Comparison of Shrimp and Finfish Catch Rates and Ratios for Texas and Louisiana

NOEL H. WATTS and GILMORE J. PELLEGRIN, Jr.

Introduction

The Fishery Conservation Zone off Texas was closed to shrimp trawling from 22 May to 15 July 1981 to provide shrimp with an extended growing period in anticipation that they would be larger when harvested and bring a better market price. This closure coincided with a state-imposed closure from shore out to the Texas territorial boundary, closing the entire Texas coast to shrimping for 55 days.

To evaluate impacts of the Texas closure period, the National Marine Fisheries Service (NMFS) undertook a series of investigations, ranging from shrimp population dynamics to shrimp economics. Emphasis was on yield and catch-per-unit-effort statistics; however, attention also was given to effects of the closure on finfish bycatch from the shrimp fleet. This paper presents results from this latter effort along with applicable findings related to the shrimp fishery.

Previous investigations into shrimp fleet bycatch in the Gulf of Mexico include Gunter (1936) in Barataria Bay and adjacent Gulf waters; Blomo and Nichols (1974) in the western Gulf; and Bryan and Cody[1], Chittenden and McEachran (1976), and Bryan (1980) off the Texas coast. Only three of the papers provide estimates of finfish/shrimp catch ratios. Bryan and Cody (footnote 1) sampled the brown shrimp fleet off Texas from June 1973 to June 1975 and reported on overall finfish/shrimp ratio of 2.0 (heads-on). Chittenden and McEachran (1976) studied bycatch on both white and brown shrimp grounds off Texas from September 1973 to June 1974 and reported an overall fish-to-headed-shrimp ratio of 10.0 (approximately 6.0 heads-on ratio). Bryan (1980) found finfish/shrimp ratios ranged from 1.1 to 3.6 (heads-on shrimp) on the Texas brown shrimp grounds in 1973-74.

Methods

Contemporary Data

Observers trained by NMFS were on board cooperative commercial shrimping vessels in 1981 to document shrimp and bycatch catches following the Texas closure. Texas closure data collected in 1981 were compared with similar observer data collected in 1980 off Texas and Louisiana during a sea turtle incidental catch and mortality study. During both studies, observers recorded total shrimp (heads-on weight) and live catch for each tow. The first successful tow of each day was further sampled for bycatch analysis. A 40-50 pound sample of the bycatch was taken and individual species were counted and weighed. Additional samples were collected if the vessel moved to a new area during the day or a change occurred in the gross appearance of the bycatch. Sampling procedures for both years were the same with allowances made only for weather

The authors are with the Mississippi Laboratories, Southeast Fisheries Center, National Marine Fisheries Service, NOAA, Pascagoula, MS 39567-0112. This paper is Contribution No. 82-28P from the Southeast Fisheries Center.

[1]Bryan, C. E., and T. J. Cody. 1975. Discarding of shrimp and associated organisms on the Texas Brown shrimp (*Penaeus aztecus* Ives) grounds. Tex. Parks. Wildl. Dep., unpubl. rep.

ABSTRACT — A comparison was made between 1980 and 1981 commercial fishing to judge effects of the 1981 Texas closure on shrimp and finfish catches off Texas and Louisiana. Historical data (1973-78) for the two areas were used as baselines, and comparisons were made of finfish/shrimp catch ratios and species composition. Mean shrimp catch rates (heads-on) standardized to 100-foot trawls for Texas and Louisiana in 1980 were 42.56 pounds/hour and 42.53 pounds/hour, respectively, and in 1981 were 89.03 pounds/hour and 62.20 pounds/hour. Mean finfish catch rates for Texas and Louisiana in 1980 were 333.90 pounds/hour and 242.84 pounds/hour, respectively, and in 1981 were 156.19 pounds/hour and 408.88 pounds/hour. Average finfish/shrimp ratios for Texas were 12.94 in 1980 and 2.55 in 1981. For Louisiana, the average finfish/shrimp ratios were 22.15 in 1980 and 37.23 in 1981.

