NOTES

COMPARISON OF CATCHES IN 4.3 M AND 12.2 M SHRIMP TRAWLS IN THE GULF OF MEXICO

Shrimp trawls used to assess shrimp and fish populations in the southern United States have varied in length, width, and basic design, making comparisons of results among studies difficult. Fishery management plans by State and Federal agencies emphasize the need for data that can be reliably compared. Techniques and equipment necessary to measure trawl performance so that data collected with different trawls can be compared is costly and time consuming (Watson 1976; Loesch et al. 1976; Wathne 1977; Kjelson and Johnson 1978). Recent emphasis has been placed on standardizing gear and sampling methods (Watson and Bane 1985) and determining the effects on catch and mean length of organisms for different tow durations, mesh sizes, trawl widths, and towing vessels (Clark 1963; Chittenden and Van Engle 1972; Green and Benefield 1982; Matthews 1982; Cody and Fuls 1985). However, sample sizes generally have been small and only selected species have been analyzed.

The present study evaluates small trawls as population sampling devices for penaeid shrimp and other organisms in the Gulf of Mexico. The objective of this study was to compare the catch rates and mean lengths of organisms caught with 4.3 m and 12.2 m trawls pulled during day and night.

Materials and Methods

The study area was the Gulf of Mexico off Texas between the Colorado River and Port Mansfield in depths from 7 m to 24 m (Fig. 1). Sample sites were established in 1° latitude by 1° longitude grids within the study area. Twenty randomly selected sites were sampled monthly from November 1982-February 1983. Samples were equally and randomly distributed between day and night.

At each site two trawls were towed simultaneously for 15 min at approximately 3 kn from the Texas Parks and Wildlife Department (TPWD) RV *Western Gulf*, a double-rigged 21.9 m steel-hull shrimp trawler. The 4.3 m trawl (small net) was spread by wooden trawl doors 0.4 m high and 0.8 m long and the 12.2 m wide trawl (large net) was spread by wooden trawl doors 0.9 m high and 2.1 m long. Both nets had 5.1 cm stretched mesh webbing in the body, 4.4 cm mesh in the bag, and were equipped with tickler chains.

Trawl catches weighing ≤10 kg were processed by identifying and counting all organisms in the catch. For larger catches a 10 kg subsample was randomly selected from the total catch, and the total number for each species was estimated by dividing subsample counts by the proportion of subsample weight to total weight. Total lengths were measured on no more than 50 individuals of each *Penaeus* shrimp species and no more than 20 individuals of all other species. The arithmetic mean for length data was calculated for each species in each sample.

The relationship between number caught (or mean length) in the two trawls was tested for linear, multiplicative and exponential models, and log and square root transformations (Sokal and Rohlf 1981). No significant improvement was found over a linear regression with no transformation. Mean length regressions were developed for species with 10 or more pairs of mean length data (≥2 measurements) in each size of trawl (Fig. 2). Catch regressions were developed for those species that were present in at least 20 samples in the large net and were represented by at least 5 samples with >20 individuals in the small net. This insured a sufficiently wide distribution to yield meaningful results (Fig. 3).

Differences ($P \leqslant 0.01$) between day and night regressions for each species were evaluated using analysis of covariance (Snedecor and Cochran 1980).

Results

Small trawls can be used to obtain trend data on mean lengths of species caught in offshore waters. Relationships exist between the catch in the 4.3 m trawl vs. the catch in the 12.2 m trawl. No significant differences were found in the day-night regressions of mean length for any species tested. There was no difference in the day-night catch vs. catch relationship for total organisms or *Penaeus setiferus* but one did exist for *Trachypenaeus* sp. and *Squilla empusa*.

Mean lengths in the two trawls were directly correlated for all species that met criteria for regression analysis (Table 1). The regressions of the mean length of fish caught in one net vs. the other for day and night were not significantly different for any

