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DISTRIBUTION AND MOVEMENTS OF NEUSTONIC YOUNG OF ESTUARINE DEPENDENT (*MUGIL* SPP., *POMATOMUS SALTATRIX*) AND ESTUARINE INDEPENDENT (*CORYPHAENA* SPP.) FISHES OFF THE SOUTHEASTERN UNITED STATES

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Mugil cephalus (striped mullet), *Mugil curema* (white mullet), and *Pomatomus saltatrix* (bluefish) spawn in continental shelf waters off the southeastern United States; juveniles enter estuaries of the region and pass the first summer's growth period there. The purpose of this study was to elucidate mechanisms of transport of young stages to the estuaries through an examination of distribution and abundance of larvae in continental shelf and upper slope waters. Results were compared with those on larvae of *Coryphaena hippurus* (dolphin) and *Coryphaena equisetis* (pompano dolphin), which also spawn in shelf and upper slope waters but which remain in the pelagic habitat throughout their life cycle. Neuston samples (326) and water column plankton samples (259, from oblique bongo sampler tows) were available from seven cruises (January–February 1976; February–March 1973; April–May 1974; May 1973; August–September 1974; August–September 1975; October–November 1973) conducted in continental shelf and upper continental slope waters between Cape Fear, North Carolina (latitude 34° N) and Cape Canaveral, Florida (latitude 28° 30′N).

Larvae of all five species are predominantly neustonic, as shown by higher concentrations in neuston tows than in bongo sampler tows (Table 1). Larvae of all species are characterized by early development of heavy body pigmentation, which may be an adaptation to high levels of ultraviolet radiation in the surface layer. The seasonal abundance cycle peaked in winter (January–March) for *Mugil cephalus*, in spring (April–May) for the other four species.

Larvae of *Mugil cephalus*, *Mugil curema*, and *Pomatomus saltatrix* were distributed over the whole area studied, from stations furthest offshore to stations nearest shore, whereas larvae of *Coryphaena hippurus* and *Coryphaena equisetis* were most abundant near the 180 m contour and were absent at stations near shore. The smallest larvae of *M. cephalus*, *M. curema*, and *P. saltatrix* were concentrated near the 180 m contour. Standard lengths of larvae were inversely related to distance from shore (Fig. 1, Table 2). The inverse relationship of larval length to distance from shore was strongest for *Mugil cephalus*, somewhat weaker for *Mugil curema*, and weak for *Pomatomus saltatrix*; strength of the relationship varied between different years in which sampling was conducted (Table 2). No relationship of length of larvae to distance from shore was observed for *Coryphaena hippurus* or *Coryphaena equisetis*. Surface waters at the 180 m

Table 1. Relative catches (all cruises) in neuston and bongo samplers.

Species	Total catch		Catch/ /1 000 m^3		Ratio
	neuston	bongo	neuston	bongo	N:B
Mugil cephalus	451	1	1.63	0.02	67.8
Mugil curema	3 269	63	11.80	1.41	8.4
Pomatomus saltatrix	2 950	112	10.65	2.51	4.2
Coryphaena equisetis	158	0	0.57	0	0
Coryphaena hippurus	305	0	1.10	0	0

