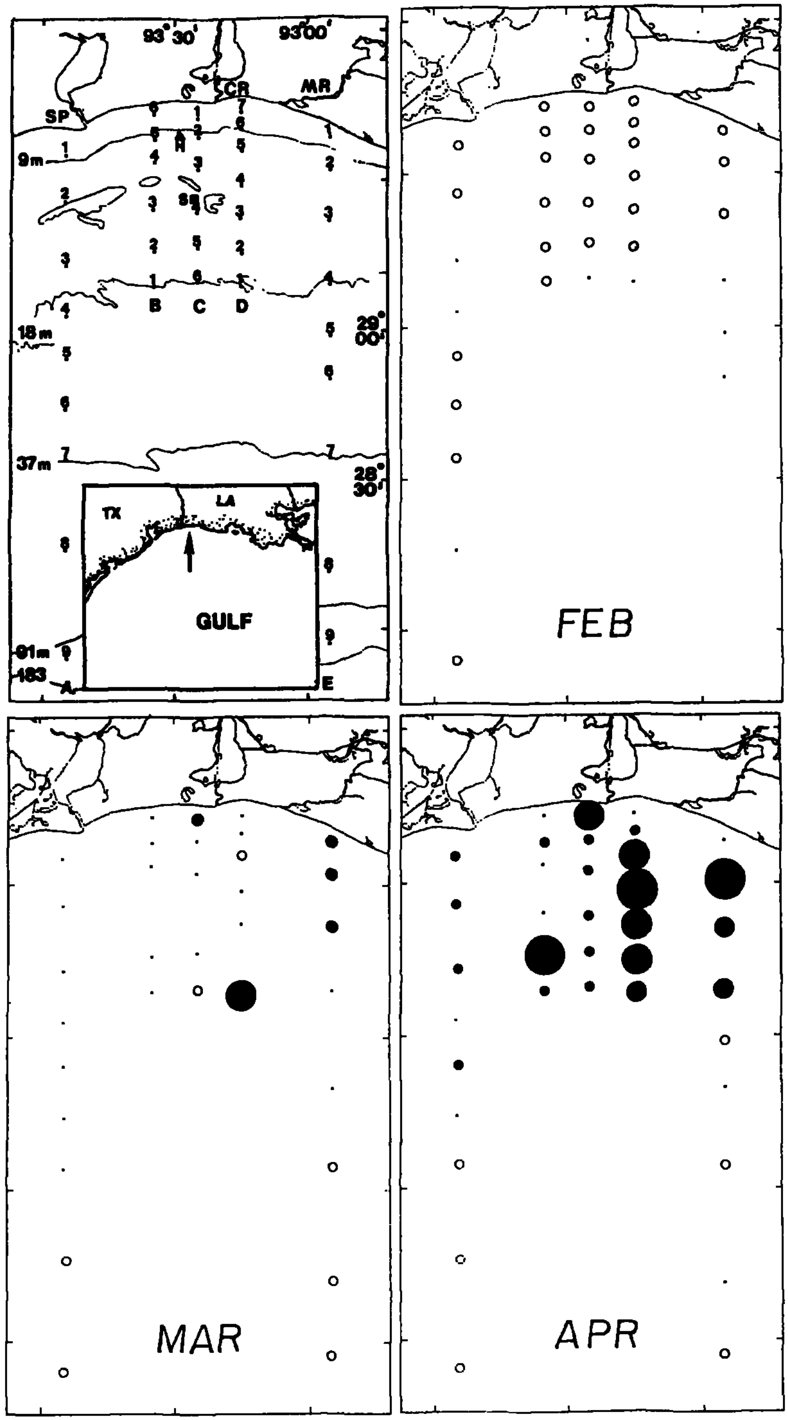

FIGURE 1.—Density distribution of sand seatrout, *Cynoscion arenarius*, larvae by month, February–April 1982. Densities are as follows: o = 0; · >0–10; • >10–50; ● >50–99; ● >99–250; ● >250/100 m^3 of water filtered from all plankton tow types. Also shown is the station sampling grid with moored current meter sites (H and S) and selected isobaths. SP = Sabine Pass, CR = Calcasieu River, and MR = Mermentau River.

TABLE 1.—Total number, months of occurrence and monthly density of sciaenid larvae collected in west Louisiana shelf waters from December 1981 to April 1982.

Taxa	Total number	Months of occurrence and density (No./100 m^3)				
		Dec.	Jan.	Feb.	Mar.	Apr.
Cynoscion arenarius	4,100	—	1 larva	0.3	2.9	46.1
Micropogonias undulatus	567	2.0	2.2	3.2	2.2	0.2
Leiostomus xanthurus	264	7.8	1.3	0.9	0.1	—
Menticirrhus sp.	160	—	—	—	—	1.9
Pogonias cromis	68	—	1 larva	0.5	0.2	0.2
Menticirrhus americanus	53	—	—	—	—	0.6
Larimus fasciatus	13	—	—	—	—	0.2

from 15 to 36 ppt (Table 2) and at station depths ranging from 5 to 70 m, but most were collected inside the 18 m isobath. Larval sand seatrout density increased in April with many stations exhibiting densities in excess of 250 larvae/100 m^3; the larvae appeared to be associated with a freshet of water on the shelf, probably issuing from the Atchafalaya River east of the study area (Shaw et al. 1985a). The presence of riverine runoff on the shelf, which was most evident in March and April 1982, caused the development of an oceanic salinity front referred to as the coastal boundary layer, 10–35 km from shore (Wiseman et al. 1987).