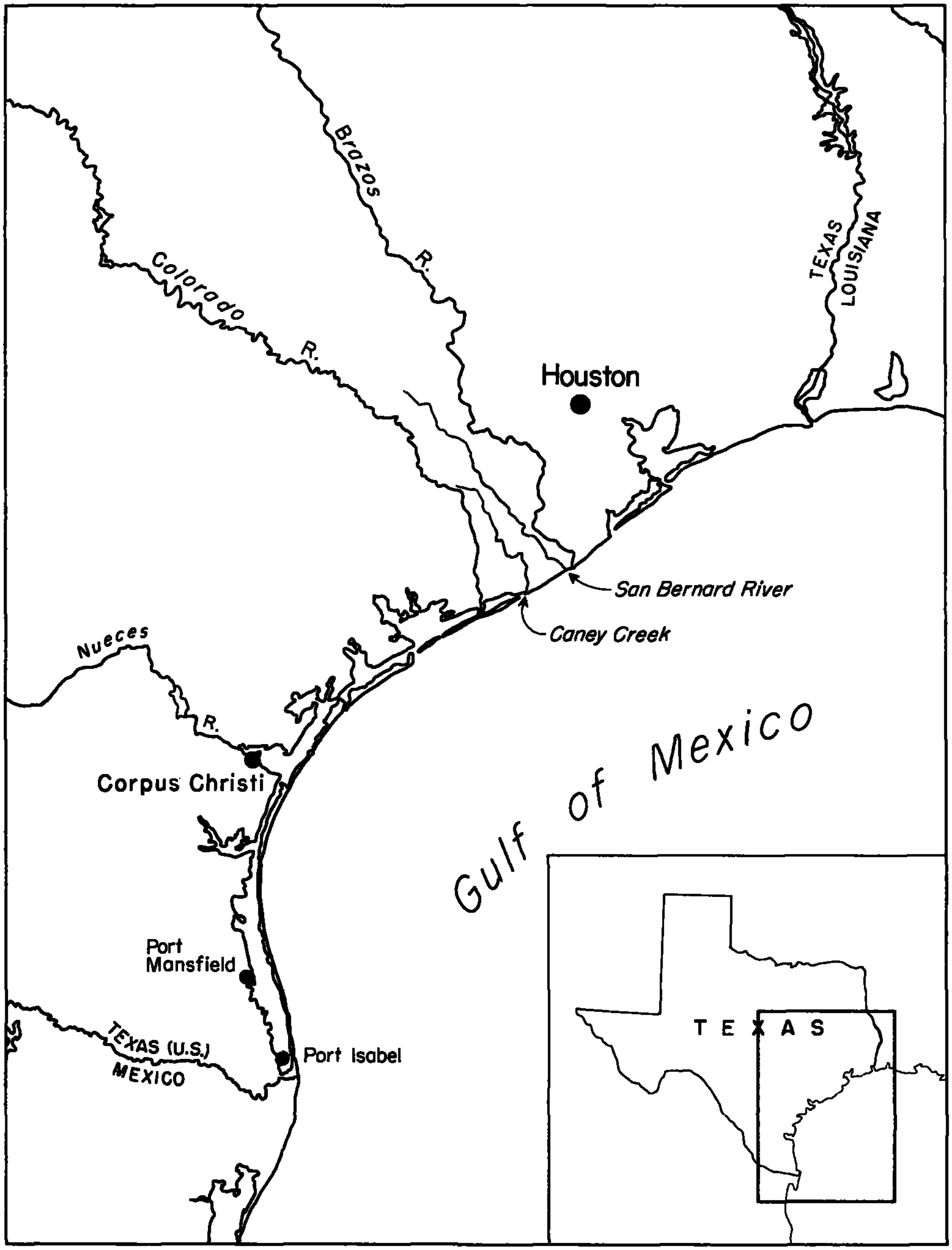

FIGURE 1.—Gulf of Mexico sampling area off the Texas coast for 4.3 m and 12.2 m trawls towed simultaneously during November 1982-February 1983.

of the species tested (Table 2). The combined regressions had significant positive correlations (0.51-0.89) explaining 26-79% of the variation.

Catch per tow in the two trawls was positively correlated. Correlation coefficients (0.48-0.93) were significant for all species meeting the criteria for analysis (Table 3). The percent of variation explained (r^2) varied from 23 to 86%.

There were no significant differences in the day-night catch vs. catch relationships for total organ-

TABLE 1.—Linear regression results of 4.3 m trawl mean length (X_i) versus the 12.2 m trawl length (Y_i) for selected species.

Species	Time	Range of X_i	Number	Y-intercept	Slope (b)	Correlation coefficient	$S^2\ Y \cdot X$	95% confidence interval of b
Penaeus setiferus	Day	93-135	29	12.31	0.91	0.85**	61.33	0.68-1.13
	Night	94-164	32	16.29	0.87	0.93**	22.98	0.74-1.00
	Combined	93-164	61	14.48	0.89	0.88**	39.86	0.76-1.01
Stellifer lanceolatus	Day	44-125	11	26.35	0.70	0.91**	88.77	0.45-0.95
	Night	44-115	24	28.32	0.67	0.88**	65.60	0.51-0.83
	Combined	44-125	35	27.42	0.68	0.89**	68.19	0.56-0.80
Trachypenaeus sp.	Day	50-78	22	38.03	0.47	0.61**	17.55	0.18-0.76
	Night	50-84	36	43.03	0.40	0.61**	19.28	0.22-0.58
	Combined	50-84	58	41.77	0.42	0.62**	18.03	0.28-0.56
Portunus gibbesii	Day	30-48	14	26.44	0.39	0.53*	11.78	−0.01-0.78
	Night	30-55	30	23.81	0.41	0.62**	9.70	0.21-0.61
	Combined	30-55	44	25.43	0.38	0.56**	10.53	0.21-0.56
Squilla empusa	Day	77-104	10	49.37	0.46	0.62ns	48.08	0.04-0.89
	Night	48-132	31	69.43	0.32	0.51**	86.95	0.11-0.52
	Combined	48-132	41	65.78	0.34	0.51**	83.87	0.15-0.53
Cynoscion nothus	Day	62-110	25	52.02	0.42	0.63**	43.87	0.20-0.64
	Night	70-122	21	45.59	0.44	0.71**	30.64	0.23-0.65
	Combined	62-122	46	46.18	0.46	0.67**	42.16	0.31-0.62

*$P < 0.05$.
**$P < 0.01$.

TABLE 2.—Summary of ANCOVA for mean length of selected species.

Species	df	Calculated F_s for $H_0{:}\sigma_1 = \sigma_2$	df	Calculated F_s for $H_0{:}\beta_1 = \beta_2$	df	Calculated F_s for $H_0{:}\alpha_1 = \alpha_2$
Penaeus setiferus	(27,30)	2.67 ns	(1,57)	0.04 ns	(1,58)	0.07 ns
Stellifer lanceolatus	(9,22)	1.35 ns	(1,31)	0.03 ns	(1,32)	0.04 ns
Trachypenaeus sp.	(34,20)	1.10 ns	(1,54)	0.09 ns	(1,55)	0.00 ns
Portunus gibbesii	(12,28)	1.22 ns	(1,40)	0.00 ns	(1,41)	2.89 ns
Squilla empusa	(29,8)	1.81 ns	(1,37)	0.15 ns	(1,38)	4.46 ns
Cynoscion nothus	(23,19)	1.43 ns	(1,42)	0.01 ns	(1,43)	7.12 ns

TABLE 3.—Linear regression results of 4.3 m trawl catch/tow (X_i) versus the 12.2 m trawl catch/tow (Y_i) for total organisms and selected species.