Differences between 1980 and 1981 shrimp catch rates off Texas and Louisiana, and between Texas and Louisiana in 1981, were significant at the 95 percent confidence level. Finfish catch rates off both states were significantly influenced by depth, with no significant differences found between years for either state when the effect of depth was removed. Species composition of the bycatch in waters 10 fathoms or less was relatively consistent regardless of state or year. The composition of bycatch from deeper waters was much more variable and significantly different from catches made in the shallower waters. Overall, the analyses supported a hypothesis of increased shrimp catch rates due to the Texas closure. Finfish catch rates and compositions, however, were not shown to change as a result of the closure. This latter conclusion assumes the distribution of fishing effort by depth zone was unaffectd by the closure.

conditions, nature of the vessel, or restrictions imposed by the vessel captain. Total catch weights were obtained through direct measurement or by a weight-calibrated volumetric technique (i.e., number of baskets of known weight). Net type and size, vessel characteristics, fishing location, date, fishing time, and bottom type also were recorded.

Historical Data

Historical data consisted of data collected during 1973-78 by the NMFS Shrimp Fleet Bycatch Program at the Southeast Fisheries Center's Pascagoula Laboratory. Data were acquired with random trawl tows from research vessels and by contractual arrangements with several state agencies. For the latter, observers were placed on board commercial shrimp vessels for direct sampling of the catches.

Only selected data from resource assessment surveys conducted from fisheries research vessels *Oregon II* and *George M. Bowers* were used in the analyses (selection method described in Pellegrin, Drummond, and Ford, in prep.). Samples equal to at least 10 percent of the total catch were taken from each station with a commercial concentration of shrimp. They were sorted by species, with each species being weighed and number of individuals counted. Additionally, data were collected concerning date, depth, fishing location, time, minutes fished, and gear type.

Data Analysis

Catch rates of various net sizes and types were standardized to 1-hour tows and 100-feet of headrope. This was accomplished by dividing the catch weight by total headrope length and hours fished, and multiplying the result by 100. The 100-foot standard was selected for convenience of calculation and not due to any relationship to the average trawl size used on the shrimp grounds. This form of standardization is not ideal, as it assumes catch is proportional to headrope length and time fished. Errors that arise from this assumption, however, should be relatively minor as long as the size of the nets used is not too different from the 100-foot standard. In any case, finfish/shrimp ratios and catch composition should be relatively unaffected by the standardization.

Data summaries and statistical tests were performed with untransformed data. Catch data frequently follow skewed distributions, and common practice is to use logarithmic transformations to normalize the distributions. To insure that analytical conclusions were not significantly affected by the skewed distributions, all analyses were also performed with logarithmically transformed data and compared. While the transformations tended to increase the precision of the estimators, none of the findings were affected. This was probably due to the relatively large sample sizes used in the analyses.

Student *t*-tests were used for comparisons of catch rates and ratios (Ostle, 1963), supplemented with nonorthogonal analyses of variance techniques to evaluate effects of confounding (Applebaum and Cramer, 1974; Kleinbaum and Kupper, 1978). Kendall's rank correlation coefficients (tau) were used to test for associations between bycatch species compositions (Daniel, 1978). Unless otherwise stated, tests for significance were performed at the 95 percent level of confidence (P = 0.05).

Results and Discussion

Catch Rates and Ratios

Contemporary (1980 and 1981) sampling effort is summarized by hours fished in Figure 1 and by spatial distribution in Figure 2. In 1980, from May through September, observers sampled 377 tows representing 1,298.3 fishing hours and collected 120 bycatch samples. Approximately the same level of effort occurred in 1981 from May through August with 341 tows sampled representing 1,003.8 fishing hours. Eighty-seven bycatch samples were collected. The distribution of sampling effort, however, did differ between years. Eleven percent of the sampling effort was outside of 10 fathoms (fm) in 1980, and 66 percent was outside of