Observed spawning seasonality and location for sand seatrout are in part consistent with previously published information (Shlossman and Chittenden 1981 for review). The presence of a 4 mm TL larva in January indicates some spawning had taken place at least 2 months earlier than

TABLE 2.—Monthly data summaries at time of capture for three sciaenid larvae (*Cynoscion arenarius*, *Micropogonias undulatus*, and *Leiostomus xanthurus*) collected in west Louisiana shelf waters from December 1981 to April 1982.

Species/month	Total number	Length range (mm TL)	Temperature range (°C)	Salinity range (ppt)	Depth range (m)
Cynoscion arenarius					
January	1	4	14	35	18
February	20	2.5–4.5 (mode = 2–3)	14–20	34–36	15–70
March	203	1.5–10.5 (mode = 2–3)	14–18	25–36	5–40
April	3,876	1.5–20.5 (mode = 2–3)	20–21	15–36	5–70
Micropogonias undulatus					
December	28	2.5–10.5 (mode = 3–4)	12–20	30–36	10–65
January	158	2.5–10.5 (mode = 4–5)	10–18	30–36	5–70
February	221	2.5–17.5 (mode = 14–15)	11–17	27–36	5–40
March	144	2.5–19.5 (mode = 14–15)	14–20	25–36	5–115
April	16	11.5–18.5 (mode = 17–18)	20.5	22	7
Leiostomus xanthurus					
December	110	2.5–7.5 (mode = 3–4)	14–18	30–36	16–65
January	89	2.5–13.5 (mode = 4–5)	10–18	30–36	5–40
February	62	3.5–15.5 (mode = 12–13)	10–17	28–36	5–40
March	3	3.5–16.5	14–17.5	26–36	11–40

previously reported. Monthly length-frequency data for sand seatrout show that larvae as large as 11 mm TL were first present in March samples (Fig. 2A). Based on the estimated growth rate determined for sand seatrout (Cowan 1985; Shaw et al., in press), an 11 mm larva could be as old as 65 days; this further supports January spawning. Sand seatrout are reported to spawn from March to August, during two discrete periods—one in March–May, the other August–September, with little spawning between the two peak periods (Hoese 1965; Daniels 1977; Shlossman and Chittenden 1981).

An examination of distribution and length-frequency data (Figs. 1, 2A) suggests that most spawning initially took place in midshelf to offshore waters at depths ranging from 15 to 80 m or to about 175 km from shore. As the season progressed into March and April, spawning location, as determined by the presence of larvae <3.0 mm TL, was more inshore (5–18 m) with few small larvae occurring at depths >25 m.

Other than the indication that spawning may move from offshore to inshore waters as the season progresses, this spatial information agrees with the limited life history data available on sand seatrout. Most spawning has been shown to occur in the shallow waters of the Gulf of Mexico, primarily between 7 and 15 m in depth (Gunter 1945; Moffet et al. 1979; Shlossman and Chittenden 1981). Running ripe *C. arenarius* have been captured in deepter waters (70–90 m) in February and March, but no spawning was indicated (Franks et al. 1972; Perry 1979).

In a four-way ANOVA employed to determine patterns of larval sand seatrout density and distribution, month was a highly significant main effect ($P < 0.01$; Table 3) reflecting spawning seasonality and the magnitude of the density increase in April. The test for interaction between month and day-night was employed to determine if daytime gear avoidance was evident as size and mobility of larva increased. Most sand seatrout collected, however, were small and no clear monthly modal increase in larva size was evident (Fig. 2A). The significant interaction ($P < 0.01$) was probably due to an increased catch in oblique tows at night as the season progressed (0.0 in January, 64.9/100 m^3 in April). The significant interaction between month and depth group and the highly significant depth group main effect ($P < 0.01$) represents the shift in larva concentration from midshelf early in the study, to a more coastal distribution in March and April (Fig. 1). Mean larva density was greatest in depth group 1 (23.7/100 m^3) followed by depth groups 2, 3, and 4 (12.7, 9.2, and 0.3/100 m^3, respectively). The third main effect, day vs. night tows, was highly significant ($P < 0.01$); many more sand seatrout larvae were collected at night (averge catch rates in all night (74) tows combined = 21.6/100 m^3 vs. day (113) tows = 7.4/100 m^3). Highest nighttime catches occurred in oblique (49) tows (26.9/100 m^3) while the day-oblique-catch rate averaged 7.6/100 m^3 in 76 tows. Overall, average catch rate was highest in oblique (125) tows (14.6 larvae/100 m^3), followed by surface (31) tows (9.2/100 m^3), and then bottom (1.9/100 m^3; 31 tows). Intrepretation of the data suggests that

TABLE 3.—Summary data from four-way analysis of variance done on $\log_{10}$ transformed [(larvae/100 m^3) + 1] data from ichthyoplankton samples collected from January to April 1982. The results are for A. *Cynoscion arenarius*, B. *Micropogonias undulatus*, and C. *Leiostomus xanthurus*. The four main effects tested were months (Jan.–Apr.), station depth group (d.g. 1 ≤ 10 m, 10 m < d.g. 2 ≤ 14 m, 14 m < d.g. 3 < 24 m and d.g. ≥ 24 m), day - night (2000 hours ≤ night ≤ 0500 hours) and horizontal tow type (surface vs. near-bottom).

