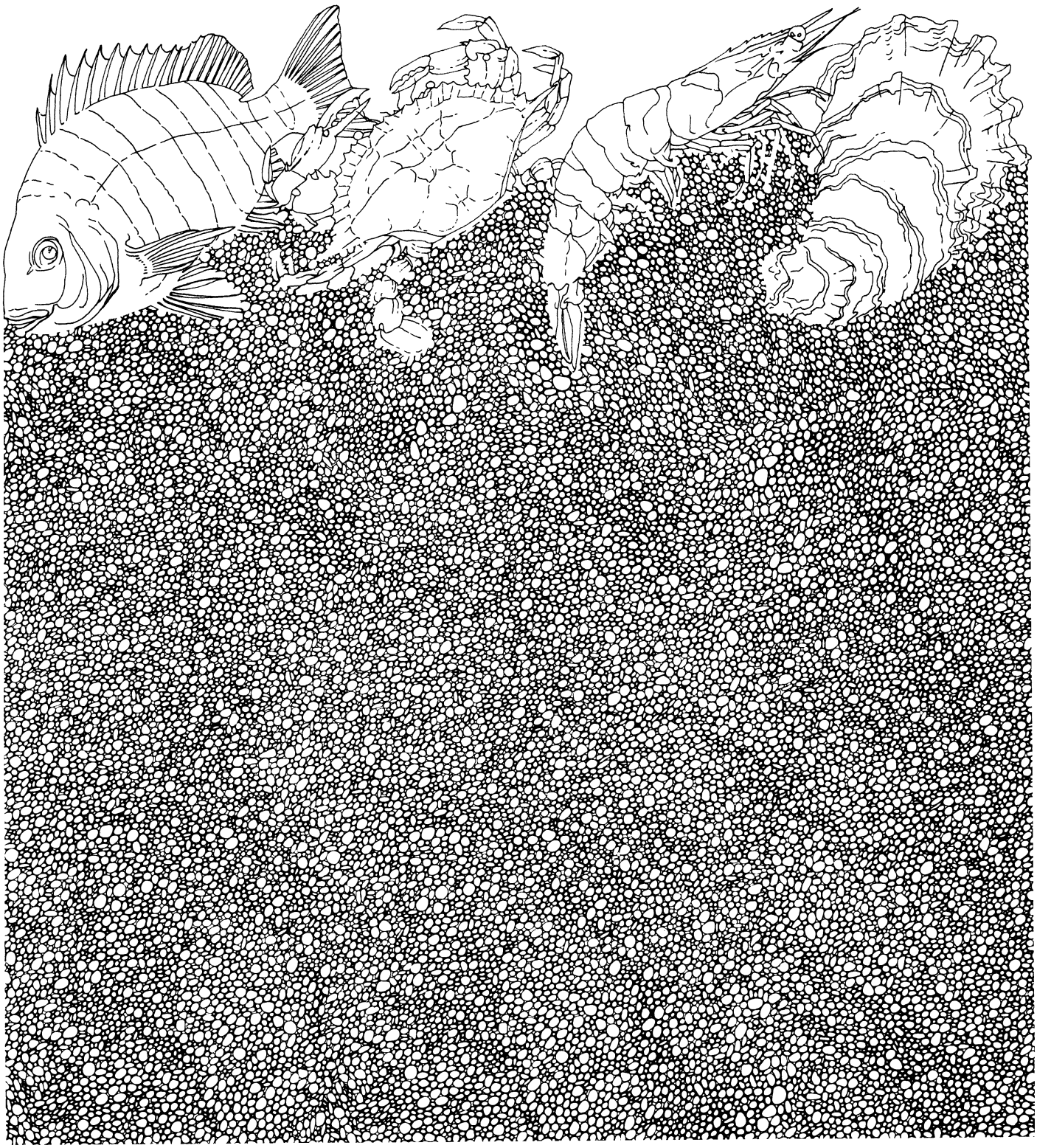
Number and Size of Brown Shrimp Caught in the Gulf of Mexico During the Texas Closure

by Billy E. Fuls and C. E. Bryan

Management Data Series Number 102
1986

Texas Parks and Wildlife Department
Coastal Fisheries Branch



NUMBER AND SIZE OF BROWN SHRIMP CAUGHT IN THE GULF OF MEXICO DURING THE TEXAS CLOSURE

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Coastal Fisheries Branch
4200 Smith School Road
Austin, Texas 78744

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ABSTRACT

Commercial trawls caught an estimated 11 ± 4 million brown shrimp (Penaeus aztecus) annually in the Gulf of Mexico (within the 0-7.3-m depth zone) off central Texas during May-July 1970-1982. Mean total lengths ranged from 81.6-106.0 mm. These estimates can be used in evaluating the effect on brown shrimp of allowing trawling for white shrimp within the 7.3-m depth zone while the remaining Gulf waters are closed to shrimping.