Species	Time	Range of X_i	Number	Y-intercept	Slope (b)	Correlation coefficient	$S^2\ Y \cdot X$	95% confidence interval of b
Total organisms	Day	16-212	40	352.71	5.83	0.58**	143,234.17	3.18-8.47
	Night	43-210	40	593.65	6.04	0.48**	310,412.80	2.45-9.64
	Combined	16-212	80	420.42	6.53	0.55**	237,569.91	4.31-8.75
Penaeus setiferus	Day	0-55	40	12.21	5.37	0.90**	1,129.54	4.51-6.23
	Night	0-51	39	−0.87	6.96	0.87**	2,291.77	5.65-8.26
	Combined	0-55	79	7.40	6.14	0.88**	1,757.99	5.38-6.90
Squilla empusa	Day	0-28	40	6.03	4.50	0.93**	139.44	3.92-5.07
	Night	0-37	39	−5.58	6.81	0.85**	1,438.75	5.38-8.25
Trachypenaeus sp.	Day	0-45	40	20.63	13.38	0.80**	13,040.70	10.15-16.60
	Night	0-43	40	60.23	19.51	0.73**	40,354.41	13.46-25.67
Portunus gibbesii	Night	0-114	40	24.65	5.92	0.78**	9,961.84	4.40-7.45
Lolliguncula brevis	Day	0-42	40	9.92	1.66	0.72**	292.57	1.14-2.19

**$P < 0.01$.

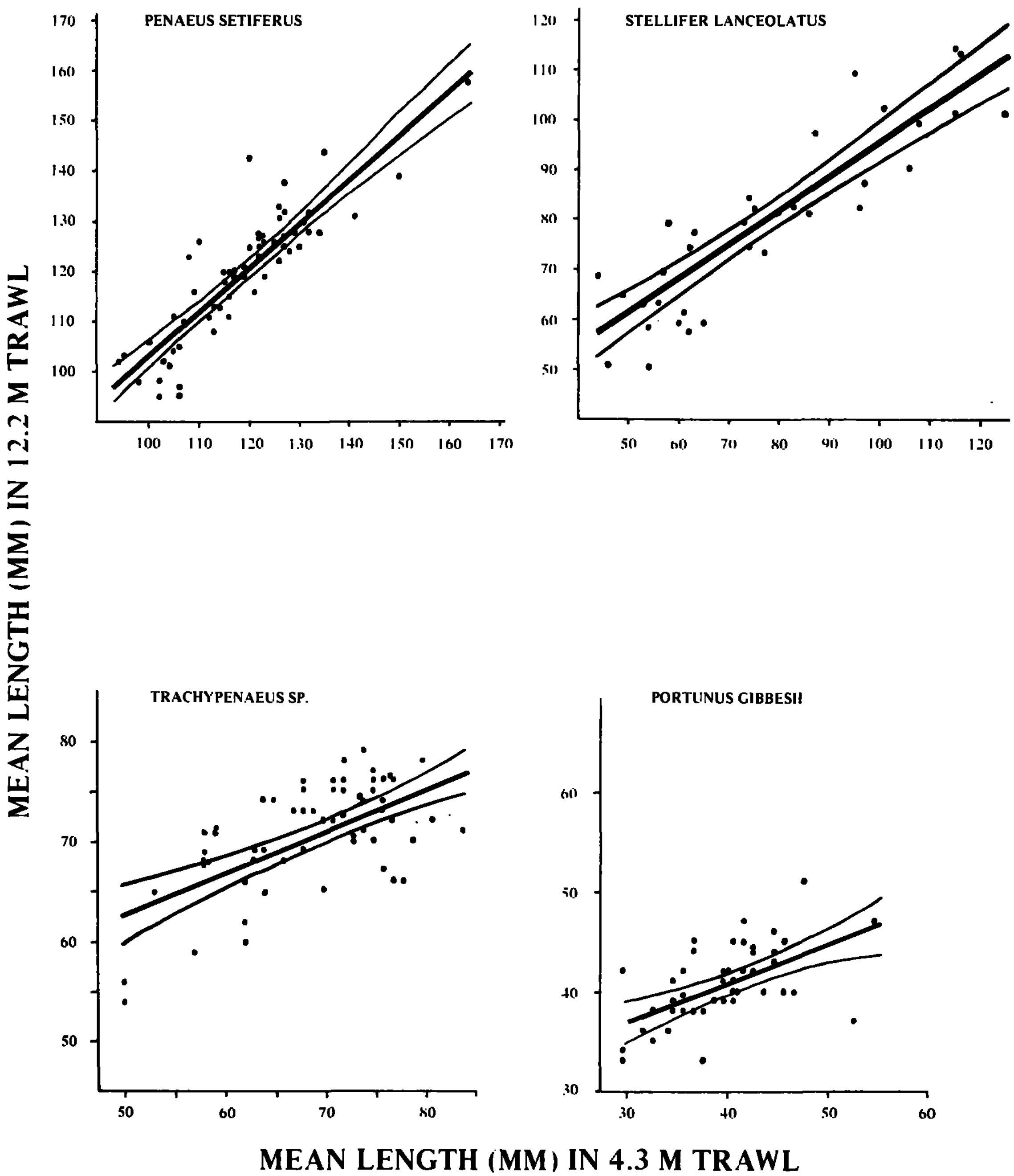

FIGURE 2.—Regression of mean length in 12.2 m trawl (Y_i) on mean length in 4.3 m trawl (X_i) for comparative tows during November 1982-February 1983. Observations, regression line, and 95% confidence intervals are shown.