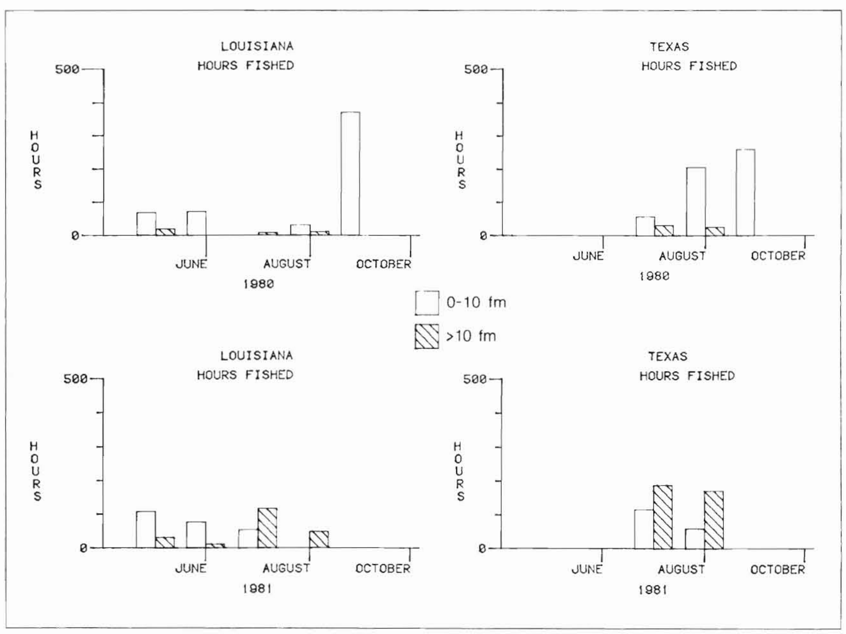

Figure 1.—Sampling effort by state, depth, and year.

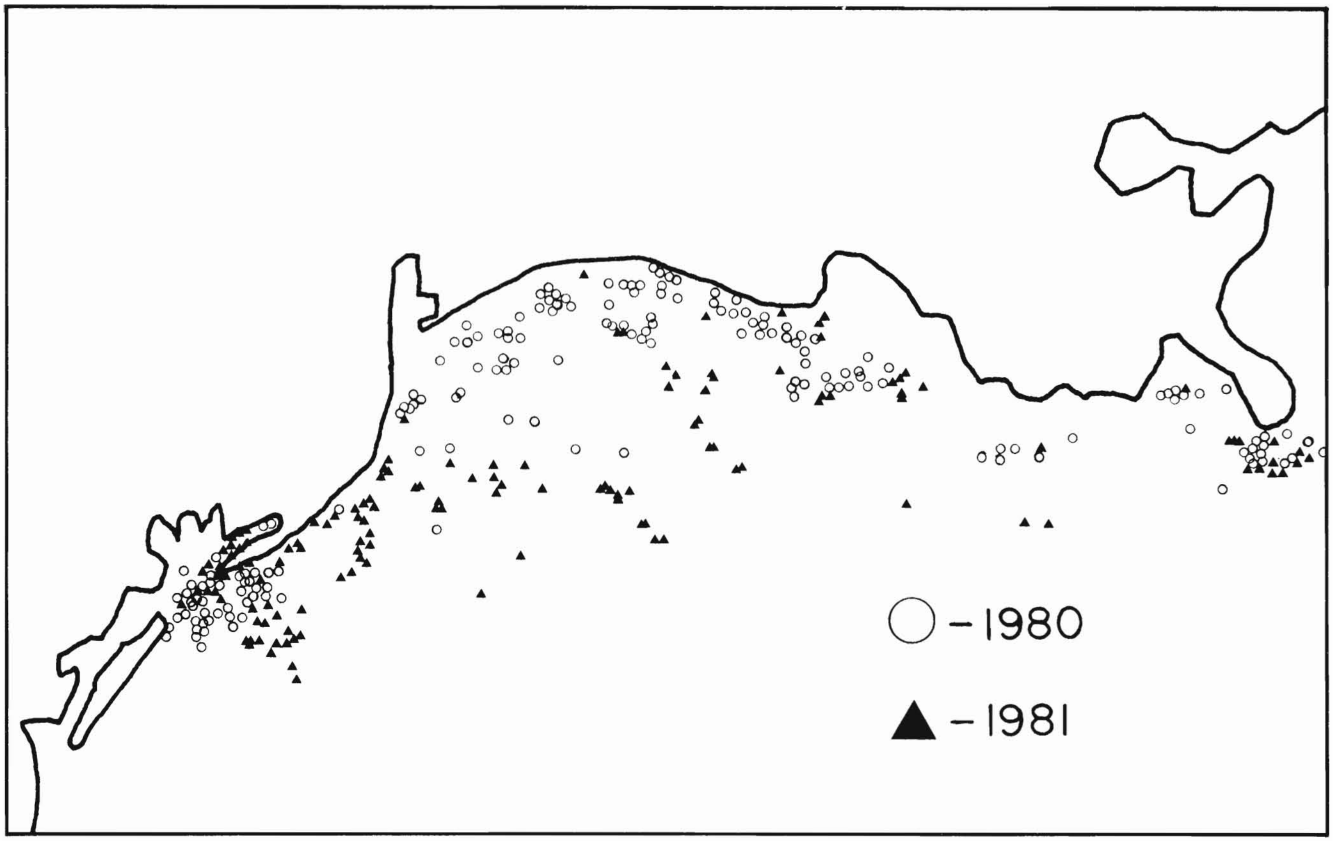

Figure 2.—Distribution of effort by year.