INTRODUCTION

Effective management of the shrimp (Penaeus sp.) fishery in Texas requires estimates of abundance, catch and landings. Estimates of bay abundance have been obtained by the Texas Parks and Wildlife Department (TPWD) since 1978 using bag seines and since 1982 using trawls (Hammerschmidt 1984). Commercial landings have been reported since 1908 (U. S. Department of Commerce 1984). Brown (P. aztecus), white (P. setiferus) and pink (P. duorarum) shrimp constitute the most valuable commercial fishery, with brown shrimp comprising 70-80% of the total catch from Texas coastal waters. Management of the brown shrimp fishery is designed to maximize ex-vessel value while maintaining diversity within the fishery (Anonymous 1985).

In 1981, implementation of the Gulf of Mexico Fishery Management Council's (GMFMC) management plan for the shrimp fishery closed the Fishery Conservation Zone (FCZ) off Texas to shrimping in conjunction with the annual 1 June-15 July (since 1959) closure of Texas' territorial ($\leq$16.7 km) waters (Van Lopik et al. 1980). The dates may be adjusted by TPWD if data indicate a need for an earlier, later or longer season. The closure can be no less than 45 days nor longer than 60 days. Also in 1981 the Texas Legislature eliminated the minimum average size restriction for commercially landed shrimp (143/kg headless shrimp; 86/kg heads-on shrimp). An exception to the closure in Texas Territorial waters allows shrimping for white shrimp during daylight in water $\leq$7.3 m deep. Brown shrimp are present in this depth zone during the closure (Bryan et al. 1978), and those that are caught may not be retained legally. However, commercial landings of brown shrimp are reported from the 7.3-m zone during May-July [National Marine Fisheries Service (NMFS) computer files, Southeastern Fisheries Center, Miami, Florida]. If fishermen comply with the law, brown shrimp are discarded and waste occurs because discarded brown shrimp have low survival (Berry and Benton 1969). This appears to be inconsistent with the Texas Closure objectives of (1) protecting small brown shrimp emigrating from the bays to the Gulf until they reach a larger more valuable size and (2) minimizing waste caused by discarding of small shrimp during the commercial harvest (Bryan et al. 1978, 1982). In addition, the GMFMC encouraged Texas to evaluate the effect of the inshore white shrimp fishery on brown shrimp (Van Lopik et al. 1980).

This study was conducted to estimate the number and size of brown shrimp caught by commercial trawlers within the 7.3-m depth zone off the central Texas coast during the Texas Closure (May-July 1970-1982).

MATERIALS AND METHODS

The commercial catch of brown shrimp within the 7.3-m depth zone during May-July 1970-1982 was estimated as the product of the mean ratio of the number of white shrimp to brown shrimp collected in TPWD trawls and the number of white shrimp reported landed by commercial fishermen within the same period and depth zone.

Trawls were pulled by the R/V WESTERN GULF (a double-rigged, 21.9-m steel hull trawler) in the 7.3-m depth zone of the Gulf off the central Texas coast (Fig. 1). Most samples were collected in 7.3 m (Appendix B.1). Samples were collected with trawls ranging in width from 12.2 to 14.3 m with stretched mesh ranging from 4.4 to 5.7 cm. Trawls were equipped with a tickler chain and spread by 0.9 x 2.1-m wooden doors. Tow durations ranged from 5 to 30 minutes. All shrimp were weighed en masse by species. Up to 50 randomly selected individuals of each species of brown shrimp and white shrimp were measured from the tip of rostrum to tip of telson to the nearest 1 mm (total length). The total number of brown shrimp or white shrimp in samples with >50 individuals of each species was estimated using the following formula:

$$N = (T/S)\,(n)$$

where: N = total number of shrimp in sample
T = total weight of species
S = weight of shrimp measured
n = number of shrimp measured

Reported commercial landings of shrimp (tail weight) within the 7.3-m depth zone off the central Texas coast (NMFS statistical areas 19 and 20) during May-July were obtained from NMFS computer files. Each year's landings (eight reported size categories) was converted to number of shrimp using the following formula:

$$N = \sum_{i=1}^{n} [(W)(C)]$$

where: W = total tail weight (kg)
C = number of heads-off shrimp/kg (Appendix A.1)
i = size category

Landings for NMFS's "mixed pieces" category (< 0.1% of total landings for white shrimp and brown shrimp) were not used.

