Abundance, growth, and mortality of young-of-the-year pinfish, *Lagodon rhomboides*, in three estuaries along the gulf coast of Florida

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Abstract.–Fixed-station and random-sampling data from 1989–94 were used to examine spatial and temporal patterns in abundance and size structure of young-of-the-year (YOY) pinfish, *Lagodon rhomboides*, in three Florida estuaries. Young-of-the-year pinfish first appeared at shallow-water (<1.4 m) seine stations in November in Choctawhatchee Bay (Florida Panhandle), and in December in Tampa Bay and Charlotte Harbor, both along the southwest Florida peninsula. Pinfish were caught at deep-water (>1.6 m) trawl stations within one month after their initial appearance at shallow-water (<1.4 m) sites in Choctawhatchee and Tampa bays. However, YOY were absent in the deep water of Charlotte Harbor until 1–3 months after their first appearance in shallow water. Most YOY pinfish were caught in waters <3.5 m. Young-of-the-year pinfish in shallow-water areas were associated with bottom vegetation, mostly seagrasses, in all bays. Annual variation in YOY abundance was correlated with variations in adult abundance in Tampa Bay and with temperature in Charlotte Harbor. Instantaneous growth rates were rapid (0.10 to 0.26/month) and were similar to published rates for other Florida and gulf coast populations. Similar rates of total instantaneous mortality (0.021 to 0.023/day) were estimated for all bay populations.

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Young-of-the-year pinfish, *Lagodon rhomboides,* play important ecological roles in the northeastern Gulf of Mexico as prey for fish (Carr and Adams, 1973; Seaman and Collins, 1983) and as predators on a range of invertebrates, often to a degree where entire assemblages of macrobenthic fauna are affected (Young et al., 1976; Young and Young, 1977; Nelson, 1978). In addition, YOY pinfish are an important link between primary and secondary production because they consume seagrasses (Stoner, 1982; Weinstein et al., 1982; Montgomery and Targett, 1992).

Despite the ecological importance of pinfish, their population dynamics have been inadequately examined. It is unknown if seasonal changes in abundance or movements occur throughout entire estuaries, if growth rates are similar among populations, or if abundances fluctuate annually because past studies have had limited spatial coverage (usually 1–4 seagrass sites were sampled in waters <2 m) and short sampling durations (<2 yr)(Reid, 1954; Caldwell, 1957; Hellier, 1962; Hoese and Jones, 1963; Cameron, 1969; Hansen, 1970; Stoner, 1983). In addition, factors that may influence year-class strength have not been examined, and mortality rates have not been estimated.

In this study, I use two to six years of data to document seasonal changes in abundance, distribution, and movements within shallow- and deepwater areas to identify factors that may influence spatial and annual abundance and to estimate and compare growth and mortality rates among three estuarine populations of YOY pinfish along the gulf coast of Florida, USA.

Methods

Young-of-the-year pinfish were studied in 1) Choctawhatchee Bay and Santa Rosa Sound (surface area: ca. 450 km^2), located in the western Florida Panhandle, 2) Tampa Bay (ca. 886 km^2), and 3) Charlotte Harbor (ca. 575 km^2), the latter two located on the gulf side of the Florida peninsula (Fig. 1). All three bay systems are characterized by average depths of <5 m, salinities of 0–36 ppt, freshwater inflow from rivers, and expanses of bottom vegetation, primarily seagrasses (*Halodule wrightii* and *Thalassia testudinum*), in shallow areas. Seasonal mean water temperatures range from 10 to 29°C in Choctawhatchee Bay and Santa Rosa

Sound, from 15 to 30°C in Tampa Bay, and from 18 to 32°C in Charlotte Harbor.

Pinfish were sampled monthly from 1989 to 1994 at fixed seine and trawl stations. Fixed stations were approximately evenly distributed throughout shallow- and deepwater areas and included sites in major rivers in Tampa Bay and Charlotte Harbor. Monthly sampling began in 1992 in Choctawhatchee Bay, in 1989 in Tampa Bay, and in 1991 in Charlotte Harbor. Samples were collected with a 21.3-m × 1.8-m, 3.2-mm stretched-mesh seine, or a 6.1-m, 38-mm stretched-mesh otter trawl containing a 3.2-mm stretched-mesh codend liner. At beach stations, seines were set adjacent to the shoreline and hauled onshore; at offshore stations (<1.4 m), seines were set in open-water habitats away from the shoreline and retrieved offshore. In rivers, seines were set from the shoreline in a semicircular pattern from a boat. In deep water (>1.6 m), trawls were towed 1 knot for 5 min at river sites and for 10 min at bay sites. Three hauls or tows were made at each fixed station during daylight hours. Sampling occurred during the first two weeks of each month.

Pinfish were also sampled in spring (March to June) at randomly selected sites to provide more accurate estimates of YOY abundance. To coordinate sampling logistics, each bay was subdivided into 5–6 arbitrarily lettered, permanent zones (bay: zones A–E; rivers: zone F). All bay zones encompassed about equal area. Within each zone, 1' latitude × 1' longitude microgrids, representing the sites to be sampled, were randomly selected within randomly selected 1° latitude × 1° longitude grids. Sampling entailed randomly selecting a zone and then sequentially sampling all sites within each zone. At each site, three hauls were made with the same gears and deployment techniques used at fixed stations. Random sampling began in Choctawhatchee Bay in 1993 and in Tampa Bay and Charlotte Harbor in 1989 and occurred over eight, twelve, and ten weeks, respectively.

For all hauls, total numbers of pinfishes were counted, standard lengths were measured (±1 mm) for 20 randomly selected individuals per sample, and all fish were released. When large numbers of individuals (>1,000) were captured, the total number was estimated by fractional expansion of subsampled portions of the total catch split with a modified Motoda splitter (Motoda, 1959). Salinity (ppt), temperature (°C), depth (m), and bottom types were also recorded at all sites. Dominant vegetation types were recorded at seine sites only.