Source	df	PR > F	
A. Dependent variable:			
Log_{10} [(*Cynoscion arenarius*/100 m^3) + 1]			
Model	21	0.0001**	$r^2 = 0.75$
Month	3	0.0001**	
Depth group	3	0.0001**	
Day-night	1	0.0026**	
Horizontal tow type	1	0.2574 (NS)	
Month vs. Day-night	3	0.0001**	
Month vs. Depth group	9	0.0001**	
Day-night vs. Tow type	1	0.4180 (NS)	
Error	177		
Corrected Total	198		
B. Dependent variable:			
Log_{10} [(*Micropogonias undulatus*/100 m^3) + 1]			
Model	21	0.0001**	$r^2 = 0.63$
Month	3	0.0045**	
Depth group	3	0.3551 (NS)	
Day-night	1	0.0001**	
Horizontal tow type	1	0.4448 (NS)	
Month vs. Day-night	3	0.2168 (NS)	
Month vs. Depth group	9	0.0001**	
Day-night vs. Tow type	1	0.1288 (NS)	
Error	177		
Corrected Total	198		
C. Dependent variable:			
Log_{10} [(*Leiostomus xanthurus*/100 m^3) + 1]			
Model	21	0.0001**	$r^2 = 0.51$
Month	3	0.0001**	
Depth group	3	0.0033**	
Day-night	1	0.1875 (NS)	
Horizontal tow type	1	0.3216 (NS)	
Month vs. Day-night	3	0.2138 (NS)	
Month vs. Depth group	9	0.0001**	
Day-night vs. Tow type	1	0.0324*	
Error	177		
Corrected Total	198		

* = Statistically significant ($P < 0.05$).
** = Highly significant ($P < 0.01$).
(NS) = Not significant.