TPWD data (Appendix B.1) and NMFS commercial landings data for white shrimp and brown shrimp (Table 1) were compiled by year (May-July) for data analysis. Because of insufficient TPWD data during 1972 and 1975 these years were not used in the data analysis.

TPWD brown shrimp and white shrimp data, by sample, for years in which there were no statistical differences (P> 0.05) among years were entered into the ratio (r) estimation equations;

$$n = \frac{\sum_{i=1}^{n} Y_i}{\sum_{i=1}^{n} X_i}$$

where: Y_i = brown shrimp in the i^{th} sample.
X_i = white shrimp in the i^{th} sample (Schaeffer et al. 1979).

The similarity of ratios of brown shrimp to white shrimp among years was determined using one-way analysis of variance ($P \leq 0.05$)(Sokal and Rohlf 1981). Data used in the analysis were the percentages of brown shrimp in each TPWD sample in which brown shrimp, white shrimp or both were caught, and was determined using the formula:

$$\% = \frac{\text{brown shrimp}}{\text{brown shrimp + white shrimp}} \times 100$$

Percentages were used because individual ratios were not defined when there were no white shrimp in the sample. Data were transformed to arc sine ($\sqrt{P_i}$ where P_i = arc sine) to reduce variance heterogeneity (Sokal and Rohlf 1981).

Comparison intervals (95%) by the GT2-method for a one-way analysis of variance, with unequal sample size (Sokal and Rohlf 1981), were used to determine differences between pairs of TPWD sample year means (arc sine transformed data) to determine which years could be combined for a mean seasonal white shrimp to brown shrimp catch ratio. Untransformed data, by sample, for years in which there were no differences in 95% comparison intervals (eliminating years in which 95% mean intervals do not overlap with all other years) were entered into the ratio estimation equation.

Assumptions used in estimating the commercial catch of brown shrimp within the 7.3-m depth zone were:

1) TPWD shrimp trawl catch rates were proportional to commercial trawl catches and to shrimp populations throughout the sampling period and area despite various size trawl gear and tow durations.

2) NMFS landings from the 0 to 9.1-m depth zone represent all shrimp commercially landed within the 7.3-m open zone.

3) All commercially caught white shrimp were of marketable size and landed.

RESULTS

Approximately 11 ± 4 million brown shrimp were caught annually by commercial trawlers within the 7.3-m depth zone off the central Texas coast during May-July 1970-1982 (Table 1). Estimated number of commercially caught brown shrimp ranged from 50.7 ± 16.5 million in 1970 to less than 1 million in both 1973 and 1974. Mean brown shrimp lengths (81.6-106.0 mm) were smaller than white shrimp lengths (156.5-184.0 mm) in all TPWD samples (Table 2).

There was a significant difference among years in mean percent of brown shrimp in TPWD catches (F_s = 6.5, df = 10,55). Confidence intervals for mean percent of brown shrimp in catches indicated 1973 and 1974 were significantly lower than several other years (Figure 2). Therefore, catches for the years 1970-1971 and 1976-1982 were combined for a white shrimp to brown shrimp catch ratio of 1:4.3 ± 1.4 (df = 48) and 1973 and 1974 catches were combined for a ratio of 1:0.4 ± 0.3 (df = 16) for estimating the commercial catch of brown shrimp.

DISCUSSION

Allowing commercial trawling for white shrimp during the Texas Closure may interfere with completely satisfying Texas' objective of maximizing ex-vessel value of Gulf brown shrimp landings. From this study it is apparent that small brown shrimp emigrating from bays are captured within the Gulf open 7.3-m depth zone during the Texas Closure while shrimpers legally trawl for white shrimp. This results in the illegal landing of brown shrimp and/or waste of the resource through discarding of small brown shrimp (Bryan et al. 1982). Test observations by Berry and Benton (1969) indicate that at least half of the shrimp discarded during normal Gulf shrimping operations die from effects of exposure to air when temperatures are $\geq$20 C.