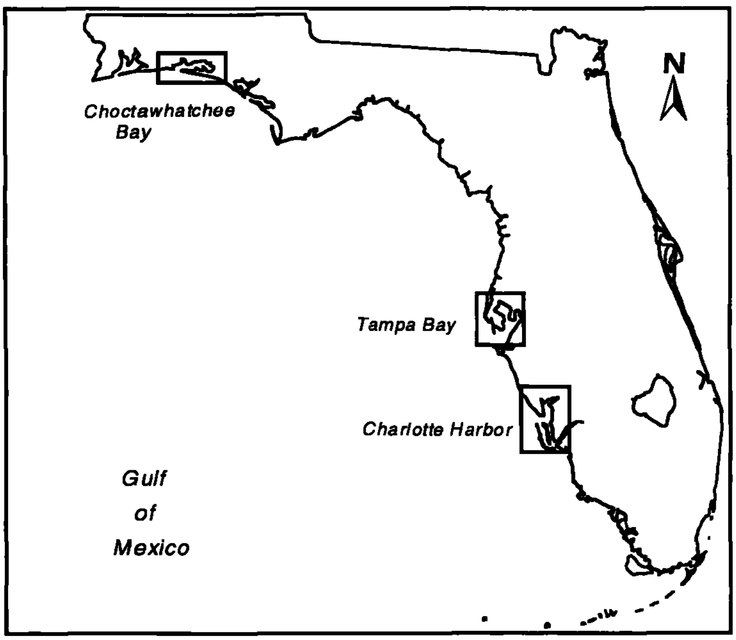

Figure 1

Map of Florida showing the locations of Choctawhatchee Bay, Tampa Bay, and Charlotte Harbor.

Seasonal changes in YOY abundance and size structure

To examine seasonal changes in YOY abundance in shallow- and deepwater areas, comparable monthly mean number of individuals per 100 m^2 were calculated from fixed station data by year. I separated YOY data used in all analyses from data on older individuals by using maximum size limits selected from monthly length-frequency plots. Monthly length frequencies based on proportions of fish found in each length class were combined over years to describe within-year trends rather than year-to-year variability. Length maximum size limits used for Choctawhatchee Bay data were in agreement with the maximum lengths of scale-aged YOY pinfish from Pensacola Bay (Hansen, 1970).

Depth distribution

To determine whether YOY were restricted to depth ranges during the period surrounding peak abundance, the cumulative frequency distributions of trawl and YOY pinfish depth occurrences were compared by using the Kolmogorov-Smirnov test (Perry and Smith, 1994). The cumulative frequency distributions for YOY pinfish were constructed by weighting depth at each random site by the number of YOY pinfish captured at that site. Only spring data from the first trawl made at each random site were used to ensure independence of observations. Data from 1989–94 were combined to examine within-year trends rather than year-to-year variability.

Factors influencing spatial YOY abundance

I examined variation in YOY pinfish abundance in shallow-water areas for year, deployment technique, month, zone, sediment type (mud or sand), absence or presence of bottom vegetation (mostly seagrasses), temperature, and salinity effects by bay. Spring catch data (transformed by using $\ln(x+1)$ prior to analysis) from the first seine haul at each randomly selected site were analyzed with general linear models (GLM; Hilborn and Walters, 1992) and PROC GLM (SAS Institute, 1988). Year, month, deployment technique, zone, sediment type, and bottom vegetation were treated as main effects, and temperature and salinity (transformed by using $\ln(x+1)$ prior to analysis) as covariates. All first-order interactions of the main effects were also tested. Any variable or first order interaction not significant at $\alpha = 0.05$ with type-III (partial) sum of squares was dropped from the initial GLM model and the analysis was repeated. In addition, least squares means and their 95% confidence intervals (Searle et al., 1980; SAS Institute, 1988) from the GLM's were back-transformed (Sokal and Rohlf, 1981) to examine significant abundance and main effect relationships.

Initial analyses revealed that the only significant first-order interactions were related to the random selection of zones for sampling. Because these interactions were not considered relevant to this study, they were absorbed in the error term, and the main effects and covariates were retested.

Factors influencing YOY annual abundance

To determine if annual variations in YOY abundance were correlated with variations in temperature, I compared annual relative abundance indices (least squares means for the effect of year) to monthly means of sea-surface temperature before and during the first appearance of YOY pinfish, using Pearson product moment correlation (Sokal and Rohlf, 1981; Tyler, 1992). Temperature data were obtained from the National Oceanic and Atmospheric Administration's (NOAA) oceanographic monthly summary series.

I also used Pearson product moment correlation to determine if annual variations in YOY relative abundance were correlated with variations in adult abundance. Adult (>80 mm SL) pinfish abundance indices were derived from data collected in the Marine Recreational Fisheries Statistics Survey (MRFSS on Florida's west coast in 1988–93)(U.S. Dep. Commer., 1990; 1992). The GLM approach was used only to derive annual least-squares mean catch-per-intercept estimates (relative abundance) by adjusting the total number of fish caught per intercept for the classification variables of two-month sampling wave, fishing mode (party or charter boat, private or rental boat, or shore-based fishing boat), area fished, counties where interviews were conducted, and for the covariates of number of anglers per intercept and hours fished by anglers. All variables were significant contributors to the overall variation in catch rates in Tampa Bay (model: $F_{[28,3853]}=11.55, P<0.001, r^2=0.08$), but only year, sampling wave, county, and hours fished by anglers were significant for Charlotte Harbor (Model: $F_{[20,1060]}=5.74, P<0.001, r^2=0.10$).

Growth

I examined annual growth of YOY by estimating instantaneous growth rates (G) using mean lengths for each bay and year. Growth was estimated with the following model:

$$\ln L_t = \ln L_0 + G \times t,$$

where G = the instantaneous growth rate (per month);
L_t = monthly mean length (mm);
L_0 = the theoretical length at which pinfishes recruit to each bay; and
t = time in months (Ricker, 1975; DeAngelis et al., 1980).

Mortality

Daily instantaneous total mortality rates were estimated for each bay population of pinfish by means of the relationship

$$Z = \frac{-\ln\left(\frac{N_{t+1}}{N_t}\right)}{30},$$

where Z = the daily instantaneous total mortality; and
N = the index of relative abundance at months t and $t+1$ (Ricker, 1975).

Monthly indices of relative abundance from fixed seine stations were used in the equation. Although immigration and emigration in the shallow-water areas can bias the rate of decline in abundance used to estimate mortality, I used data only from months over which these processes appeared low.

Results

Seasonal changes in YOY abundance and size structure

Young-of-the-year pinfish appeared first as postlarvae (9–12 mm) at shallow-water fixed seine stations during early November in Choctawhatchee Bay and early December in Tampa Bay and Charlotte Harbor, one to two months before mean temperatures were lowest (Fig. 2). In Choctawhatchee Bay and Tampa Bay, pinfish were first collected at deepwater trawl stations in the same month or one month after their initial appearance at seine stations (Fig. 2). In Charlotte Harbor, however, YOY were absent at trawl stations until January–March, one to three months after their first appearance at seine stations (Fig. 2).