Table 1.—Historical (1973-78) and contemporary (1980-81) tabulation of shrimp and finfish catch rates and finfish/shrimp ratios for Texas and Louisiana.

Parameter/ statistic	Historical				1980				1981			
	Texas		Louisiana		Texas		Louisiana		Texas		Louisiana	
	0-10 fm	>10 fm	0-10 fm	>10 fm	0-10 fm	>10 fm	0-10 fm	>10 fm	0-10 fm	>10 fm	0-10 fm	>10 fm
Shrimp												
n	54	193	206	223	135	17	210	15	58	112	94	77
$\bar{x}$	33.58	43.71	58.91	32.87	43.29	36.69	44.09	21.49	90.00	88.53	57.21	68.28
s	28.37	34.40	73.20	29.38	42.45	12.69	49.92	31.34	63.52	58.67	68.04	76.20
Finfish												
n	54	193	206	223	47	5	62	6	14	33	23	17
$\bar{x}$	301.48	92.07	441.02	222.02	356.59	120.61	214.81	532.48	257.88	113.04	474.58	320.00
s	454.87	94.53	766.27	353.80	264.15	58.98	257.02	400.22	203.72	87.78	689.91	493.07
Finfish/ shrimp												
n	54	193	206	223	47	5	62	6	14	33	23	17
$\bar{x}$	17.20	3.32	14.96	9.42	13.92	3.80	11.08	136.51	4.64	1.67	49.79	20.24
s	40.51	3.53	32.74	14.62	12.27	1.91	16.03	176.66	5.20	1.48	119.23	64.16

10 fm in 1981. How much this change affected results is not known.

Shrimp, finfish, and finfish/shrimp catch rates and ratios are summarized by state, depth zone, and period in Table 1. All shrimp weights and related computations are with heads-on. Shrimp and finfish catch rates for the historical period (1973-78) should be used with caution due to the inclusion of data from research vessels in the summaries. The finfish/shrimp catch ratios, however, should not be affected. Mean shrimp catch rates during the contemporary period ranged from a low of 21.49 pounds/hour off Louisiana (>10 fm) in 1980 to a high of 90.00 pounds/hour off Texas (0-10 fm) in 1981. Mean finfish catch rates also varied greatly, ranging from a low of 113.04 pounds/hour off Texas

(>10 fm) in 1981 to a high of 532.48 pounds/hour off Louisiana (>10 fm) in 1980. Mean finfish/shrimp catch ratios, however, exhibited the greatest variation, ranging from a low of 1.67 off Texas (>10 fm) in 1981 to a high of 136.51 off Louisiana (>10 fm) in 1980.

Significant differences in shrimp catch occurred between 1980 and 1981 off both Texas and Louisiana (Table 2), with 1981 being the best year for both states. The Texas shrimp catch rate also was significantly higher in 1981 than off Louisiana, even though there was no detectable difference between the two states in 1980.

Finfish catch rates were significantly lower off Texas than off Louisiana in 1981, while again there was no difference between the two states in 1980 (Table 2). The finfish catch rate off Texas was significantly lower in 1981 than in 1980, with the rate remaining relatively consistent off Louisiana for the two years.

Finfish/shrimp catch ratios for 1980 and 1981 essentially reflected the same general conclusions drawn from the summarized shrimp and finfish catch rate analyses (Table 2). The ratio was significantly lower off Texas in 1981 than in 1980 without a significant difference being detected for Louisiana between the two years. Texas and Louisiana were relatively similar with respect to this parameter in 1980. In 1981, the ratio was significantly lower off Texas than off Louisiana.