The commercial discarding of small brown shrimp, or non-reporting by commercial fishermen, was indicated by higher TPWD estimates of commercially caught brown shrimp than were reported each year until 1981 and 1982 when estimated catch and reported landings were about equal (Table 1). In 1981 the size restriction for commercially landed shrimp was eliminated and may have resulted in either increased commercial reporting, or discarding of fewer shrimp. However, commercial discarding or non-reporting, is difficult to quantify since the smallest size category ($\leq$ 150 tails/kg) reported by NMFS is not broad enough to account for all small brown shrimp landed. TPWD samples indicated the predominant mean length of brown shrimp present within 7.3 m ranged from 81.6 to 106.0 mm or 356 to 169 tails/kg (Fontaine 1971). Since shrimp $\geq$150 tails/kg average 111 mm total length, numbers of brown shrimp derived from landings are underestimated.

Data on numbers of brown shrimp commercially caught can be used for evaluating the effect on brown shrimp of allowing shrimping for white shrimp within the 7.3-m depth zone while remaining Gulf waters are closed. The estimated number of brown shrimp commercially captured within the 7.3-m depth zone coastwide was conservative since only catches along the central Texas coast were included. There were no white shrimp to brown shrimp catch ratios available for the remainder of the Texas coast. In 1985, TPWD instituted an extensive coastwide Gulf shrimp monitoring program which will provide information on some of the assumptions used in this report, especially distribution of shrimp within the 7.3-m depth zone.

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Table 1. Estimated number of commercially caught brown shrimp (Penaeus aztecus) within the 7.3-m depth zone using Texas Parks and Wildlife Department white shrimp (P. setiferus) to brown shrimp catch ratios[a] and National Marine Fisheries Service (NMFS) reported commercial landings of white shrimp in statistical areas 19 and 20 during May-July 1970-1982.

Year	NMFS reported white shrimp landings No.	NMFS reported brown shrimp landings No.	Estimated commercial catch of brown shrimp ± 1 SE
1970	11,790,441	370,790	50,698,896 ± 16,506,617
1971	1,333,438	90,182	5,733,783 ± 1,866,813
1973	1,352,199	6,552,393	540,880 ± 405,660
1974	1,939,143	34,720	775,657 ± 581,743
1976	2,681,987	1,330,652	11,532,544 ± 3,754,782
1977	1,244,169	21,431	5,349,927 ± 1,741,837
1978	3,191,956	1,895,221	13,725,411 ± 4,468,738
1979	1,932,875	1,540,302	8,311,362 ± 2,706,025
1980	1,800,173	4,056,284	7,740,744 ± 2,520,242
1981	934,087	5,520,033	4,016,574 ± 1,307,722
1982	2,514,851	10,288,044	10,813,859 ± 3,520,791
Mean	2,792,302	2,881,823	10,839,967 ± 4,181,858

[a] 4.3 for the years 1970-1971 and 1976-1982 and 0.4 for the years 1973 and 1974

Table 2. Total catch and mean total length[a] (TL) ± 1SE of brown shrimp (Penaeus aztecus) and white shrimp (P. setiferus) collected within the 7.3-m depth zone (within National Marine Fisheries Services statistical areas 19 and 20) by Texas Parks and Wildlife Department during May-July, 1970-82.

Year	Samples collected containing shrimp	Brown shrimp		White shrimp	
		No.	Mean TL (mm)	No.	Mean TL (mm)
1970	3	249	93.9 ± 0.1	342	171.6 ± 0.1
1971	4	397	81.6 ± 0.1	54	175.2 ± 0.3
1973	7	149	93.4 ± 0.2	187	156.5 ± 0.5
1974	10	8	106.0 ± 0.6	141	172.7 ± 0.2
1976	6	1059	86.1 ± 0.1	53	170.7 ± 0.6
1977	6	2691	103.0 ± 0.1	127	171.7 ± 0.2
1978	2	39	85.7 ± 0.6	4	183.5 ± 2.4
1979	4	549	89.5 ± 0.1	45	156.0 ± 0.3
1980	4	511	91.7 ± .1	124	167.4 ± 0.1
1981	18	1024	87.0 ± 0.1	384	166.7 ± 0.1
1982	2	13	90.6 ± 1.1	29	168.6 ± 0.1

[a]Mean total length calculated by weighting by catch per hour

Figure 1. Texas Parks and Wildlife Department Gulf trawl sampling areas (National Marine Fisheries Service statistical areas 19 and 20) within the 7.3-m depth zone during 1970-1982.