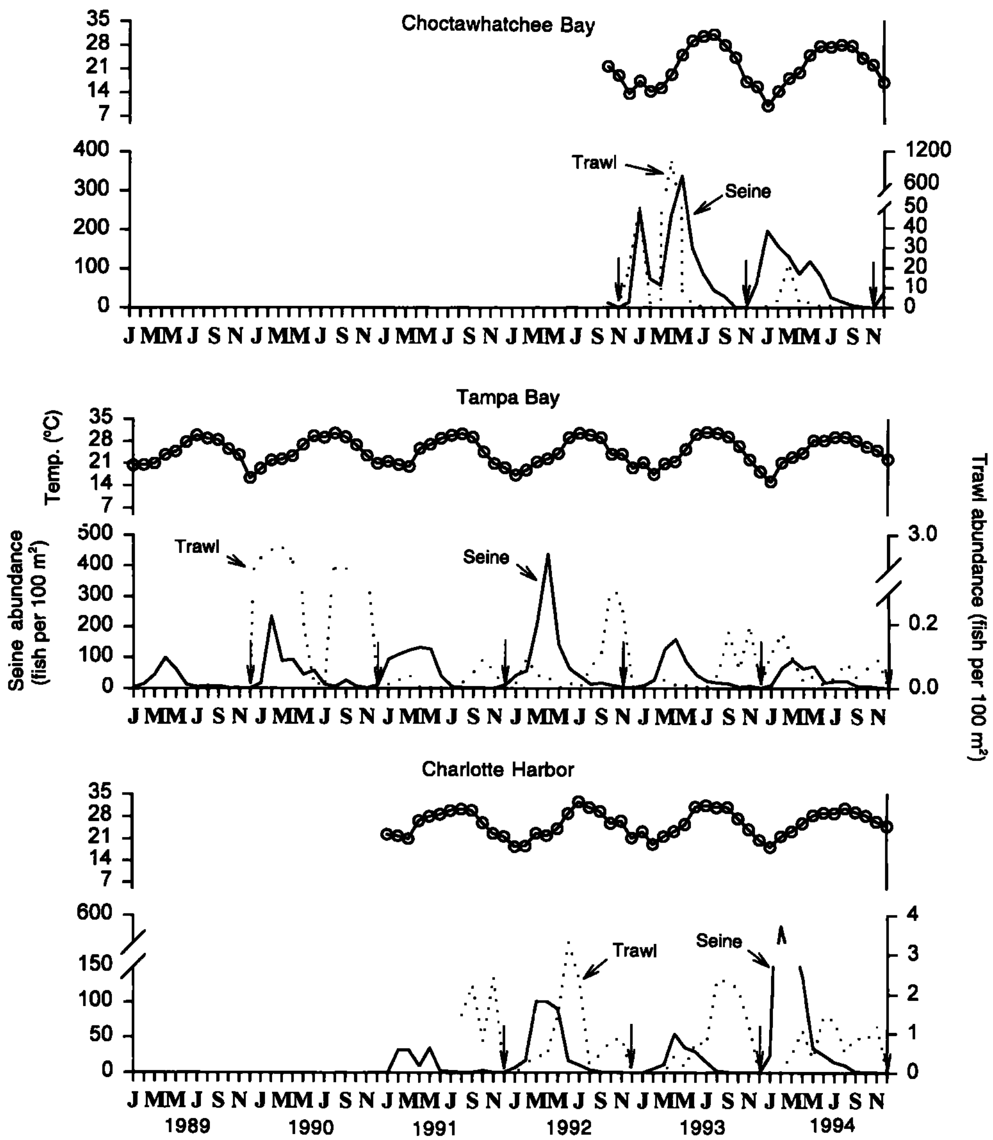

Figure 2

Monthly relative indices of young-of-the-year pinfish abundance (no. of fish) and mean monthly water temperature at fixed seine and trawl stations from 1989–94 for Choctawhatchee Bay, Tampa Bay, and Charlotte Harbor. Vertical arrows indicate the month of initial recruitment.

Relative abundance at fixed seine stations peaked in January and May in Choctawhatchee Bay, generally during March–April in Tampa Bay and Charlotte Harbor, and declined thereafter (Fig. 2). In Choctawhatchee Bay and Tampa Bay, relative abundance at trawl stations generally followed fluctuations in seine catches, but usually peaked one to two months before the peak at seine stations (Fig. 2). A second peak in trawl abundance was observed in Tampa Bay from August to October (Fig. 2). In Charlotte Harbor, relative abundance at trawl stations peaked during June–September, two to five months after the peak in seine abundance (Fig. 2).

In all bays, smaller pinfish were generally captured at fixed trawl stations during November to March than at fixed seine stations (Figs. 3–5). Progression of the smallest fish size beyond the minimum size measured during the months of first capture indicated that settlement of postlarvae to fixed stations ended by March–April in all bays (Figs. 3–5). In Tampa Bay, catch proportions of YOY <40 mm decreased at trawl stations in March. In July, YOY >60 mm were captured in higher proportions at trawl stations in all bays than during the preceding months (Fig. 3–5). Pinfish overwintering at shallow-water seine stations in Choctawhatchee Bay tended to be smaller than those remaining at seine stations in Tampa Bay and Charlotte Harbor (Figs. 3–5).

Depth distribution

About 80% of the trawl catches of YOY pinfish in spring occurred in waters <3.1 m, <3.5 m, and <2.8 m in Choctawhatchee Bay, Tampa Bay, and Charlotte Harbor, respectively. Few fish (<1% of total catches) were captured in waters >5 m. The Kolmogorov-Smirnov test showed that cumulative frequency distributions for YOY pinfish depth were significantly different from those for trawl depth in all bays (Choctawhatchee Bay: D=0.51, n_{depth}=80, n_{fish}=34, P<0.001; Tampa Bay: D=0.44, n_{depth}=373, n_{fish}=76, P<0.001; Charlotte Harbor: D=0.48, n_{depth}=268, n_{fish}=59, P<0.001).

Factors influencing YOY spatial abundance

The final GLM's accounted for proportions of 0.33–0.44 of the total variation in spring catches, depending on bay system (Table 1). Pinfish abundance was associated with the presence of bottom vegetation in all bays (Table 1; Fig. 6A), with rivers (zone F) and zones near bay mouths in Tampa Bay (D and E) and

Table 1

Final results of the general linear model analyses of pinfish catches for Choctawhatchee Bay, Tampa Bay, and Charlotte Harbor in spring. Partial (type-III) mean squares are shown. * = P<0.05, **= P<0.01, and *** = P<0.001.