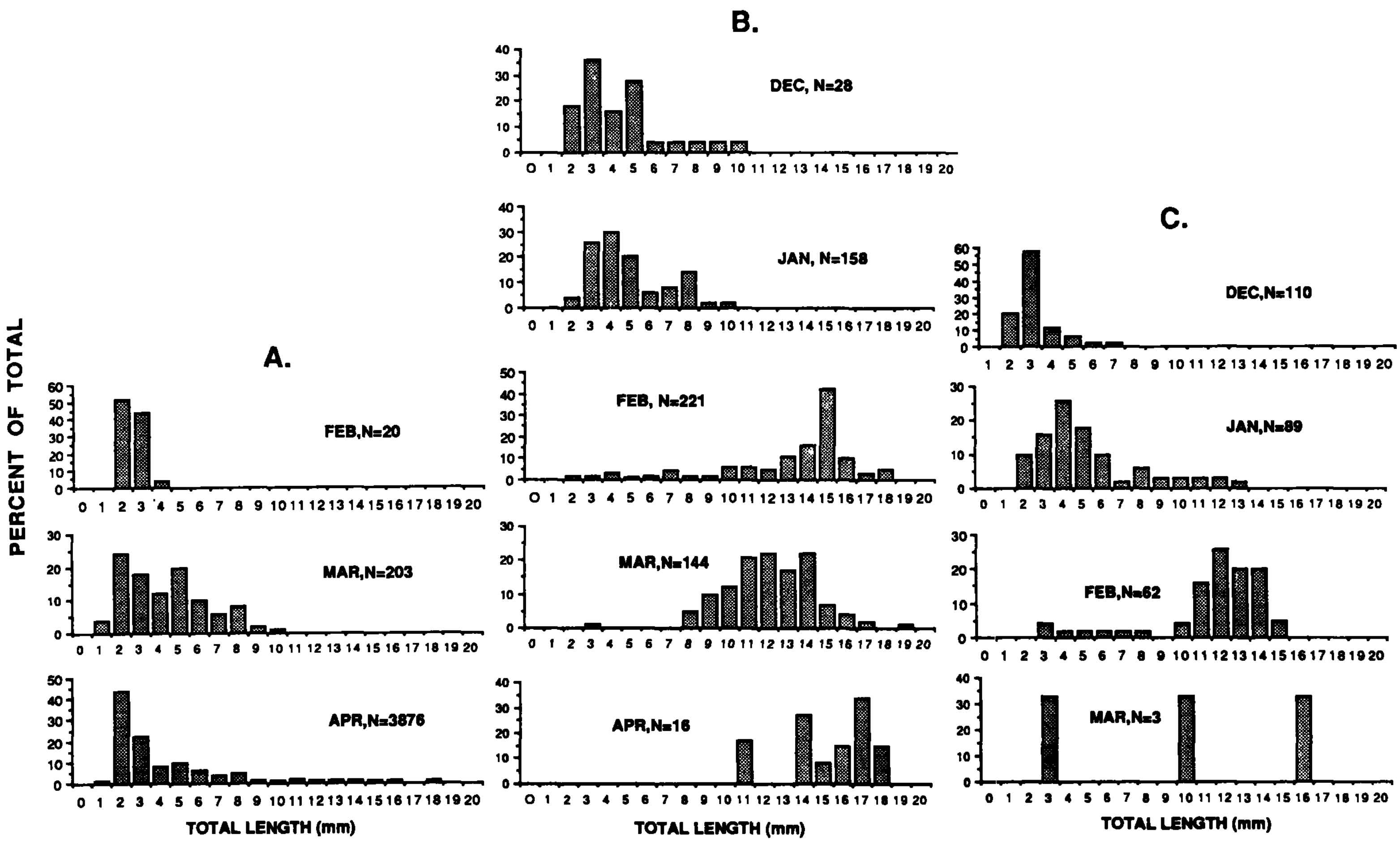

FIGURE 2.—Length-frequency data by month for larval sciaenids, December–April 1982. A. *Cynoscion arenarius*, B. *Micropogonias undulatus*, and C. *Leiostomus xanthurus*. N = total number caught and measured.

sand seatrout larvae were somewhat surface oriented.

Atlantic croaker, *Micropogonias undulatus*

The second most abundant sciaenid taken was Atlantic croaker ($N = 567$). Larval Atlantic croaker density was greatest in February at 3.2/100 m^3, but density was relatively constant from December through March (Table 1). Mean densities for December, January, March, and April were 2.0, 2.2, 2.2, and 0.2/100 m^3, respectively. Atlantic croaker was the only sciaenid collected in all months of the study. Their overall distribution (all sizes combined) was generally uniform over most of the shelf (Fig. 3) except in March and April when they were more often found inshore. Recently spawned larvae (<3.0 mm TL) were also collected over much of the shelf at station depths ranging from 15 to 115 m or from about 20 to 200 km from shore. However, most small larvae were collected near midshelf about 65–125 km from shore. In December and January the majority of the larvae were small. By April, no recently spawned individuals were collected (Fig. 2B). For the study overall, larvae were found in salinities and temperatures ranging from 22 to 36 ppt and from 10° to 20.5°C (Table 2).

Spawning by Atlantic croaker in Gulf of Mexico waters is reported to occur from September to March, with a distinct peak in October (Hoese 1965; Sabins and Truesdale 1974; White and Chittenden 1977; Benson 1982) and to occur primarily offshore over a wide area (Pearson 1929; Hildebrand and Cable 1930; Wallace 1940; Haven 1957; Bearden 1964; Hoese 1965; Nelson 1967). Atlantic croaker larvae, however, have been taken on the outer continental shelf off Texas from September to May (Finucane et al. 1979).

As with sand seatrout, a four-way ANOVA was used to determine patterns in larva density and distribution (Table 3). Larval Atlantic croaker density by month was a highly significant main effect ($P < 0.01$). Densities at the end of their spawning period were low, increased only slightly in February, and then dropped off by April (Table 1). The interaction between month and day-night was not significant. The highly significant interaction between month and depth group was not surprising. Larvae were in more offshore waters early in the study while later becoming more abundant inshore (Fig. 3). However, as a main effect, depth group was not significant. Larval Atlantic croaker mean densities for depth groups 1 through 4 were 3.9, 0.8, 0.4, and 0.7/100 m^3, respectively. Day-night, as a main effect, was highly significant ($P < 0.01$). Larval Atlantic croaker density was over 5 times higher at night (all tow types combined) than during the day (3.7 vs. 0.7/100 m^3). However, the interaction between day-night and horizontal tow type was not significant. The fourth main effect tested, horizontal tow type, was not significant. Average catch rates at the surface and near-bottom were similar (1.0 and 1.8/100 m^3, respectively).

Spot, *Leiostomus xanthurus*

The third most abundant sciaenid collected was spot ($N = 264$). Density of spot larvae was highest in December at 7.8 larvae/100 m^3 (Table 1). However, the high December value must be viewed with a consideration of the abbreviated cruise track for that month and the resultant reduction in spatial coverage. Mean densities for January to March were 1.3, 0.9, and 0.1/100 m^3, respectively. No spot larvae were collected in April. In general, larva density was low and their distribution was uniform over the shelf out to the 40 m isobath, about 130 km offshore (Fig. 4). Spot were collected in temperatures and salinities ranging from 10° to 18°C and from 26 to 36 ppt (Table 2), and at stations with depths ranging from 5 to 65 m.