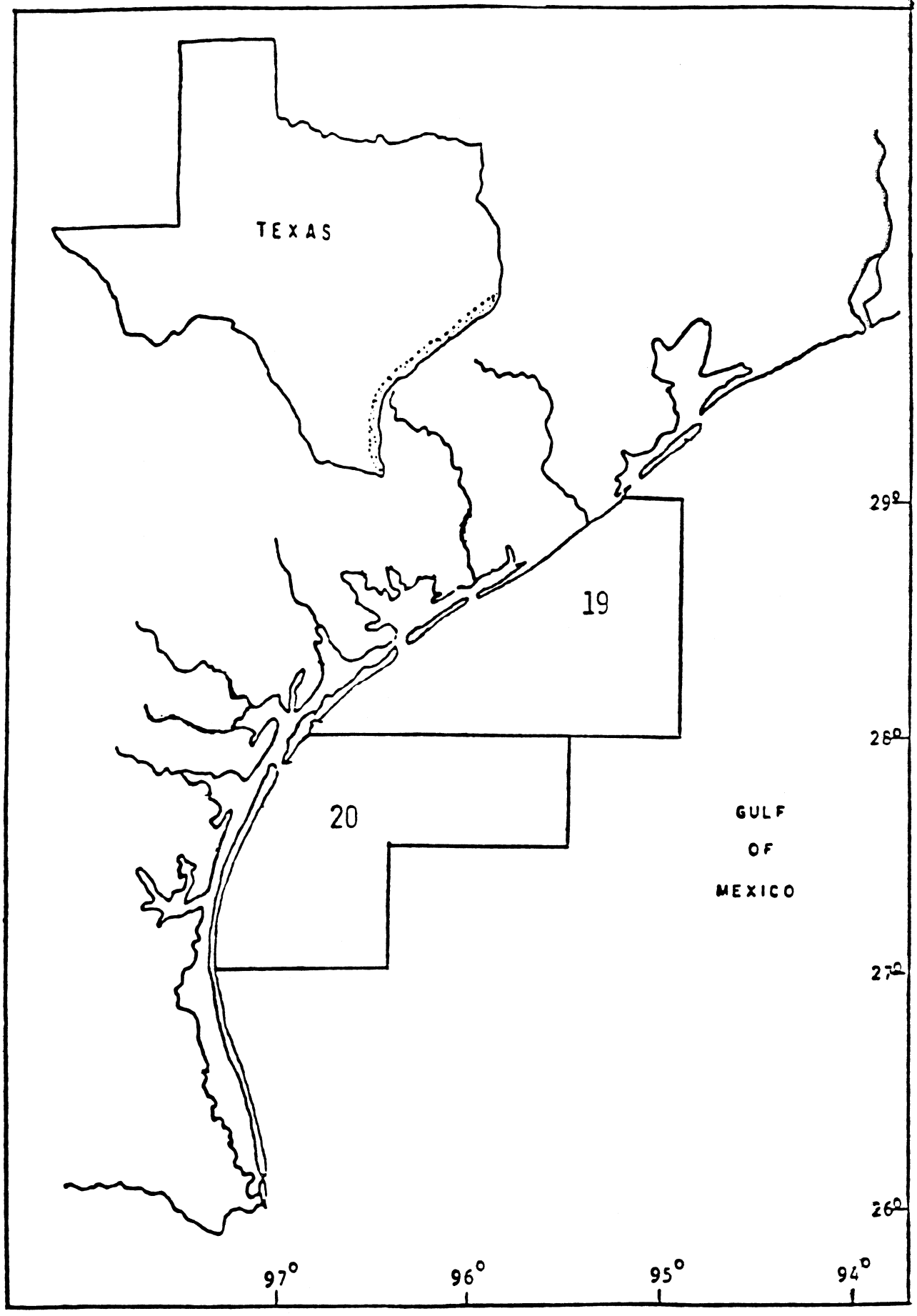