Location	Source	df	Mean square	F-value	r^2
Choctawhatchee Bay	Model	3	71.120	23.70***	0.436
	Year	1	0.097	0.03	
	Deployment	1	42.637	14.21***	
	Bottom vegetation	1	179.747	59.89***	
	Error	92	3.001		
	Corrected total	95	5.152		
Tampa Bay	Model	11	67.312	19.84***	0.334
	Year	5	14.041	4.14**	
	Zone	5	65.287	19.25***	
	Bottom vegetation	1	193.316	56.99***	
	Error	425	3.392		
	Corrected total	436	5.005		
Charlotte Harbor	Model	13	59.461	15.85***	0.421
	Year	5	24.823	6.62***	
	Zone	4	33.193	8.85***	
	Bottom vegetation	1	24.406	6.51*	
	Bottom sediment	1	43.380	11.56***	
	Salinity	1	62.795	16.74***	
	Temperature	1	22.778	6.07*	
	Error	283	3.752		
	Corrected total	296	6.198		

Charlotte Harbor (B and C) (Table 1; Fig. 6B), with beach seine sets in Choctawhatchee Bay (Table 1; Fig. 6C), and with mud bottom in Charlotte Harbor (Table 1; Fig. 6D). Young-of-the-year pinfish catches were related to salinity and temperature in Charlotte Harbor only (Table 1).

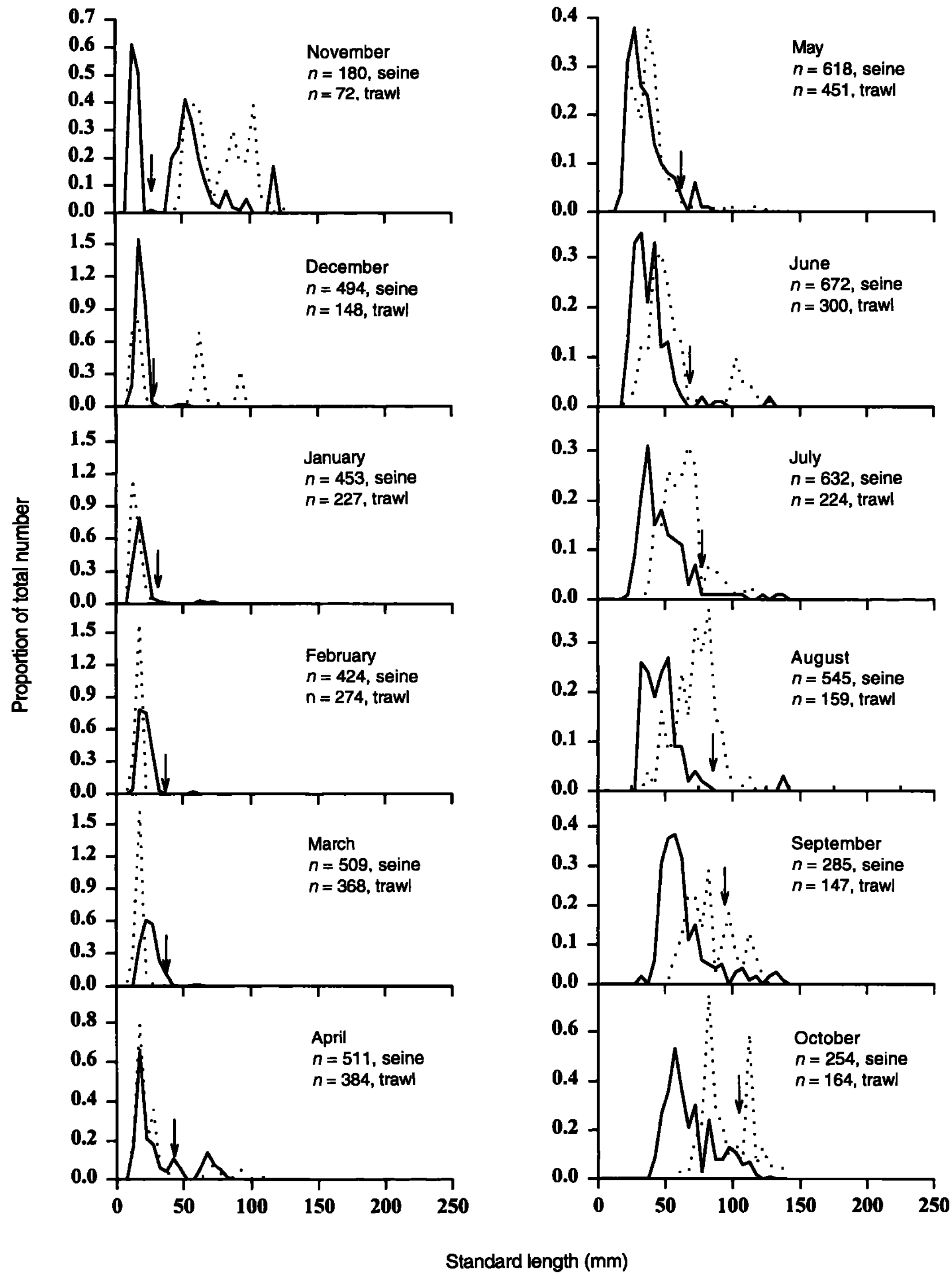

Figure 3

Monthly length-frequency distributions of pinfish captured at fixed seine (—) and trawl (· · ·) stations in Choctawhatchee Bay from 1989 to 1994. Vertical arrows indicate the monthly maximum size limits for young-of-the-year data. *n* is the number of pinfish measured.

Young-of-the-year pinfish abundance varied significantly between years in Tampa Bay and Charlotte Harbor (although not significant, year was included in the model for Choctawhatchee Bay to compute least squares means)(Table 1; Fig. 7). Pinfish abundance was also generally highest in Choctawhatchee