Historically, the finfish/shrimp catch ratio for Texas was significantly lower than for Louisiana (Table 2). The year 1980 was unusual for both states, with the ratios being significantly higher compared with the historical 5-year average (1973-78). The Texas 1981 ratio, however, was not significantly different from the historial mean. The ratio off Louisiana for 1981 was significantly higher than the ratio computed from the historical data.

Concern was expressed previously about changes in sampling coverage which occurred during the 2-year contemporary period as related to the depth zone. To satisfy this concern, a multivariant regression analysis was performed on the data. This analysis permitted examination of the effects of year, depth, and the interaction between these terms adjusted for depth (0-10 fm and >10 fm) and year (1980 and 1981).

The effect of depth on shrimp catch rates was not significant for either state (Tables 3, 4). Year (1980 and 1981) had the greatest effect which is entirely

Table 2.—Results of *t*-tests applied to comparisons of contemporary (1980-81) and historical (1973-78) shrimp and finfish catch rates and finfish/shrimp ratios for Texas and Louisiana. Catch rates are in pounds/hour/100 feet of headrope.

Difference	Sample sizes	Difference between means	Standard deviation	*t*-value
Shrimp, contemporary				
TX 1981 — TX 1980	170-152	46.47	51.74	8.05***
LA 1981 — LA 1980	171-225	19.62	60.00	3.22***
TX 1981 — LA 1981	170-171	26.83	66.27	3.74***
TX 1980 — LA 1980	152-225	- 0.02	45.79	-0.01
Finfish, contemporary				
TX 1981 — TX 1980	47-52	-177.71	214.61	-4.11***
LA 1981 — LA 1980	40-68	166.04	438.18	1.90
TX 1981 — LA 1981	47-40	-252.69	428.23	-2.74**
TX 1980 — LA 1980	52-68	91.06	273.98	1.80
Ratios, contemporary				
TX 1981 — TX 1980	47-52	- 10.39	9.03	-5.72***
LA 1981 — LA 1980	40-68	15.08	78.00	0.97
TX 1981 — LA 1981	47-40	- 34.68	67.53	-2.39**
TX 1980 — LA 1980	52-68	- 9.21	47.40	-1.05
Ratios, historical				
TX 1981 — TX Historical	47-247	- 3.80	18.32	-1.30
TX 1980 — TX Historical	52-247	6.59	18.80	2.30**
LA 1981 — LA Historical	40-429	25.15	37.53	4.05***
LA 1980 — LA Historical	68-429	10.07	32.67	2.36**
TX Historical — LA Historical	247-429	- 5.73	34.93	-2.05**

*Significant at 90 percent confidence level (*P* = 0.10).
**Significant at 95 percent confidence level (*P* = 0.05).
***Significant at 99 percent confidence level (*P* = 0.01).

Table 3.—Summarized regression ANOV's for Texas contemporary (1980-81) data. The full model has the form $\hat{Y} = \mu + D + P + DP + \varepsilon$, where *D* = depth (0-10 fm or >10 fm), *P* = year (1980 or 1981), and *DP* = interaction between depth and year.

Effect	Degrees of freedom	Mean square error	*F*
Shrimp			
Full model	3	58,032.23	21.56***
DP/D,P	1	285.89	0.11
D,P	2	86,905.40	32.37***
D/P	1	454.56	0.17
P/D	1	127,881.58	47.64***
Residual	318	2,691.98	
Finfish			
Full model	3	412,507.88	9.77***
DP/D,P	1	25,717.67	0.61
D,P	2	605,902.98	14.41***
D/P	1	432,153.27	10.28***
P/D	1	79,630.72	1.89
Residual	95	42,206.16	
Ratio			
Full model	3	1,071.46	13.82***
DP/D,P	1	158.41	2.04
D,P	2	1,527.98	19.50***
D/P	1	390.96	4.99**
P/D	1	790.17	10.08***
Residual	95	77.51	

*Significant at 90 percent confidence level (*P* = 0.10).
**Significant at 95 percent confidence level (*P* = 0.05).
***Significant at 99 percent confidence level (*P* = 0.01).

Table 4.—Summarized regression ANOV's for Louisiana contemporary (1980-81) data. The full model has the form $\hat{Y} = \mu + D + P + DP + \varepsilon$, where *D* = depth (0-10 fm or >10 fm), *P* = year (1980 or 1981), and *DP* = interaction between depth and year.