Larvae >7 mm TL in our mid-December (Fig. 2C) collections and small larvae (<3.0 mm TL) in all but the last cruise indicate that spawning probably began by at least November and continued through March. Spawning occurred from near midshelf (about 65 km) out to 175 km from the coast. Data presented here partly concur with previously published information on spot spawning periodicity. In the northern Gulf, spawning reportedly occurs from late December to March, peaking in January, and takes place well offshore in moderately deep water (Pearson 1929; Kilby 1955; Townsend 1956; Dawson 1958; Springer and Woodburn 1960; Pacheco 1962; Nelson 1967; Joseph 1972; Music 1974; Sabins and Truesdale 1974).

A four-way ANOVA indicated that month, as a main effect for spot larvae, was highly significant ($P < 0.01$), which probably reflects the decreasing catch rates seen from January to March (Table 3). The interaction between month and depth group was also highly significant ($P < 0.01$) as was depth group as a main effect. Larval spot

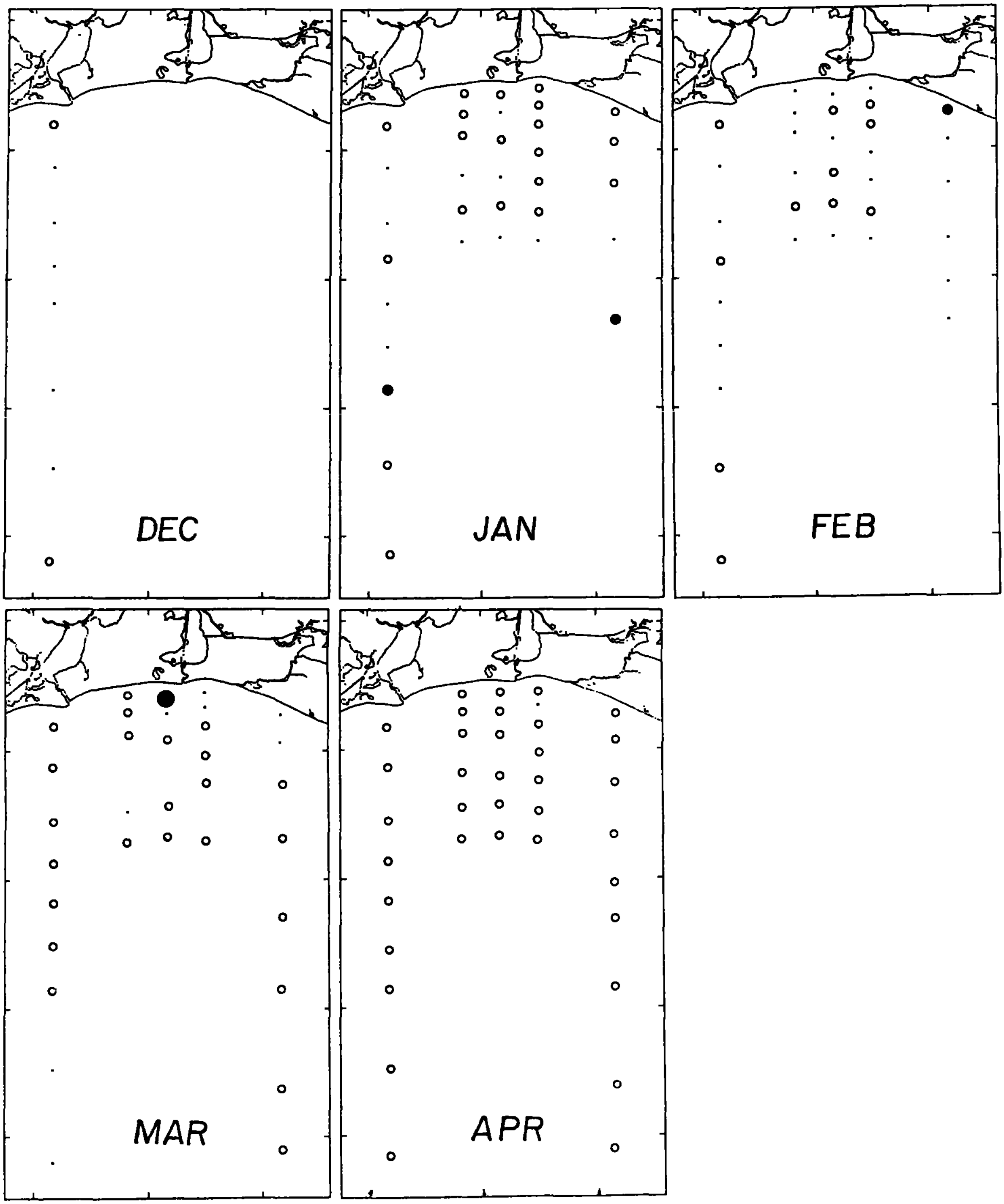

FIGURE 3.—Density distribution of Atlantic croaker, *Micropogonias undulatus*, larvae by month, December 1981—April 1982. Densities are as follows: o = 0; · >0–10; • >10–50; ● >50;–99; ● >99–250; ● >250/100 m^3 of water filtered from all plankton tow types.