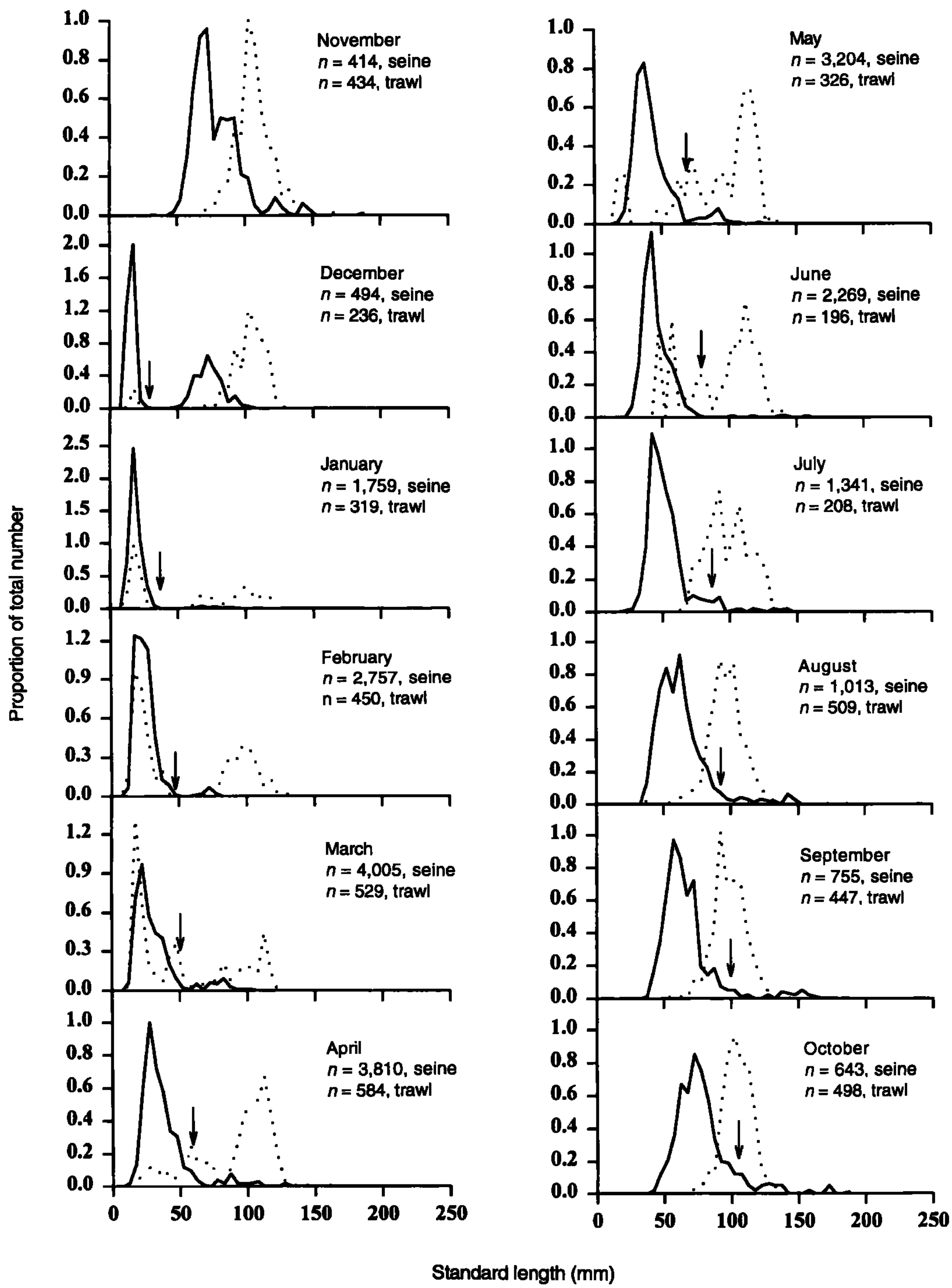

Figure 4

Monthly length-frequency distributions of pinfish captured at fixed seine(—) and trawl (· · ·) stations in Tampa Bay from 1989 to 1994. Vertical arrows indicate the monthly maximum size limits for young-of-the-year data. *n* is the number of pinfish measured.

Bay (range: 55.0–59.8 fish/haul), followed by Charlotte Harbor (5.5–50.4 fish/haul) and Tampa Bay (7.8–27.8 fish/haul)(Fig. 7).

Factors affecting YOY annual abundance

Relative abundance of YOY pinfish was significantly

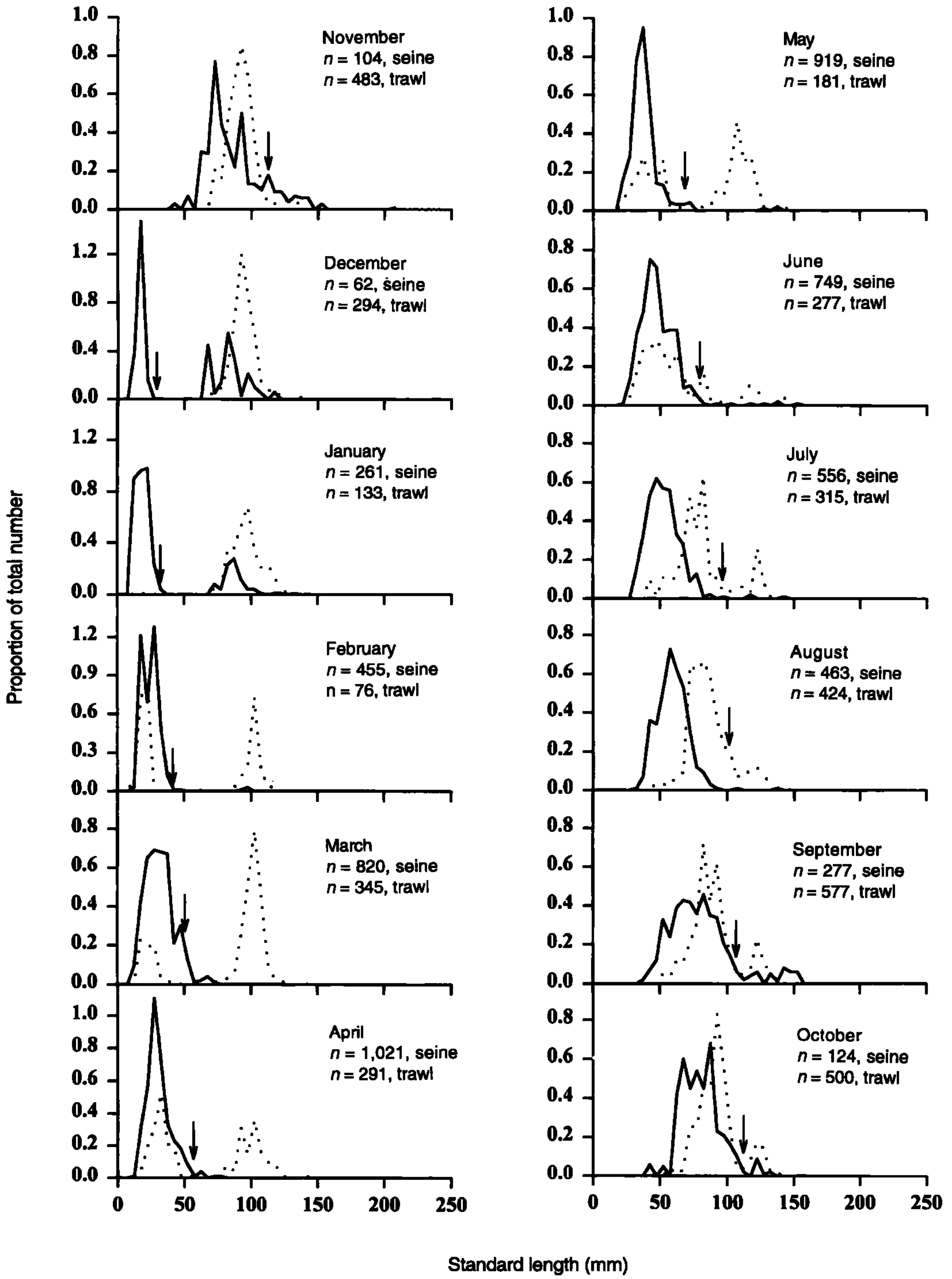

Figure 5

Monthly length-frequency distributions of pinfish captured at fixed seine(—) and trawl (· · ·) stations in Charlotte Harbor from 1989 to 1994. Vertical arrows indicate the monthly maximum size limits for young-of-the-year data. *n* is the number of pinfish measured.

and positively correlated with mean sea-surface temperatures in November (the month before first appearance) in Charlotte Harbor and with indices of adult abundance from 1988 to 1993 in Tampa Bay (Table 2).