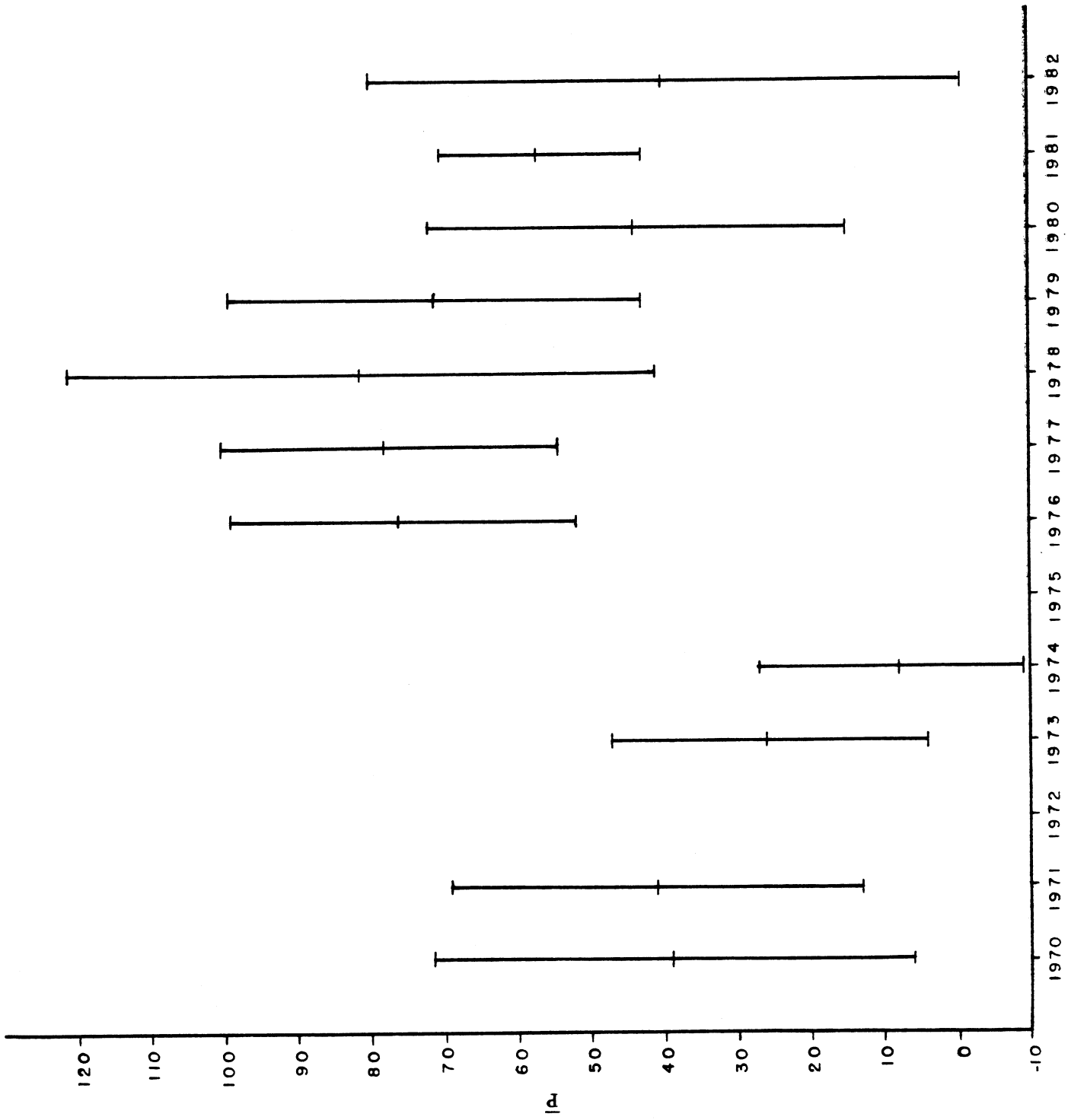