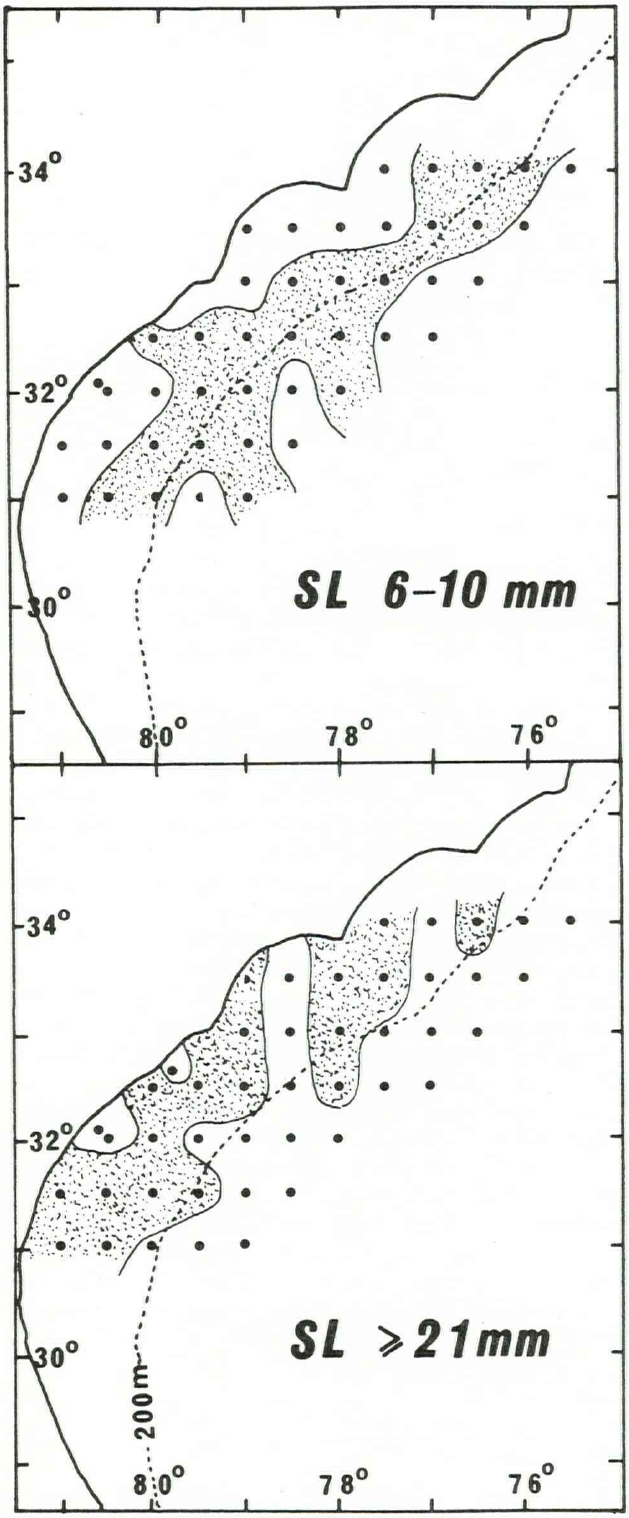

Figure 1. Distribution of larval *Mugil cephalus* of two length classes off the Southeast USA.

Table 2. Regressions of standard length (Y, mm) on distance from shore (X, km).

Species	Cruise	Regression
Mugil cephalus	Winter, 1973	$Y = -0.13X + 30.56^{a}$
	Winter, 1976	$Y = -0.11X + 20.48^{b}$
Mugil curema	Spring, 1973	$Y = -0.09X + 19.80^{b}$
	Spring, 1974	$Y = -0.06X + 12.72$
Pomatomus saltatrix	Spring, 1973	$Y = 0.0058X + 9.08$
	Spring, 1974	$Y = -0.032X + 13.41^{b}$

[a]Significantly different from zero at $p = 0.01$
[b]Significantly different from zero at $p = 0.05$

Others — not significantly different from zero

contour, where the smallest larvae of all five species were concentrated, are of relatively high salinities (⩾35‰) and temperatures (⩾24° C) throughout the year, due to the presence of the northerly-flowing Florida Current. Winter (10° to 15° C, 27–34‰) and spring (20° to 23° C, 30–34‰) surface water conditions in coastal waters are such that strong gradients of temperature and salinity exist between shelf edge and nearshore areas. In summary, observed distributions of larvae of the three estuarine-dependent species are generally consistent with a life-cycle involving spawning in warm, saline offshore waters and movement to cooler, less saline coastal waters; however, evidence for shoreward movement is weaker for *Mugil curema* and *Pomatomus saltatrix* than for *Mugil cephalus*. Distributions of *Coryphaena* larvae are consistent with their pelagic life-cycle.

What physical mechanisms might account for the observed larval distributions, the abundance of young *Mugil cephalus*, *Mugil curema*, and *Pomatomus saltatrix* in coastal and estuarine waters of the Southeast USA recorded in published studies, and the implied movements of larvae? In winter, when *Mugil cephalus* larvae are most abundant, wind-driven (Ekman) drift has a shoreward component, which may cause shoreward larval movement as apparently occurs in the Atlantic menhaden, *Brevoortia tyrannus* (Nelson et al., 1977). Ekman drift is offshore in April–May, so cannot account for shoreward movement of larval *Mugil curema* or *Pomatomus saltatrix*. It has been suggested (Kendall and Walford, 1979) that most *Pomatomus saltatrix* spawned off the Southeast USA may drift north of Cape Hatteras in the Florida Current before moving shoreward; my results are consistent with this hypothesis in that they show a weak association of larval length with distance from shore, but some larvae must reach the coast, since *Pomatomus saltatrix* juveniles are found in coastal waters here. Active swimming toward shore would involve sustained speeds in excess of 1 body length per second for at least several days against the offshore Ekman drift: this mechanism may contribute to shoreward movement of larvae but is doubtful as the major mechanism. "Spin-off" eddies from the western edge of the Florida Current effect shoreward water transport between Cape Fear and Cape Hatteras (Blanton, 1971), but affect mainly subsurface waters; drift bottle observations (Bumpus, 1973) suggest that such eddies are insignificant in transporting surface water shoreward south of Cape Fear. For *Mugil curema*, spawning populations in the Gulf of Mexico and northern Caribbean Sea might seed southeast United States waters with large larvae, which could have achieved sufficient size at time of arrival to swim actively shoreward. Length frequencies of *Mugil curema* larvae in the present study were consistently bimodal, suggesting that small and large larvae may have originated from two populations separated in space. With present evidence it is impossible to delineate mechanisms for shoreward transport of larvae *Mugil curema* and *Pomatomus saltatrix* from spring continental shelf spawning; probably a combination of several mechanisms is at work.

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