Growth

Growth rates were estimated with mean length data from fixed seine stations only from April through July to minimize biases associated with potential movements of YOY pinfish. Year-class growth rates were similar among bays. Instantaneous growth coefficients ranged from 0.18 to 0.26/month for Choctawhatchee Bay, 0.06–0.21/month in Tampa Bay, and 0.14–0.26/month for Charlotte Harbor, indicating that monthly growth of YOY pinfishes is rapid during late spring and mid-summer months (Table 3). Comparisons among bays revealed no consistent interannual patterns in growth except from 1993 to 1994 when rates declined in all bays (Table 3).

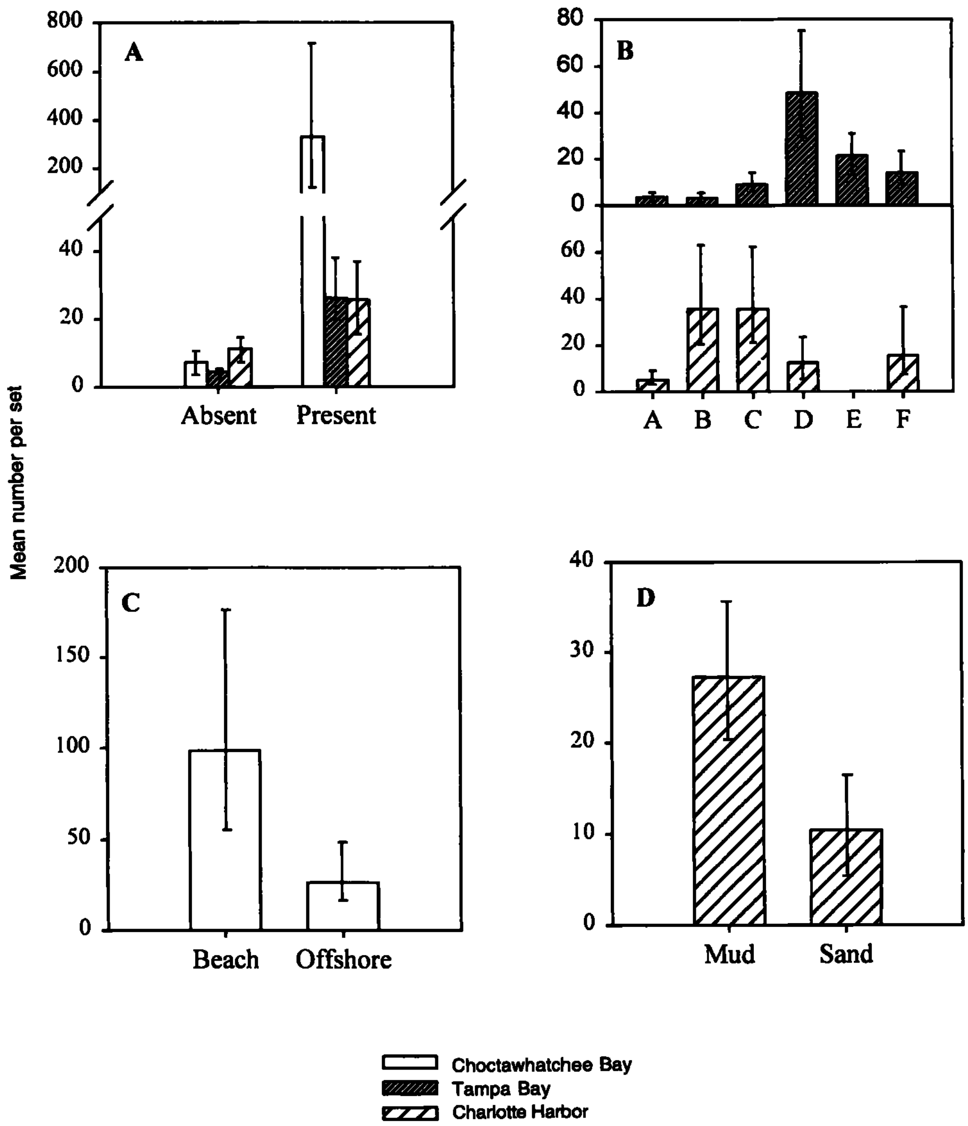

Figure 6

Least-squares means and 95% confidence intervals for main effects of (**A**) presence or absence of bottom vegetation, (**B**) zones, (**C**) deployment techniques, and (**D**) sediment type. Zones A–E encompass bay areas, whereas zone F encompasses rivers.

Mortality

The estimates of Z were calculated from the decline in indices of relative abundance at shallow-water fixed stations from May (month of secondary peak in abundance) to June for Choctawhatchee Bay, and April (month of peak abundance) to May for Tampa Bay and Charlotte Harbor. Relative abundance indices were averaged over all years prior to calculation in order to reduce the effects of interannual variability. Estimates of Z were 0.022/d, 0.021/d, and 0.023/d for Choctawhatchee Bay, Tampa Bay, and Charlotte Harbor, respectively (Table 4).