TEXAS
19
20
GULF
OF
MEXICO
29°
28°
27°
26°
97°
96°
95°
94°

Figure 2. Confidence intervals (95%) for mean percent brown shrimp (P) (Penaeus aztecus) in the combined catch of brown shrimp and white shrimp (P. setiferus) in Texas Parks and Wildlife Department Gulf trawl samples within the 7.3-m depth zone during 1970-1982 (P = back transformed mean arc sine $\sqrt{P_i}$, blank = no data).


120
110
100
90
80
70
60
50
40
30
20
10
0
-10
PI
1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982

Appendix A. National Marine Fisheries Service commercial shrimp landings data.

Table A.1. Count category (No. of heads-off shrimp/kg) used for the eight National Marine Fisheries Service count category ranges for Gulf of Mexico commercially landed brown shrimp (Penaeus aztecus) and white shrimp (P. setiferus).

NMFS reported count categories (shrimp/kg)	Count category (shrimp/kg)
<32	22
33-44	40
46-55	51
57-66	62
68-88	77
90-110	99
112-147	128
≤150	150

Appendix B. Texas Parks and Wildlife Department trawl data.

Table B.1. Date, location, number, weight (kg) and mean total length (TL) of brown shrimp (Penaeus aztecus) and white shrimp (P. setiferus) collected within the 7.3-m depth zone of the Texas territorial sea (within National Marine Fisheries Service statistical areas 19 and 20) by Texas Parks and Wildlife Department during May-July, 1970-1982. ND = no trawl data collected; blanks = no data available.

Year Date	Tow time (min)	Depth (m)	Location	Brown shrimp No.	Brown shrimp Weight (kg)	Brown shrimp Mean TL (mm)	White shrimp No.	White shrimp Weight (kg)	White shrimp Mean TL (mm)
1970									
May 25	15	5.5	Cedar Bayou	0	0.00		0	0.00	
Jun 08	15	7.3	Aransas Pass	170	1.70	97	95	4.99	171
Jul 08	15	7.3	Aransas Pass	19	0.11	88	192	9.07	170
Jul 20	15	7.3	Pass Cavallo	60	0.40	87	55	2.72	178
1971									
May 25	15	5.5	Aransas Pass	389	2.61	81	3	0.09	156
Jun 08	15	6.4	Aransas Pass	0	0.00		0	0.00	
Jun 21	15	7.3	Aransas Pass	1	0.02	142	19	0.91	174
Jul 09	15	7.3	Aransas Pass	2	0.04	131	2	0.08	174
Jul 14	15	7.3	Aransas Pass	5	0.04	96	30	1.81	178
1973									
May 08	15	7.3	S. of Colorado River	1	0.01	100	50	1.25	141
May 08	5	7.3	Pass Cavallo	0	0.00		2	0.06	154
May 09	10	7.3	Cedar Bayou	0	0.00		47	1.47	148
May 30	15	7.3	Aransas Pass	2	0.01	88	4	0.14	165
May 31	15	7.3	Water Exchange Pass	0	0.00		0	0.00	
Jun 25	15	7.3	Aransas Pass	103	1.70	91	34	1.42	169
Jun 27	15	7.3	Pass Cavallo	3	0.02	92	37	1.70	175
Jul 17	15	7.3	Aransas Pass	40	0.37	100	13	0.59	175

Table B.1. (Cont'd).

Year Date	Tow time (min)	Depth (m)	Location	Brown shrimp No.	Brown shrimp Weight (kg)	Brown shrimp Mean TL (mm)	White shrimp No.	White shrimp Weight (kg)	White shrimp Mean TL (mm)
1974									
May 07	15	7.3	Pass Cavallo	0	0.00		7	0.25	167
Jun 11	15	7.3	Aransas Pass	2	0.02	100	1	0.02	150
Jun 18	15	7.3	Aransas Pass	0	0.00		53	2.15	171
Jun 18	15	7.3	Aransas Pass	6	0.07	108	11	0.41	169
Jun 21	15	7.3	Aransas Pass	0	0.00		12	0.47	171
Jun 26	15	7.3	Matagorda Ship Channel	0	0.00		2	0.09	181
Jun 27	15	7.3	Matagorda Ship Channel	0	0.00		31	1.31	175
Jun 27	15	7.3	Cedar Bayou	0	0.00		7	0.45	178
Jul 15	15	7.3	Aransas Pass	0	0.00		0	0.00	
Jul 22	15	7.3	Cedar Bayou	0	0.00		1	0.05	181
Jul 23	15	7.3	Matagorda Ship Channel	0	0.00		16	0.79	178
1976									
May 11	30	7.3	Aransas Pass	53	0.34	82	0	0.00	
May 24	30	7.3	Pass Cavallo	155	1.14	91	32	1.36	165
Jun 14	30	7.3	Aransas Pass	16	0.08	92	4	0.21	185
Jun 29	15	7.3	Pass Cavallo	653	2.87	83	0	0.00	
Jul 14	15	7.3	Pass Cavallo	24	0.08	78	3	0.14	177
Jul 20	30	7.3	Aransas Pass	158	1.85	110	14	0.69	177
Jul 27	15	7.3	Aransas Pass	0	0.00		0	0.00	

Table B.1. (Cont'd).