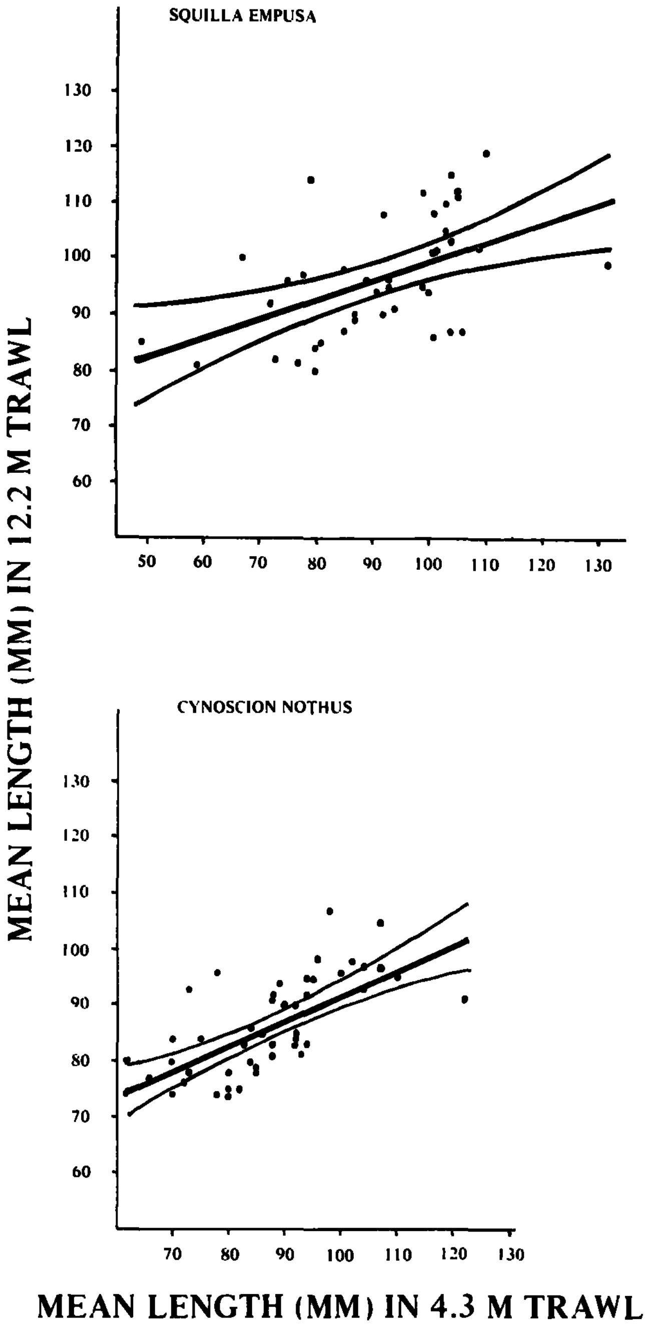

FIGURE 2.—*Continued.*

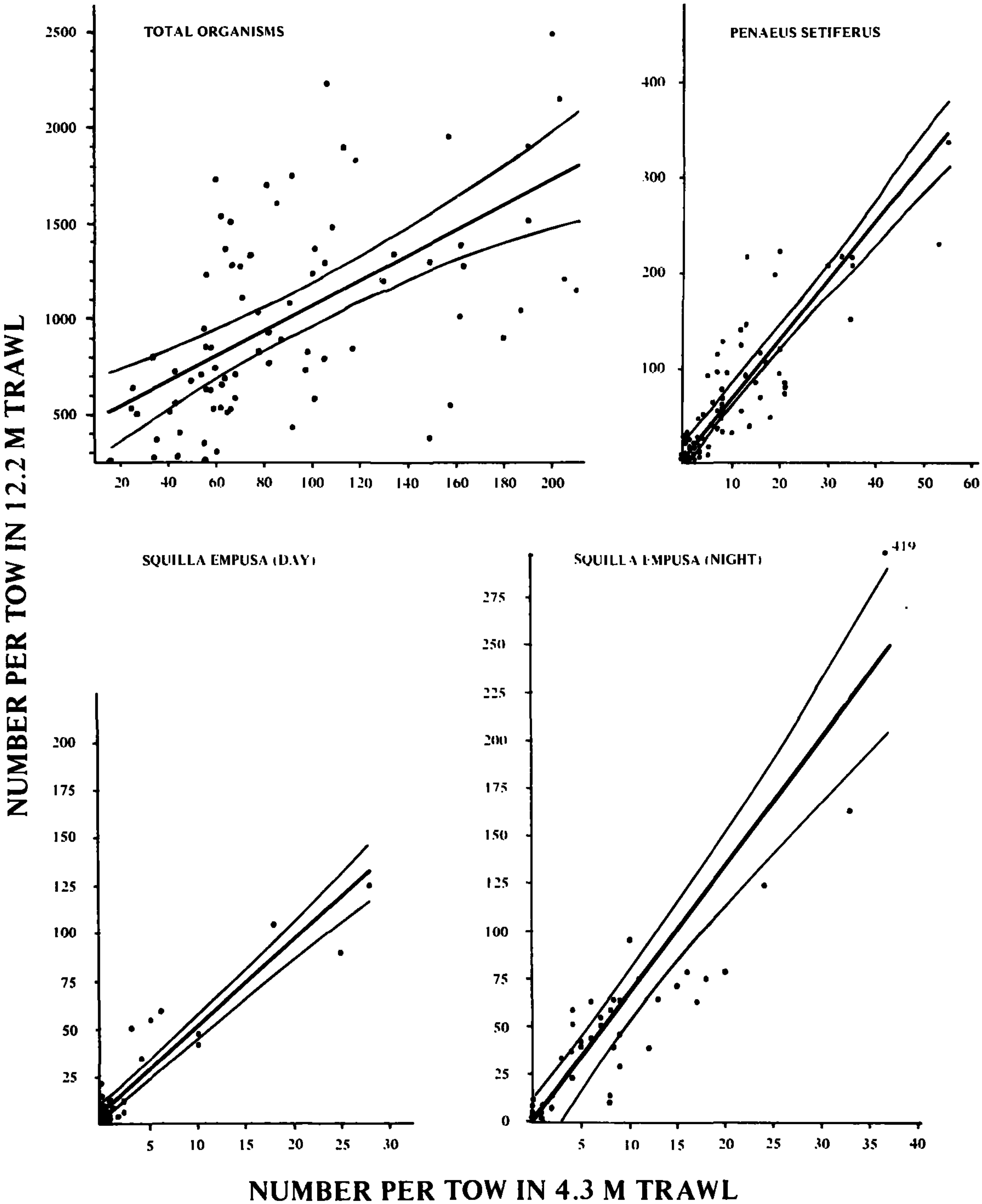

FIGURE 3.—Regression of catch per tow in 12.2 m trawl (Y_i) on catch per tow in 4.3 m trawl (X_i) for comparative tows during November

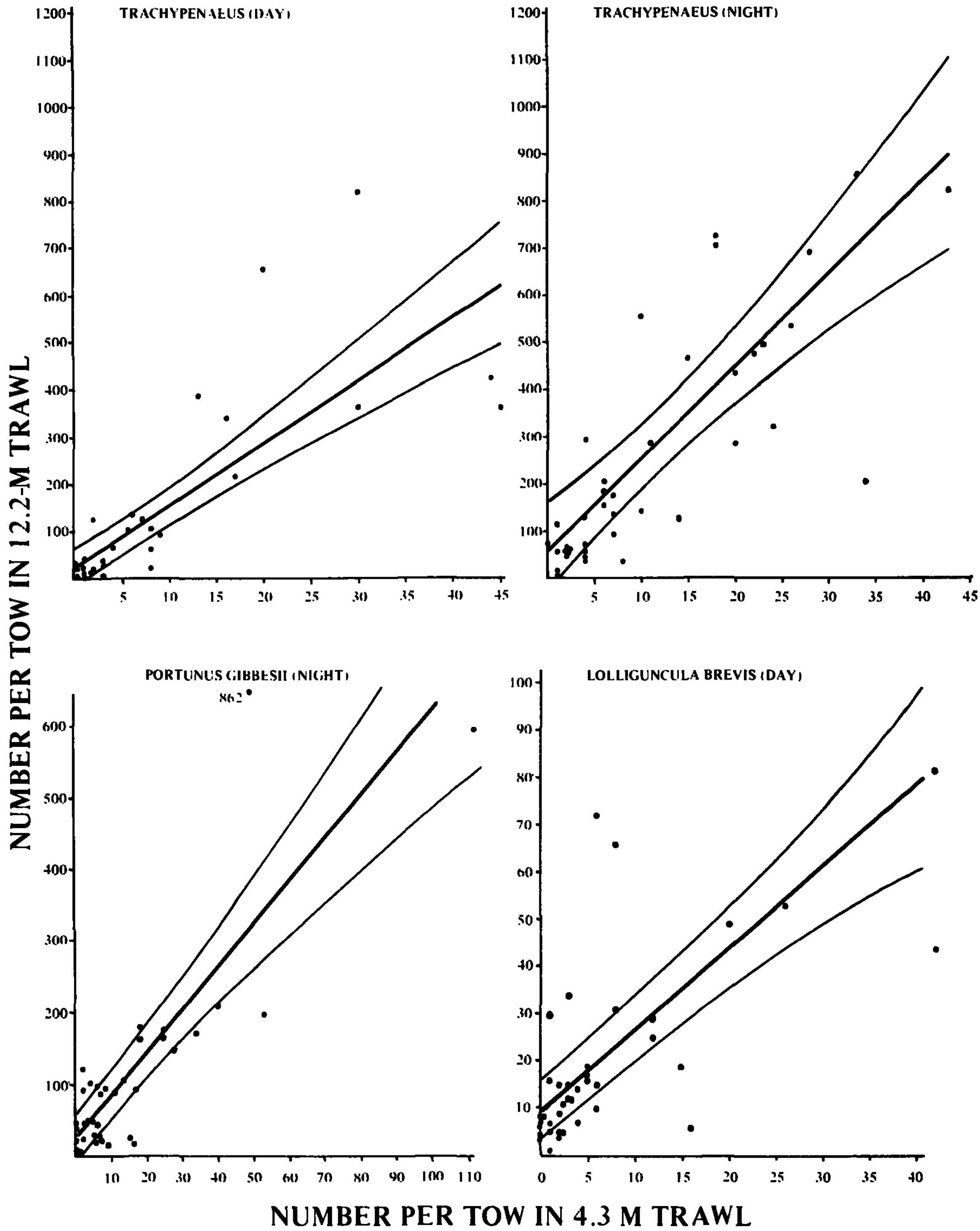

FIGURE 3.—*Continued.*—1982-February 1983. Observations, regression line, and 95% confidence intervals are shown.

isms or *P. setiferus*. Significantly different residual variances were found for *S. empusa* and *Trachypenaeus* sp. (Table 4).