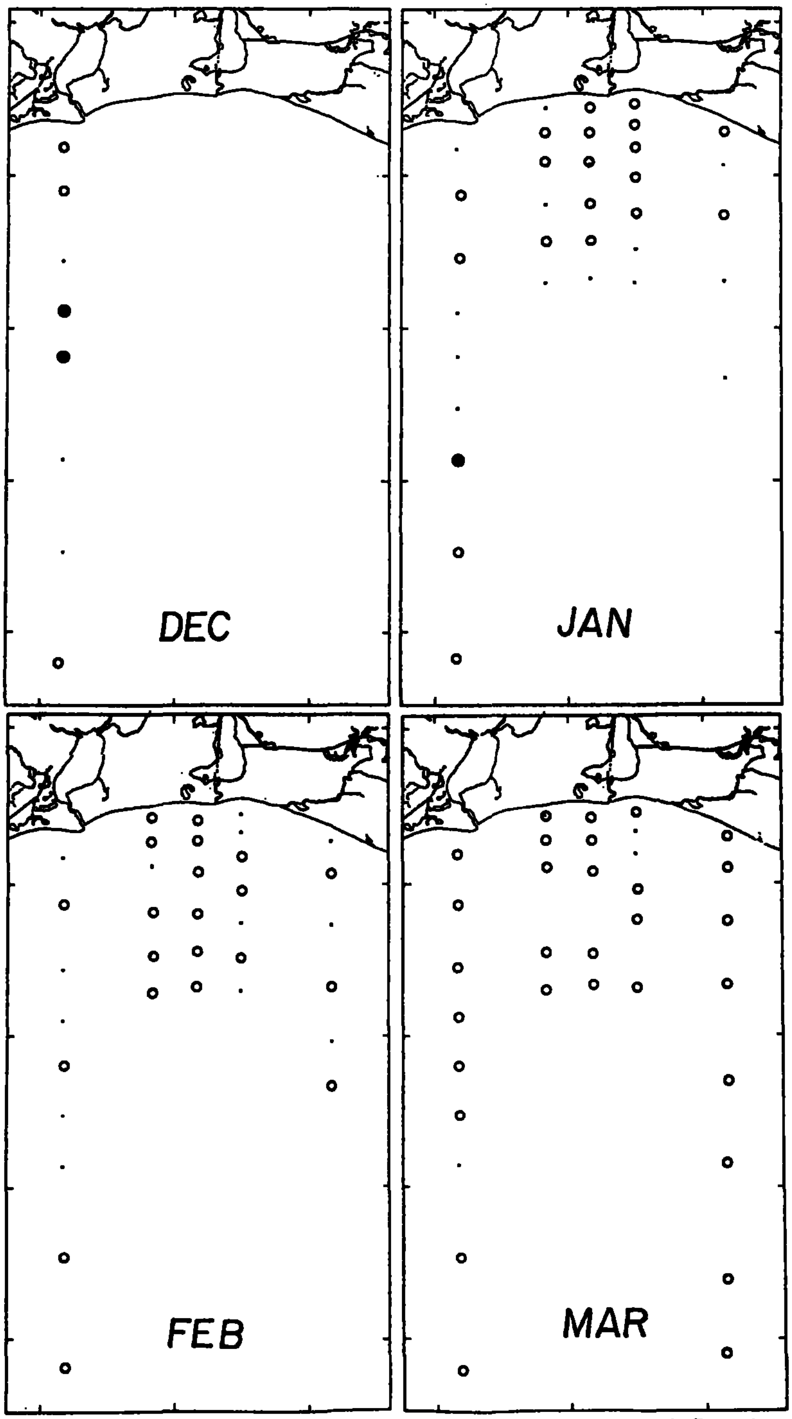

FIGURE 4.—Density distribution of spot, *Leiostomus xanthurus*, larvae by month, December 1981–March 1982. Densities are as follows: o = 0; · >0–10; • >10–50; ● >50–99; ● >99–250; ● >250/100 m^3 of water filtered from all plankton tow types.

densities were higher offshore in the early part of the study and then greater inshore during February and March. Depth group 4 had the highest mean density (1.3/100 m^3) followed by depth groups 1 and 3 (0.4/100 m^3 each) and depth group 2 (0.1/100 m^3). Day-night comparisons proved nonsignificant as a main effect for spot larvae. The average catch rates for all day and night tows were identical (0.5/100 m^3). However, the interaction between day-night and horizontal tow type was statistically significant ($P < 0.05$). In this case, vertical migration and stratification may be indicated. Average catch rate of spot larvae during the day at the surface was 0.1/100 m^3, while near the bottom it averaged 1.6. Conversely, nighttime average catch rate at the surface was 1.0/100 m^3, while the near-bottom rate averaged 0.04. These are very low densities but the vertical differences are an order of magnitude and their reversing pattern suggests that spot larvae were stratified and undergoing diel vertical migration. Daytime bottom and nighttime surface average catch rates were higher than for oblique (O) tows (day, O = 0.45/100 m^3; night, O = 0.49/100 m^3). Average catch rates for surface and near-bottom tows, regardless of time of day, were 0.5 and 0.9/100 m^3, respectively.