Effect	Degrees of freedom	Mean square error	*F*
Shrimp			
Full model	3	16,573.62	4.62***
DP/D,P	1	11,927.47	3.32*
D,P	2	18,896.69	5.23**
D/P	1	410.95	0.11
P/D	1	26,747.33	7.41***
Residual	392	3,587.40	
Finfish			
Full model	3	493,326.59	2.67*
DP/D,P	1	782,248.12	4.24**
D,P	2	348,865.83	1.83
D/P	1	3,376.06	0.02
P/D	1	550,026.98	2.89*
Residual	104	184,539.58	
Ratio			
Full model	3	33,440.25	6.32***
DP/D,P	1	84,241.10	15.92***
D,P	2	8,039.82	1.33
D/P	1	10,363.24	1.71
P/D	1	842.19	0.14
Residual	104		

*Significant at 90 percent confidence level (*P* = 0.10).
**Significant at 95 percent confidence level (*P* = 0.05).
***Significant at 99 percent confidence level (*P* = 0.01).

consistent with results given in Table 2. Depth, however, significantly affected both finfish catch rates and finfish/shrimp ratios. Notable was the effect of depth on finfish catch rates off Texas where, when year was adjusted for depth, the effect of year was no longer significant (Table 3). In other words, finfish catch rates off both Texas and Louisiana did not change significantly from 1980 to 1981 when adjusted for depth. The effect of depth on finfish/shrimp catch ratios was mixed between the two states, presumably because the ratios manifest changes in both shrimp and finfish catches. Its effect off Texas was significant, but not to the extent which would require adjustments to conclusions reached in Table 2. Confounding of the effect of depth by year (i.e., significant interaction) occurred off Louisiana, thereby obscuring main effects of the two parameters (Table 4).

Table 5.—Summarized regression ANOV for historical (1973-78) finfish/shrimp catch ratios. The full model has the form $\hat{Y} = \mu + D + S + DS + \varepsilon$, where D = depth (0-10 fm or >10 fm), S = state (Texas or Louisiana), and DS = interaction between depth and state.

Effect	Degrees of freedom	Mean square error	F
Full model	3	5,520.57	10.40***
$DS/D,S$	1	2,109.32	3.97**
D,S	2	7,226.20	13.56***
D/S	1	9,312.25	17.47***
S/D	1	1,959.59	3.68*
Residual	672	530.61	

*Significant at 90 percent confidence level (P = 0.10).
**Significant at 95 percent confidence level (P = 0.05).
***Significant at 99 percent confidence level (P = 0.01).

The effect of depth on historical finfish/shrimp catch ratios also was examined through a regression analysis of variance (Table 5). Its effect, adjusted for state, was highly significant even though confounded by the effect of state (i.e., significant interaction). The effect of state, adjusted for depth, was not significant at the 95 percent confidence level.

Species Composition

The 13 most commonly occurring shrimp bycatch species (occurred in more than 50 percent of the catches) are listed by percent of total catch in Table 6. Sciaenids dominate the listings with Atlantic croaker, *Micropogonias undulatus,* comprising the greatest percentage of bycatch for an individual species in all but two of the lists.

Percentages for the different states, time periods, and depth zones were ranked and used to evaluate differences in species composition (Fig. 3). Correlations were assumed significant at the 90 percent level of confidence.

Species composition rankings, when averaged across depth zone, were generally dissimilar between states and time periods. When the rankings were stratified by depth zones, however, significant similarities were found (Fig. 3). Specifically, all shallow-water areas (0-10 fm) were similar in species composition regardless of state or time period. Findings for the deeper water areas (>10 fm) were mixed, with Texas and Louisiana generally being dissimilar between years. Within states, however, the rankings were generally similar between years with the exception of 1980 for both states. Comparisons between shallow- and deep-water species composition rankings were consistently dissimilar by state between years.

The rankings suggest that within the shallow-water areas, species compositions have not changed significantly from the historical period to 1981. Bycatch composition in the offshore areas, however, seems to be much more variable spatially and temporally.