Year Date	Tow time (min)	Depth (m)	Location	Brown shrimp No.	Brown shrimp Weight (kg)	Brown shrimp Mean TL (mm)	White shrimp No.	White shrimp Weight (kg)	White shrimp Mean TL (mm)
1977									
May 22	30	7.3	Aransas Pass	186	0.64	91	1	0.03	170
May 31	30	7.3	Pass Cavallo	50	0.30	86	19	0.77	164
Jun 07	15	7.3	Pass Cavallo	483	5.11	108	25	1.08	171
Jun 29	30	7.3	Aransas Pass	1436	10.05	98	26	1.08	174
Jul 13	30	7.3	Aransas Pass	532	7.18	113	56	2.32	174
Jul 27	15	7.3	Pass Cavallo	4	0.06	108	0	0.00	
1978									
May 30	30	7.3	Aransas Pass	0	0.00		0	0.00	
Jun 14	15	7.3	Aransas Pass	4	0.04	109	0	0.00	
Jun 28	15	7.3	Aransas Pass	35	0.17	83	4	0.15	184
Jul 14	15	7.3	Aransas Pass	0	0.00		0	0.00	
Jul 19	15	7.3	Aransas Pass	0	0.00		0	0.00	
1979									
May 15	30	7.3	Aransas Pass	43	0.16	77	0	0.00	
May 17	30	7.3	Aransas Pass	96	0.66	89	0	0.00	
May 24	30	7.3	Aransas Pass	6	0.06	86	22	0.81	160
Jun			ND						
Jul 30	30	7.3	Aransas Pass	404	2.80	91	23	0.94	154

Table B.1. (Cont'd).

Year Date	Tow time (min)	Depth (m)	Location	Brown shrimp No.	Brown shrimp Weight (kg)	Brown shrimp Mean TL (mm)	White shrimp No.	White shrimp Weight (kg)	White shrimp Mean TL (mm)
1980									
May			ND						
Jun 05	15	7.3	Aransas Pass	63	0.36	82	11	0.47	161
Jun 05	15	7.3	Aransas Pass	0	0.00		0	0.00	
Jun 25	15	7.3	Aransas Pass	447	3.28	93	111	4.52	168
Jul 09	15	7.3	Aransas Pass	1	0.03	129	1	0.05	183
Jul 19	15	7.3	Aransas Pass	0	0.00		1	0.03	158
1981									
May 06	10	7.3	Aransas Pass	5	0.03	83	9	0.32	160
May 06	10	7.3	Aransas Pass	28	0.06	72	1	0.02	133
May 12	10	7.3	Aransas Pass	0	0.00		1	0.04	172
May 12	10	7.3	Aransas Pass	0	0.00		0	0.00	
May 19	10	7.3	Aransas Pass	15	0.06	81	135	5.33	162
May 19	10	7.3	Aransas Pass	7	0.05	93	0	0.00	
May 21	10	7.3	Aransas Pass	15	0.08	90	17	0.57	163
May 21	10	7.3	Aransas Pass	74	0.33	85	32	1.36	167
May 26	10	7.3	Aransas Pass	7	0.05	93	0	0.00	170
May 26	10	7.3	Aransas Pass	7	0.05	94	6	0.30	173
Jun 05	10	7.3	Aransas Pass	347	1.86	88	11	0.45	168
Jun 05	10	7.3	Aransas Pass	13	0.12	100	12	0.49	168
Jun 16	10	7.3	Aransas Pass	25	0.12	81	2	0.10	176
Jun 17	10	7.3	Aransas Pass	149	0.82	82	3	0.16	182
Jun 18	15	7.3	Aransas Pass	176	0.83	80	9	0.40	171
Jun 26	17	7.3	Aransas Pass	50	0.37	88	88	4.30	176
Jun 26	10	7.3	Aransas Pass	28	0.21	88	10	0.51	174
Jul 08	10	7.3	Aransas Pass	60	0.50	100	33	1.50	168
Jul 09	10	7.3	Aransas Pass	18	0.28	126	15	0.54	163

Table B.1. (Cont'd).

Year Date	Tow time (min)	Depth (m)	Location	Brown shrimp No.	Brown shrimp Weight (kg)	Brown shrimp Mean TL (mm)	White shrimp No.	White shrimp Weight (kg)	White shrimp Mean TL (mm)
1982									
May 25	15	7.3	Cedar Bayou	0	0.00		0	0.00	
Jun 08	15	7.3	Cedar Bayou	0	0.00		0	0.00	
Jun 08	15	5.5	Pass Cavallo	7	0.06	98	25	1.20	168
Jun 09	15	7.3	Matagorda Ship Channel	6	0.03	82	4	0.08	172
Jun 25	15	7.3	N. of Aransas Pass	0	0.00	82	4	0.08	172