The 12.2 m trawl caught more individuals and more species than the 4.3 m trawl (Table 5). The large trawl caught 30,000 organisms during the day and 46,000 during the night. The small trawl caught 3,000 during the day and 3,800 during the night. The large trawl caught 99 species during the day and 107 during the night, while the small trawl caught 63 species during the day and 82 during the night. The trend of more species caught in the large trawl was apparent for vertebrates both day and night and invertebrates during the day. The same number of invertebrate species were caught at night in both trawls. Species caught exclusively in one trawl were usually represented by fewer than 30 individuals during the entire study.

Only 26 of 125 species were represented by a mean catch ≥5/tow in either trawl (Table 6). These 26 species comprised 95% of the total catch.

small trawl it was 0.03. The fishery manager must decide if an increase in species diversity helps manage a particular fishery and ultimately whether it is cost effective to go after these "rare" individuals.

Catch in the large trawl may be higher than in the small trawl because of higher efficiency. Kjelson and Johnson (1978) reported higher catch efficiencies for a 6.1 m trawl than for a 3.0 m or 4.6 m trawl. Loesch et al. (1976) reported 5% efficiency for *Leiostomus xanthurus* in a 4.0 m trawl while Kjelson and Johnson (1978) reported 32% for the same species in a 6.1 m trawl.

The relationship between trawl width and catch may be asymptotic. This study showed the 12.2 m trawl caught more organisms than the 4.3 m trawl. Cody and Fuls (1985) found the same trend but reported that the catch in the 12.2 m trawl was not significantly less than the catch in the 13.7 m trawl. Matthews (1982) found no difference in mean total weight caught in 12.2 m and 13.7 m trawls. He did not, however, compare the total number or size of organisms. Because of the inherent variation found in sampling with trawls, the inability to detect differences in the 12.2 m and 13.7 m trawls would be expected.

TABLE 4.—Summary of ANCOVA for catch per tow of total organisms and selected species.

Species	df	Calculated F_s for $H_0{:}\sigma_1 = \sigma_2$	df	Calculated F_s for $H_0{:}\beta_1 = \beta_2$	df	Calculated F_s for $H_0{:}\alpha_1 = \alpha_2$
Total organisms	(38,38)	2.17 ns	(1,76)	0.01 ns	(1,77)	5.76 ns
Penaeus setiferus	(37,38)	2.03 ns	(1,75)	4.32 ns	(1,76)	0.16 ns
Squilla empusa	(37,38)	10.32 **				
Trachypenaeus sp.	(38,38)	3.09 **				

**$P < 0.01$.

Discussion

Catches in the large trawl were consistently higher than in the small trawl. Chittenden and Van Engel (1972) stated there must be some relationship between catch and tow duration because of the amount of bottom sampled, but they found that increased tow duration (which increases area covered) did not significantly increase the catch of blue crabs in a 9.1 m trawl. However, they tested only a small range of tow durations (5-15 min) and concluded that variation in the trawl catches was a significant factor. Tow duration in this study was constant, so higher catches were most likely a result of more area being sampled by the larger net.

It also seems reasonable that a large trawl would have a greater chance of encountering organisms especially if they have patchy distributions such as found with shrimp (Matthews 1982). The large net caught more species than the small net in this study. The highest mean catch per tow was 0.37 for species found exclusively in the large trawl; for the

Implications of this may apply to the commercial trawl fishery. Through the years shrimp fishermen have been reducing the size of trawls and increasing the number of trawls used in order to increase catch efficiency (Christmas and Etzold 1977). These changes may reflect the asymptotic relationship of trawl width and at the same time help reduce unwanted bycatch.

Cody and Fuls (1985) reported a regression coefficient of 2.52 for the catch vs. catch relationship for *P. setiferus* in daytime samples in contrast to 5.37 for this study. Only 13 data points over a much wider range of X_i (0-136/tow vs. 0-55/tow) were used by Cody and Fuls. When the ranges of X_i were made comparable the slopes of the two regressions were not significantly different.

The use of small trawls and determination of rela-

TABLE 5.—Total number of organisms collected with 4.3 m and 12.2 m trawls towed simultaneously off the central Texas coast from November 1982-February 1983. Blanks = no data.