As previously mentioned, other larval sciaenid species (i.e., black drum, banded drum, southern kingfish) were collected during these cruises. However, relatively few individuals were captured (Table 1), making information on their distribution inconclusive.

TRANSPORT ANALYSIS

Alongshore advection within and just outside the coastal boundary layer in the northwestern Gulf of Mexico has been hypothesized as the major mechanism transporting gulf menhaden larvae to the estuaries in western Louisiana, rather than across-shelf transport from directly offshore. In contrast, such direct across-shelf transport has been demonstrated for sciaenids and other species along the U.S. mid-Atlantic coast (Nelson et al. 1976; Norcross and Austin 1981; Miller et al. 1984). The data collected for sciaenid larvae (all species combined) were examined in light of this Gulf hypothesis. Larval sciaenid densities were less than those for gulf menhaden but similarities in distribution were evident. Both larval sciaenid and gulf menhaden densities were highest at midshelf early in the study. By March and April the highest densities were found towards the east and inshore and were associated with a horizontal density front (coastal boundary layer) caused by an intrusion of fresher water onto the shelf.

The along-transect length-frequency patterns exhibited by larval sciaenids and gulf menhaden were also similar. No apparent increase in size was seen until gulf menhaden larvae were on the inner shelf or sciaenids were on the mid- to inner shelf. The expected pattern of a gradual increase in larva size from offshore to inshore, which would result if there were significant across-shelf (south to north) transport, was not evident in either data set. Off the North Carolina coast, Warlen (1981) and Miller et at. (1984) showed that ages and lengths of both spot and Atlantic croaker larvae increased systematically toward shore in an area where winter water currents favored across-shelf (west to east) transport.

During the winter of 1981–82, moored current meter data from sites H and S (Fig. 1) indicated that flow was directed primarily alongshore in the west-northwest direction. Several researchers have reviewed the circulation in the northwestern Gulf (Nowlin 1971; Kelly et al. 1982; Crout 1983). It was not until Cochrane and Kelly (1986) developed their comprehensive circulation model for the Louisiana-Texas continental shelf, however, that the ocean current patterns, which led to the hypothesized larva transport model, were fully documented. Flow in nearshore coastal waters is westward all year except in summer when it usually reverses, while farther offshore flow is eastward all year (Cochrane and Kelly 1986).

To quantify transport, larval sciaenid densities were combined with the vertically averaged, instantaneous current measurements. The resultant curves present the number of larvae transported per unit time at each station (Fig. 5). Early in the winter, highest sciaenid larva transport (mostly Atlantic croaker and spot) was located midshelf. Later (March and April), transport values were higher inshore and reflected the increase in larval sciaenid density (primarily sand seatrout). Overall, larva transport was primarily westward and ranged from about 0.05 to 4.0 larvae/meter per second.

Although the oceanographic data collected were insufficient to precisely quantify onshore transport rates, an estimate was obtained by using the mean current vectors from the near surface meter at site H (Fig. 1) from 24 January to 12 May 1982 (14.33 cm/second alongshore westward