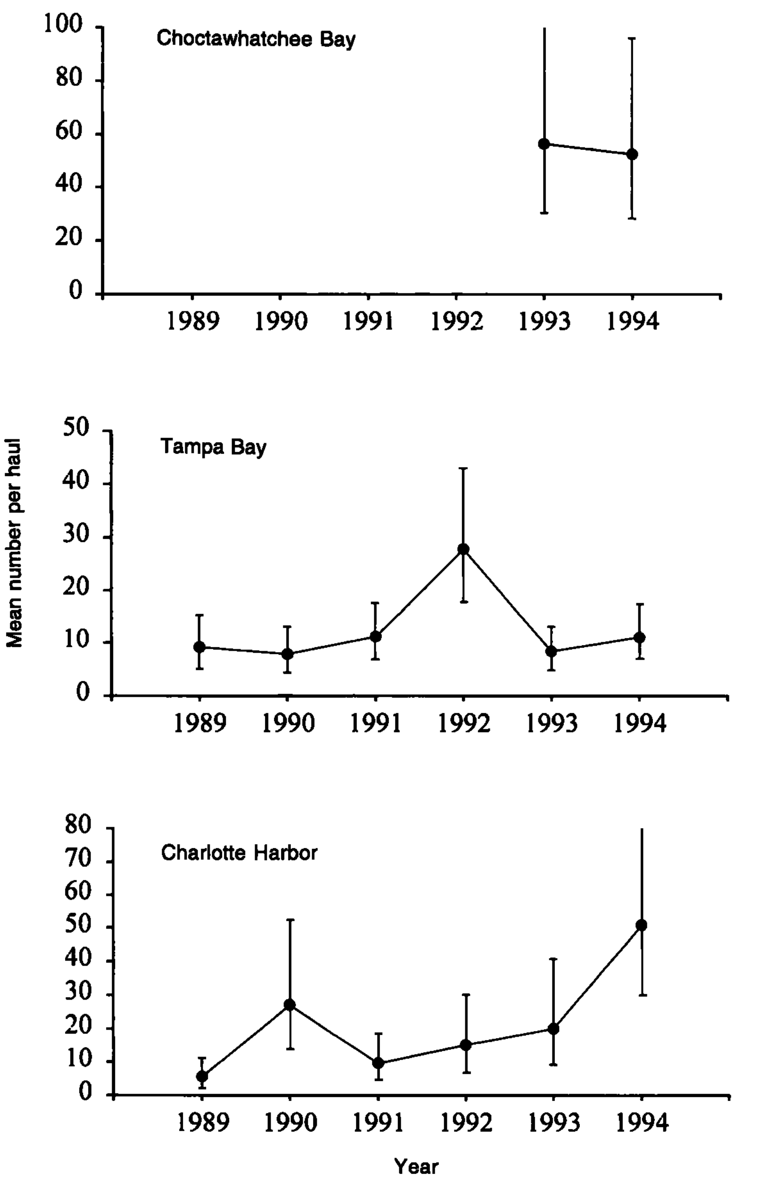

Figure 7

Annual indices of young-of-the-year abundance and 95% confidence intervals for Choctawhatchee Bay, Tampa Bay, and Charlotte Harbor from 1989 to 1994.

Discussion

Seasonal changes in YOY abundance and size structure

Pelagic pinfish larvae are transported from oceanic spawning areas and dispersed into estuaries via near-surface water currents (Darcy, 1985). After metamorphosis, postlarvae settle more or less near the bottom in estuaries (Hildebrand and Cable, 1938; Caldwell, 1957). Initial appearance of postlarvae (9–12 mm) and larger YOY (<28 mm) in shallow and deep water within a one-month period suggests pinfish settle to both areas in Choctawhatchee Bay and Tampa Bay. In Charlotte Harbor, settlement appears to occur first to shallow water, and then to deep water, because YOY pinfish were absent in trawls until 1–3 months after their first appearance at fixed seine stations. One explanation for these different patterns of settlement may lie with the bathymetry of each bay: more shallow-water area with seagrass beds (YOY pinfish are dependent on seagrass for protection from predators and food [Stoner, 1980; 1983]) is available in Charlotte Harbor (seagrass area=202 km^2) than in Choctawhatchee Bay (33 km^2) or Tampa Bay (83 km^2)(Sargent et al., 1995).

The occurrence of YOY pinfish mostly in water <3.5 m suggests that pinfish distribution is depth-restricted. The propensity of YOY pinfish to limit their depth is probably due to their dependence on seagrasses for cover (seagrasses are generally restricted to waters <2.3 m in Choctawhatchee Bay, Tampa Bay, and Charlotte Harbor [Durako[1]]), the distribution of pelagic and mobile epibenthic prey (Stoner, 1980), and light intensity (Gulbrandsen, 1996) (YOY pinfish must see their prey

[1] Durako, M. 1996. Florida Marine Research Institute, 100 Eighth Avenue SE, St. Petersburg, FL 33701-5095. Personal commun.

Table 2

Results of the Pearson product moment correlation tests for indices of recruit abundance from 1989 to 1994 versus mean sea-surface temperature during the months before and during initial recruitment from 1988 to 1993 and for indices of adult abundance from 1988 to 1993 for Tampa Bay and Charlotte Harbor. r is the Pearson product moment correlation coefficient, P is the significance probability, and n is the sample size. MRFSS = Marine Recreational Fisheries Statistical Survey.

		Tampa Bay		Charlotte Harbor		
	Month	r	P	r	P	n
YOY indices-temperature	October	–0.05	0.92	0.67	0.15	6
	November	–0.78	0.11	0.84	0.03	6
	December	0.15	0.78	–0.21	0.67	6
YOY indices–MRFSS adult indices		0.86	0.02	–0.15	0.78	6

Table 3

Regression statistics for mean length (ML) versus month (m) for young-of-the-year pinfish captured at fixed seine stations. The regression takes the form: $\text{Ln}(ML) = \ln(L_0) + G \times m$ where $\ln(L_0)$ is the intercept and G is the instantaneous growth rate or slope. Only data from April to July were used. All slopes and intercepts were significantly different from zero.

Year	$\ln(L_0)$	SE	G-value	SE	r^2	n
Choctawhatchee Bay						
1993	2.03	0.217	0.26	0.038	0.956	4
1994	2.61	0.162	0.18	0.029	0.954	4
Tampa Bay						
1989	2.77	0.078	0.18	0.014	0.988	4
1990	3.53	0.116	0.06	0.021	0.818	4
1991	3.17	0.030	0.10	0.005	0.994	4
1992	2.64	0.072	0.20	0.013	0.992	4
1993	2.49	0.274	0.21	0.049	0.904	4
1994	2.98	0.175	0.14	0.031	0.905	4
Charlotte Harbor						
1991	2.38	0.095	0.26	0.017	0.991	4
1992	2.96	0.123	0.14	0.022	0.954	4
1993	2.46	0.243	0.21	0.043	0.920	4
1994	2.81	0.266	0.16	0.047	0.857	4

Table 4

Relative abundance (no. of fish/100 m^2) for April to June averaged over all years and estimates of total instantaneous mortality (Z) for young-of-the-year pinfish (*Lagodon rhomboides*) in Choctawhatchee Bay, Tampa Bay, and Charlotte Harbor. Data used to estimate Z are boldface.

Month	Choctawhatchee Bay	Tampa Bay	Charlotte Harbor
April	163.6	**164.2**	**97.2**
May	**228.2**	**88.5**	**48.9**
June	**119.2**	39.1	18.7
–Z	0.022	0.021	0.023

and therefore feed little at night [Kjelson and Johnson, 1976]).