Species	Day 4.3 m	Day 12.2 m	Night 4.3 m	Night 12.2 m
Vertebrates				
Cynoscion nothus	257	8,781	190	8,981
Stellifer lanceolatus	80	1,110	333	4,559
Cynoscion arenarius	48	1,383	46	2,498
Peprilus burti	106	1,903	20	344
Leiostomus xanthurus	118	1,510	9	68
Arius felis	77	775	17	283
Symphurus plagiusa	40	297	60	470
Lagodon rhomboides	43	357	36	360
Syacium gunteri	29	400	29	235
Anchoa mitchilli	16	372	12	222
Larimus fasciatus	30	188	31	356
Menticirrhus americanus	9	164	23	315
Micropogonias undulatus	23	218	17	237
Trichiurus lepturus	6	309	3	167
Selene setapinnis	16	269	4	88
Sphoeroides parvus	17	162	16	178
Orthopristis chrysoptera	14	87	19	133
Peprilis alepidotus	8	91	4	77
Menticirrhus littoralis	8	66	2	100
Etropus crossotus	5	37	16	116
Prionotus salmonicolor	4	10	6	137
Astroscopus y-graecum	1	37	11	93
Brevoortia patronus	1	6	2	124
Prionotus tribulus	9	43	12	63
Chloroscombrus chrysurus		28	4	87
Hemicaranx amblyrhynchus	1	63	2	26
Citharichthys spilopterus	8	21	16	43
Halieutichthys aculeatus	6	10	8	62
Urophycis floridanus	5	27	6	38
Achirus lineatus	2	26		27
Dasyatis sabina	1	19		32
Synodus foetens		28	1	13
Ophidion welshi	1	7	4	25
Porichthys plectrodon		11	2	24
Trachurus lathami		28		2
Anchoa hepsetus		24		
Saurida brasiliensis		16		3
Paralichthys lethostigma		12		6
Chaetodipterus faber		10	3	4
Opisthonema oglinum		15		2
Lutjanus campechanus		2	3	11
Bairdiella chrysoura	1	9	1	5
Chilomycterus schoepfi		9		5
Ogcocephalus parvus		3	4	6
Centropristis philadelphica	1	4		8
Monacanthus hispidus		4	3	5
Bollmannia communis		5		4
Rhinoptera bonasus		6		3
Paralichthys albigutta	1	5		3
TRIGLIDAE (Unidentified)			4	4
Lepophidium graellsi			1	7
Pomatomus saltatrix		1	1	6
Selene vomer		4		4
Gymnachirus texae		3	1	3
Polydactylus octonemus		4		1
Narcine brasiliensis				5
Eucinostomus gula		3		2
Serranus atrobranchus		2		2
Sygnathus scovelli		2	1	1
Ophidion grayi				3
Pogonias cromis		1		2
Mugil cephalus				2
Serraniculus pumilio				2
Ancylopsetta quadrocellata		2		
Membras martinica				2

Species	Day 4.3 m	Day 12.2 m	Night 4.3 m	Night 12.2 m
Prionotus rubio		2		
Sardinella aurita		1		
Diplectrum bivittatum				1
Eucinostomus argenteus		1		
Raja texana				1
Bregmaceros atlanticus				1
Ogcocephalus radiatus		1		
GERREIDAE (Unidentified)				1
Bagre marinus				1
Lutjanus apodus			1	
Prionotus ophryas		1		
Total	992	18,995	984	20,699
Invertebrates				
Trachypenaeus sp.	297	4,798	467	11,522
Penaeus setiferus	347	2,352	594	4,180
Portunus gibbesii	113	876	561	4,332
Squilla empusa	115	758	390	2,173
Lolliguncula brevis	304	902	25	515
Callinectes similis	73	447	109	1,013
Renilla mulleri	157	379	218	369
Stomolophus meleagris	165	486	24	294
Penaeus duorarum	7	54	34	298
Sicyonia dorsalis		19	36	280
Portunus spinimanus	6	16	42	263
Brissopsis alta	181	58	35	36
ACTINIARIA (order)	31	42	62	133
Arenaeus cribrarius		15	60	139
Astropecten antillensis	110	54	30	21
Luidia clathrata	33	21	61	81
Xiphopeneus kroyeri	11	109		5
Penaeus aztecus	7	70	2	44
Aurelia aurita	16	52		6
Libinia dubia	9	19	9	28
Millita quinquiesperforata	1	21	33	1
Persephona aquilonaris	9	2	20	9
Sequilla neglecta	6	3	5	16
Libinia emarginata		7	3	17
Ovalipes guadulpensis	5	9	4	6
Hepatus epheliticus	4	2	6	11
Persephona crinita	3	2	12	4
Dactylometra quinquecirrha		4		12
Luidia alternata	1	10	2	3
Polinices duplicatus	2	1	6	6
Loligo peali	1	7	1	1
Calappa sulcata	2	5		2
Sicyonia brevirostris			1	6
Phalium granulatum			4	1
Squilla chydaea				3
Thais haemostoma	1		2	
Callinectes sapidus		1		1
Anadara ovalis			2	
Albunea paretii			1	1
Dinocardium robustum			1	1
Synalpheus fritzmuelleri			1	
Hepatus pudibundus		1		
Mnemiopsis mccradyi		1		
Architectonica nobilis			1	
Busycon perversum			1	
Calappa flammea				1
Portunus spinicarpus			1	
Sinum perspectivum			1	
REPTANTIA (suborder)		1		
Total	2,017	11,604	2,867	25,814
Grand Total	3,009	30,599	3,851	46,513

TABLE 6.—Mean catch per tow (± 1 SE) of dominant species[1], November 1982-February 1983. Blank = no catch.