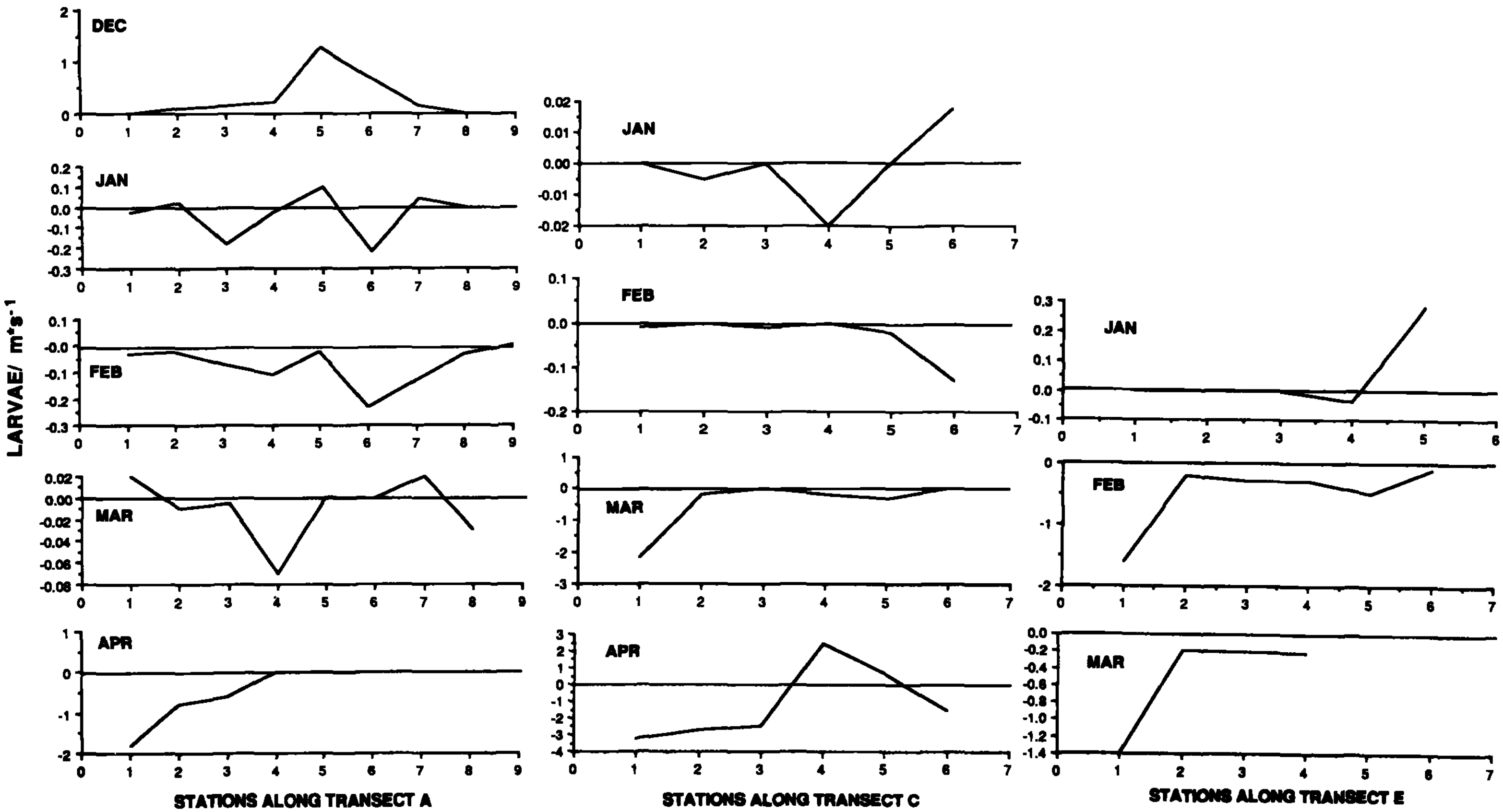

FIGURE 5.—Larval sciaenid transports (larvae/m·s) across transect A, C, and E, December 1981–April 1982. Easterly transports are positive values. Transport rates were determined from the observed larva concentrations combined with instantaneous current measurements. Note the difference in scale between months.

and 1.75 cm/second shoreward). Based on that average shoreward advection rate we calculated that larvae could be passively transported 98 km in the onshore direction in 65 days. Examination of length frequency and age at capture data (Cowan, in press) suggest that larval Atlantic croaker arrive in nearshore coastal waters, on the average, 60–90 days after hatching. Most small, newly hatched Atlantic croaker larvae were collected approximately 100 km offshore. Although the onshore component of advective transport is small in comparison with the average alongshore component, the estimate of shoreward transport rate is reasonable when age of larvae is considered.

CONCLUSIONS—RECRUITMENT IMPLICATIONS

Across-shelf transport appears to be an order of magnitude smaller than alongshore advective transport in the northwestern Gulf shelf waters during winter and spring. Sciaenid larvae collected offshore in the study area, at midshelf and beyond, would probably be lost to the estuaries in western Louisiana. Those offshore larvae would be transported towards north Texas estuaries, or back to the east if they were far enough offshore, since there is evidence for an easterly counter current (Kelly et al. 1982; Cochrane and Kelly 1986).

Sand seatrout are common in west Louisiana estuaries (Herke et al. 1984) and were the most abundant sciaenid larvae collected in this study. They spawn, in general, more inshore (Fig. 1) than Atlantic croaker or spot. Conceivably, many of the sand seatrout collected in the study area inside the coastal boundary layer on the inner shelf would have recruited to Louisiana estuaries.

Still, large numbers of postlarval sciaenids, other than sand seatrout, enter the estuaries in west Louisiana each year. Atlantic croaker and spot were the 3rd and 21st most abundant fish, of 117 species collected, in the Calcasieu River Basin, the largest estuary in west Louisiana (Herke et al. 1984). However, the distribution and transport analyses indicate that most spot and Atlantic croaker larvae directly offshore at least would not have recruited to the Calcasieu Basin. Interpretation of these data suggests that the source of the sciaenid postlarvae shown to seasonally recruit to the Calcasieu estuaries must be east of the study area. Interpretation of data summarizing several years of northern Gulf shrimp-trawl collections suggests that, during the spawning season, a sufficient concentration of adults exists to the east of our study area (Darnell et al. 1983).

In the fall and winter, high concentrations of Atlantic croaker, and to a lesser extent spot, have been found between the 20 and 40 m depth contours (65 and 125 km offshore) in an area east of the sampling grid. The area and timing of high concentration coincides with the reported spawning location and period for both Atlantic croaker and spot. If indeed this concentration represents a spawning distribution, it would help explain why so few Atlantic croaker and spot larvae, relative to the number of juveniles seen in estuaries, were collected in this and previous Gulf of Mexico ichthyoplankton studies. Unless collections were made in or near the spawning area, single-station densities would be low as eggs and larvae were dispersed. Furthermore, this study demonstrates the need for understanding both biological (vertical distribution, age and growth, behavior, etc. of larvae) and physical (ocean currents, estuarine-shelf exchange, etc.) processes which may influence estuarine recruitment.

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