Young-of-the-year pinfish that settle to deep water move to shallow-water areas in early spring. Evidence for this is the peak in trawl abundance of YOY pinfish in all years, followed by a rapid decline before the peaks in abundance at seine stations in Choctawhatchee Bay and Tampa Bay (Fig. 2). This movement to shallow water may be due to YOY seeking food and refuge from predators because it coincides with seasonal increases in seagrass biomass and prey abundance in shallow waters (Thoemke, 1979; Lewis et al., 1985) and because the shallow water and structural complexity of seagrasses may provide protection from predation (Savino and Stein, 1982; Stoner, 1983; Ruiz et al., 1993).

Young-of-the-year pinfish move from shallow-water to deepwater areas in mid- to late summer, and this movement appears to be related to YOY size. Evidence for this is the shift to larger sizes in trawls in July (Figs. 3–5) concurrent with increasing catches in trawls in Tampa Bay and Charlotte Harbor (Fig. 2). This movement may represent the initiation of their fall spawning migration (Caldwell, 1957; Hansen, 1970) because gonadal recrudescence begins as early as July (Cody and Bortone, 1992) and because the modal lengths observed in trawls in July were about 80 mm, which is the minimum size observed for YOY pinfish with developing gonads (Hansen, 1970).

Factors affecting YOY spatial abundance

Without meaningful, significant first-order interactions in the GLM analyses, the YOY abundance and main effect (zones, deployment technique, and bottom type) relationships were difficult to assess. However, because pinfish abundance was associated with vegetation (seagrasses) in this and other studies (Stoner, 1980; Stoner, 1983), the significance of the main effects can be proposed in relation to seagrass distribution. Higher YOY pinfish abundances may have occurred in zones located near bay mouths because the largest areas of seagrass are located within these zones (Sargent et al., 1995). The absence of large expanses of seagrasses in Choctawhatchee Bay (Sargent et al, 1995) may have caused YOY pinfish to populate shallow-water beach areas abundantly to avoid predation (Ruiz et al., 1993). Because mud is commonly associated with seagrass beds in shallow-water areas of Charlotte Harbor (Mitchell[2]), higher abundances of YOY over mud may be expected.

It was surprising that more YOY pinfish were captured in Choctawhatchee Bay because there is less seagrass in this bay than in Tampa Bay or Charlotte Harbor (Sargent et al., 1995). Higher abundances of YOY pinfish may occur in Choctawhatchee Bay because *Halodule wrightii*, a thin-blade seagrass preferred by YOY pinfish for refuge and amphipod foraging (Stoner, 1982; 1983), occurred more frequently (62%) at vegetated sites in Choctawhatchee Bay than at vegetated sites in Tampa Bay (46%) and in Charlotte Harbor (40%).[3] The patchily distributed seagrass beds in Choctawhatchee Bay may also support higher abundances of pinfish than the continuously distributed seagrass beds in Tampa Bay and Charlotte Harbor because the ecotone between seagrasses and unvegetated areas may provide greater habitat complexity, offering protection from predators while providing close access to alternative feeding areas (Holt et al., 1983).

Factors influencing YOY annual abundance

Although this study is an exploratory analysis, the positive correlation between YOY abundance and sea-surface temperatures in Charlotte Harbor suggests that oceanographic or biological events that occur before settlement may be important factors contributing to the annual variability in pinfish abundance. Higher temperatures may favor increased hatching success (Postuma, 1971) or increased growth of larvae, or both (Hunter, 1981; Miller et al., 1985; Pepin, 1991), or they may affect transport mechanisms (Lasker, 1984; Rothschild, 1986). For pinfish, both explanations are plausible given that adults spawn in offshore Gulf waters.

Direct spawning stock-recruitment relationships are often masked by variability in recruitment (Fogarty et al., 1991). The lack of correlation between YOY and adult abundances in Charlotte Harbor suggests that temperature may be a more influential factor for this bay. The significant correlation between YOY and adult indices at such a low sample size does suggest that for Tampa Bay, the relationship may not be markedly masked, and identification of the actual spawning stock-recruitment patterns may be possible with additional years of data.

Growth

To compare growth rates for YOY pinfish from this study with those found for pinfish from Cedar Key, FL, Redfish Bay, TX, and the Laguna Madre, TX, I fitted the same growth equation to mean length data of YOY pinfish estimated from graphical plots shown in Caldwell (1957) for Cedar Key, Cameron (1969) for Redfish Bay, and Hellier (1962) for Laguna Madre, for April–July. Instantaneous growth rates were 0.10/month for YOY pinfish from Redfish Bay, TX, 0.17/month from the Laguna Madre, TX, and 0.25/month from Cedar Key, FL, indicating that growth in these bays was similar to growth of YOY pinfish in the three bays studied (Table 4). Similar growth rates were expected given that temperatures experienced by YOY pinfish among the Gulf coast estuaries were alike during the April to July growth period (Caldwell, 1957; Cameron, 1969; Hellier, 1962).

Mortality

Daily mortality of YOY pinfish in shallow-water areas of the three Florida estuaries was low. My estimates of mortality (0.021–0.023) were similar to those made for other estuarine-dependent species such as juvenile gulf menhaden (*Brevoortia patronus*) in Fourleague Bay, Louisiana (0.017–0.021)(Deegan, 1990), spot (*Leiostomus xanthurus*) in York River, Virginia (0.017) (Weinstein, 1983), and Atlantic croaker (*Micropogonias undulatus*) in Rose Bay, North Carolina (0.023) (Currin et al., 1984). Unfortunately, I could not estimate mortality of YOY pinfish in deep water because emigration and immigration appeared to occur continuously over the spring–summer period at fixed trawl stations.

In summary, YOY pinfish first appeared in shallow-water areas during November in Choctawhatchee Bay and during December in Tampa Bay and Charlotte Harbor. In Choctawhatchee Bay and Tampa Bay, they were captured in deep water within one month

[2] Mitchell, M. E. 1997. Florida Marine Research Institute, Charlotte Harbor Field Laboratory, 1481-A Market Circle, Port Charlotte, FL 33953. Personal commun.

[3] Percent occurrence for seagrasses was estimated from random sampling data in spring.

after their shallow-water appearance. In Charlotte Harbor, YOY pinfish were absent in deep water until 1–3 months after they first appeared in shallow water. Young-of-the-year pinfish were generally restricted to depths <3.5 m in all bays. Two general movements were evident: from deep water to shallow water in spring, and from shallow water to deep water in mid- to late summer, the latter movement being size-dependent. High abundances of pinfish were commonly associated with the presence of seagrasses. Despite differences in abundance among bay populations, growth and mortality rates of young-of-the-year pinfish were similar in all bays.

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