Summary and Conclusions

Shrimp catch rates increased significantly off Texas and Louisiana between 1980 and 1981, with Texas experiencing the greatest increase. This finding was consistent with the hypothesis that the Texas closure had a positive effect on the Texas shrimp fishery. The effect of the closure on finfish catch rates (i.e., the shrimp fleet bycatch) was not clear even though catch rates were significantly lower for Texas in 1981 than for Louisiana. One year earlier there was no significant difference in the rate for the two states. The primary reasons for the difference can be presumed to result from either a sampling bias toward the offshore Texas waters (i.e., >10 fm) or a shift by the 1981 Texas shrimp fleet toward these offshore waters. Water depth was shown to have a significant effect on finfish catch rates, but not on

Table 6.—Percent of total bycatch biomass for selected species for historical (1973-78) and contemporary (1980-81) catches.

	Louisiana						Texas					
	Historical		1980		1981		Historical		1980		1981	
Species	0-10 fm	>10 fm	0-10 fm	>10 fm	0-10 fm	>10 fm	0-10 fm	>10 fm	0-10 fm	>10 fm	0-10 fm	>10 fm
Micropogonias undulatus	43.70	25.28	36.68	62.18	43.37	22.94	16.45	6.48	44.08	6.63	13.61	13.00
Arius felis	3.23	1.77	11.32	1.30	3.18	0.04	3.13	0.26	2.64	2.16	0.85	0.57
Chloroscombrus chrysurus	3.57	0.27	7.22	0.90	1.92	0.81	1.25	0.78	6.69	0.21	10.63	11.41
Menticirrhus americanus	0.59	0.03	6.10	0.63	0.73	0.03	2.83	0.59	1.71	0.55	6.59	1.59
Callinectes sapidus	2.48	0.30	5.07	0.47	3.50	2.23	0.53	1.78	0.67	6.80	3.22	18.05
Leiostomus xanthurus	4.39	3.33	4.84	4.08	7.57	0.12	1.73	0.82	0.67	1.08	3.37	0.18
Cynoscion arenarius	6.15	2.89	3.72	4.98	2.47	0.03	2.14	0.51	4.29	2.82	2.40	1.24
Cynoscion nothus	1.00	3.08	3.58	2.87	0.13	0.19	5.31	2.75	5.36	0.99	10.35	7.34
Trichirus lepturus	2.59	2.38	3.44	1.60	8.79	21.59	1.63	0.16	2.10	0.29	6.94	0.60
Peprilus burti	0.62	1.56	1.54	1.58	2.53	1.16	2.08	3.03	0.76	1.66	8.10	8.05
Stenotomus caprinus	0.27	10.63	0.47	2.27	0.05	5.31	1.03	2.21	1.23	34.74	0.43	7.08
Loligo pealei	0.15	0.03	0.46	0.73	0.10	0.21	0.85	1.80	0.53	2.40	1.28	3.98
Synodus foetens	0.14	5.64	0.33	0.05	0.15	3.22	1.23	4.69	0.31	3.15	0.74	3.98