Species	Day 4.3 m	Day 12.2 m	Night 4.3 m	Night 12.2 m
Vertebrates				
Cynoscion nothus	6 ± 1.2	219 ± 43.0	5 ± 0.9	225 ± 33.6
Stellifer lanceolatus	2 ± 0.7	28 ± 12.0	8 ± 2.6	114 ± 29.8
Cynoscion arenarius	1 ± 0.3	34 ± 7.7	1 ± 0.2	62 ± 14.5
Peprilus burti	3 ± 1.0	47 ± 16.1	0 ± 0.3	9 ± 2.9
Leiostomus xanthurus	3 ± 1.9	38 ± 27.9	0 ± 0.1	2 ± 0.7
Arius felis	2 ± 1.8	20 ± 18.0	0 ± 0.3	7 ± 3.4
Symphurus plagiusa	1 ± 0.3	7 ± 2.1	2 ± 0.3	12 ± 2.0
Lagodon rhomboides	1 ± 0.6	9 ± 4.7	1 ± 0.3	9 ± 3.2
Syacium gunteri	1 ± 0.2	10 ± 2.6	1 ± 0.2	6 ± 1.6
Anchoa mitchilli	0 ± 0.2	9 ± 4.0	0 ± 0.2	6 ± 2.4
Larimus fasciatus	1 ± 0.4	5 ± 2.2	1 ± 0.3	9 ± 3.7
Menticirrhus americanus	0 ± 0.1	4 ± 1.3	1 ± 0.2	8 ± 1.7
Micropogonias undulatus	1 ± 0.2	5 ± 1.4	0 ± 0.2	6 ± 1.4
Trichiurus lepturus	0 ± 0.1	8 ± 2.1	0 ± 0.0	4 ± 0.9
Selene setapinnis	0 ± 0.3	7 ± 5.8	0 ± 0.0	2 ± 1.5
Invertebrates				
Trachypenaeus sp.	7 ± 1.8	120 ± 30.1	11 ± 1.7	228 ± 45.6
Penaeus setiferus	9 ± 2.0	59 ± 11.9	15 ± 3.1	104 ± 24.2
Portunus gibbesii	3 ± 1.1	2 ± 4.4	14 ± 3.3	108 ± 25.2
Squilla empusa	3 ± 1.0	19 ± 5.0	10 ± 1.7	54 ± 10.9
Lolliguncula brevis	8 ± 1.7	23 ± 3.8	1 ± 0.2	13 ± 1.9
Callinectes similis	2 ± 0.8	11 ± 4.6	3 ± 0.6	25 ± 6.0
Renilla mulleri	4 ± 1.5	9 ± 3.0	5 ± 2.2	9 ± 3.3
Stomolophus melaegris	4 ± 3.4	12 ± 6.0	1 ± 0.3	7 ± 3.0
Penaeus duorarum	0 ± 0.1	1 ± 0.6	1 ± 0.4	7 ± 5.0
Sicyonia dorsalis		0 ± 0.3	1 ± 0.3	7 ± 2.0
Portunus spinimanus	0 ± 0.1	0 ± 0.2	1 ± 0.6	7 ± 2.9

[1]Mean catch ≥5/tow in either net.

tionships between day and night catches in a fishery independent assessment program can increase sampling frequency and decrease the cost of sampling by reducing processing time, manpower requirements, and variability caused by subsampling large catches. Samples from the small trawl could be processed in approximately 25% of the time required for sample processing from the large trawl. The small trawl required no subsampling. Management agencies should consider these findings when planning long-term programs.

Acknowledgments

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EARLY LIFE HISTORY OF ATLANTIC MENHADEN, *BREVOORTIA TYRANNUS*, AND GULF MENHADEN, *B. PATRONUS*

Atlantic menhaden, *Brevoortia tyrannus*, and gulf menhaden, *B. patronus*, are allopatric, morphologically similar clupeids with contrasting distributional patterns and reproductive traits. The Atlantic menhaden has a meridional distribution and encounters variable environmental conditions during its lifetime. It occurs along the eastern coast of North America from Nova Scotia to Florida, and its distribution is stratified by age and size, with the older and larger fish ranging farther north (Nicholson 1978). Atlantic menhaden are a relatively long-lived clupeid. Their maximum reported age is approximately 10 yr, and they may spawn for approximately 7 yr (Higham and Nicholson 1964; Nicholson 1975). The spatial and temporal spawning habits of Atlantic menhaden are more complex than those of its congener. In Long Island Sound and New England waters, limited spawning occurs in inshore waters during the summer and early fall. From Long Island to Chesapeake Bay, spawning occurs in offshore coastal waters from October to December and from March to May. From North Carolina to Florida, spawning occurs in offshore coastal waters from October through March and this spawning population consists of fish that have migrated from the north and contains all age groups (Nicholson 1978). The gulf menhaden, which is distributed zonally, is restricted to the Gulf of Mexico and ranges from Cape Sable, FL, to Vera Cruz, Mexico (Reintjes 1969). Their maximum reported age is approximately 4 yr, and they may spawn for approximately 2 yr (Lewis and Roithmayr 1981). They spawn from October through March in nearshore and offshore waters within the 110 m depth contour (Christmas and Waller 1975). Both species use estuaries as nursery areas for more than half their first year of life.

The major objectives of this study were to examine and compare early life history characteristics of these two menhadens and to investigate the effects of temperature on developmental processes. Characteristics examined were egg size, size at hatching, yolk utilization rates, yolk volume at first feeding, size and age at first feeding, and growth.

Methods

Atlantic menhaden were collected with a commercial purse seine from the Newport River, NC, during the summer. Fish were held in the laboratory at ambient temperatures for approximately 4 mo before spawning. Gulf menhaden were collected in late September by cast net near Gulf Breeze, FL, and transported to the laboratory by methods developed by Hettler (1983). They were held in the laboratory at ambient temperatures for about 1 mo before spawning. For each spawning, about 10 menhaden were induced to spawn by methods described by Hettler (1981, 1983). Eggs were spawned in approximately 20°C water during the night and collected the following morning. All experiments except those dealing specifically with growth were conducted in 10 L rearing tanks; growth experiments were conducted in 60 L rearing tanks. Tanks were set in a temperature controlled water bath with two 40-W fluorescent lamps positioned 40 cm above each tank, and the tanks were illuminated for 12 h daily. Temperatures were controlled to approximately ±0.5°C. Salinities ranged from 28‰ to 32‰. Rotifers, *Brachionus plicatilis*, were used as food for about the first 10 d, and *Artemia* nauplii and rotifers were used thereafter. Feeding levels were not controlled, but, based on experience, we pro-