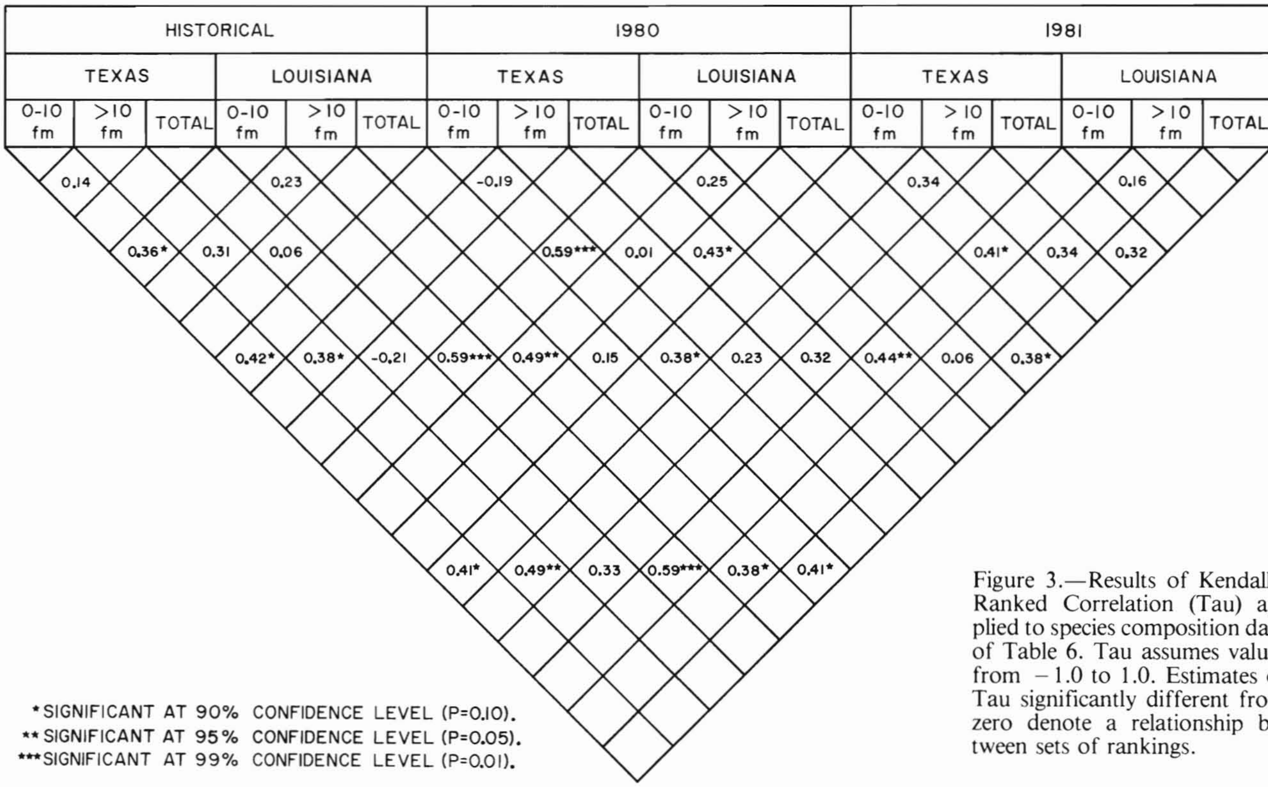

Figure 3.—Results of Kendall's Ranked Correlation (Tau) applied to species composition data of Table 6. Tau assumes values from −1.0 to 1.0. Estimates of Tau significantly different from zero denote a relationship between sets of rankings.

catch rates for shrimp during the 2-year sampling period.

Species composition of the bycatch was relatively consistent in the shallower waters for both states and all time periods, regardless of the Texas closure. This suggests these stocks are relatively stable. On the other hand, the composition of the deeper water bycatch varied significantly between years and by state, and the composition of deeper-water catches was different from catches in the shallower waters. Composition of the offshore Texas bycatch in 1981 was different from the bycatch in 1980, but not different from the historical average.

Use of finfish/shrimp catch ratios to judge effects of the closure appears to be questionable. Changes in either or both the shrimp and finfish catch rates affect the ratio. For example, the 1981 Texas ratio was different from the historical average, but since 1981 was an unusually good year for shrimp, a change in the ratio should be expected. Unfortunately, there was no way to determine if the difference was solely due to differences in catch rates for shrimp, for finfish, or for both species groupings.

Literature Cited

Appelbaum, M. I., and E. M. Cramer. 1974. Some problems in the nonorthogonal analysis of variance. Psychol. Bull. 81(6): 335-343.

Blomo, V. J., and J. P. Nichols. 1974. Utilization of finfishes caught incidental to shrimp trawling in the western Gulf of Mexico. Part I: Evaluation of markets. Sea Grant Publ. TAMU-SG-74-212, Tex. A&M Univ., Coll. Stn.

Bryan, C. E. 1980. Organisms captured by the commercial shrimp fleet on the Texas brown shrimp (*Penaeus aztecus* Ives) grounds. Masters Thesis, Corpus Christi State Univ., Corpus Christi, Tex., 44 p.

Chittenden, M. E., Jr., and J. D. McEachran. 1976. Composition, ecology, and dynamics of demersal fish communities on the northwestern Gulf of Mexico continental shelf, with a similar synopsis for the entire Gulf. Sea Grant Publ. TAMU-SG-76-208, Tex. A&M Univ., Coll. Stn., 104 p.

Daniel, W. W. 1978. Applied nonparametric statistics. Houghton Mifflin Co., Boston.

Gunter, G. 1936. Studies of the destruction of marine fish by shrimp trawlers in Louisiana. La. Conserv. Rev. 5(4):18-24, 45-46.

Kleinbaum, D. D., and L. L. Kupper. 1978. Applied regression analysis and other multivariable methods. Duxbury Press, North Scituate, Mass.

Ostle, B. 1963. Statistics in research. Iowa State Univ. Press, Ames.