V. COMPARISON WITH TPWD FISHERY INDEPENDENT SURVEYS

METHODS

The Texas Parks and Wildlife Department (TPWD) routinely monitors the abundance of estuarine organisms in Texas bay systems each month. They have divided Galveston Bay into 756 sampling grid areas from which trawl samples can be taken. Each month TPWD takes one trawl sample from each of 20 - 26 randomly selected grid areas in Galveston Bay. Sampling is conducted from either a 35.1-m or a 41.5-m research vessel; organisms are always collected with a 18.5-m (20') otter trawl during a 10 minute tow. Group weights for individuals of each species within the tow sample are recorded; individual weights were not measured. Lengths were measured for most of the individuals within the sample (Brenda Bowling, TPWD, personal communication). A detailed account of sampling methodologies used by TPWD is provided reported by Rice et al. (1988) and Dailey et al. (1991).

Survey data were obtained from TPWD for samples collected in Galveston Bay during March-October 1992. Since the purpose of this analysis was to compare the fishery-independent survey data collected by TPWD from a research vessel with the fishery-dependent bycatch data collected by NMFS from active shrimp vessels, CPUE values from the TPWD data set (number per 10 minute tow from a 18.5-m trawl) were linearly extrapolated to the level of the NMFS data set (number per hour for a 29.5-m trawl, March - July; number for a 40.6-m trawl, August - October). Three statistical comparisons were performed on the standardized data for selected species of the NMFS and TPWD data sets: a Kolmogorov-Smirnov test on the length frequency data, a Student t-test on CPUE values and a linear regression on the fish:shrimp and invertebrate:shrimp ratios (Snedecor and Cochran 1967). The Kolmogorov-Smirnov test compares the length frequency distributions of individual species from two treatments (NMFS vs. TPWD data). These species included Atlantic croaker, bay anchovy, black drum, blue crab, Atlantic brief squid, brown shrimp, cutlassfish, gulf menhaden, hardhead catfish, pink shrimp, red drum, roughback shrimp, sand seatrout, southern flounder, spot, spotted seatrout, and white shrimp.

Student t-tests were conducted for statistical comparison of the species-specific monthly CPUE values. All species which occur in both data sets were analyzed using this method. Fifty-three species were tested. Pooled variances from each data set were used during this analysis to test for significant differences in CPUE values.

A third statistical comparison between the two data sets was conducted using linear regression. This was a comparison of the number of finfish to the number of shrimp (finfish to shrimp ratio) and the number of invertebrates to the number of shrimp (invertebrate to shrimp ratio). Only the three penaeid shrimp species (brown shrimp, white shrimp and pink shrimp) were used in the shrimp category. All other invertebrates (non-penaeid species), except ctenophores and other jellyfish were grouped into the invertebrate category. All statistical comparisons and analyses

were performed using Systat 5.1 (Systat, Inc., Evanston, IL) statistical analysis software for MacIntosh computers.

RESULTS AND DISCUSSION

During March-October 1992, TPWD collected a total of 79 different species during trawl surveys in Galveston Bay (Table 18). Twelve species were found in at least one trawl per month, whereas only 7 species were found in at least one trawl sample in all months (except one). The 12 species found every month included Atlantic croaker, bay anchovy, blue crab, brown shrimp, gulf menhaden, hardhead catfish, least puffer, pinfish, sand seatrout, spot, threadfin shad, and white shrimp; the seven species found in all but one month included Atlantic spadefish, Atlantic stingray, American oyster, bighead searobin, cutlassfish, daggerblade grass shrimp, and hermit crabs. Surveys conducted during the month of May recorded the most species (50), followed by June and October (44 each), September (41), July (40), August (36), April (34) and March (31).

Kolmogorov-Smirnov Test

Species utilized in the length frequency analysis (Table 19) included bay anchovy, hardhead catfish, gulf menhaden, blue crab, sand seatrout, spot, spotted seatrout, Atlantic croaker, Atlantic brief squid, cutlassfish, and roughback, brown, white and pink shrimp. Southern flounder, black drum and red drum data from TPWD surveys were insufficient for statistical comparison with data from 1992 NMFS study. Significant differences among the two data sets (as detected by the Kolmogorov-Smirnov test) indicate that the length-frequency distributions are not comparable. Consequently, even if CPUE data for a given species are similar, the difference in size composition would prevent using TPWD data as an indicator of bycatch magnitude (based on NMFS samples).

For bay anchovy, significant differences among length-frequency distributions were found in March, April and July. In testing hardhead catfish, all months except May resulted in significant differences. No significant differences were found for gulf menhaden during July, September and October. For blue crab, no significant differences were observed in April, August, September and October. Significant differences in the length distributions of sand seatrout occurred during May, July and September.

Only data from March and May could be examined for spotted seatrout. For both months, no significant differences were found between length distributions (NMFS vs. TPWD data). A significant difference was found among all the monthly length distributions for spot. Brief squid could only be tested for 6 of the 8 months. During these 6 comparisons, all but one month (July) produced significant differences among length distributions. For Atlantic croaker, all months, except May indicated significant difference between length frequency distributions.

Brown and white shrimp comparisons maintained significant differences among the length-frequency distributions for all months. Pink shrimp could only be tested for October; no significant difference was observed between length data. Roughback shrimp could only be tested for September; results indicated a significant difference between length-frequency distributions. There were sufficient data on cutlassfish for 5 monthly tests. Three of these tests (May, June and August) produced test values that showed no significant difference between length distributions.

Student T-Test

A total of 53 species were included in the CPUE comparison tests (Table 20). Four of these species (Atlantic croaker, bay anchovy, sand seatrout, and cutlassfish) had mean CPUE values which were significantly different during each month. Twenty-five other species had mean CPUE values which were not significantly different during each month (Atlantic bumper, Atlantic midshipman, Atlantic stingray, Atlantic threadfin, black drum, crevalle jack, daggerblade grass shrimp, gray snapper, gulf butterfish, gulf toadfish, hogchoker, ladyfish, lesser blue crab, lookdown, pigfish, pinfish, pink shrimp, sheephead, silver jenny, silver perch, silver seatrout, southern kingfish, southern hake, spotted seatrout, star drum). However, 10 of these species (black drum, gray snapper, ladyfish, pink shrimp, sheephead, silver jenny, silver seatrout, southern kingfish, southern hake, and star drum) were each found during only one of the eight months. All other 24 species had mean CPUE values which were significantly different some months but not for others (Atlantic spadefish, bay whiff, bighead searobin, blue catfish, blue crab, bluntnose jack, Atlantic brief squid, brown shrimp, cutlassfish, fringed flounder, gafftopsail catfish, gizzard shad, gulf menhaden, hardhead catfish, harvestfish, inshore lizardfish, least puffer, mantis shrimp, Ohio shrimp, Spanish mackerel, spot, striped mullet, threadfin shad, and white shrimp). For shrimp, differences in CPUE were detected in all months but April for brown shrimp, and all months except June and July for white shrimp. White shrimp CPUE values in June and July were significantly different at the 90% level of significance ($\alpha = 0.1$).

Most of the monthly mean CPUE values (species-specific) that were obtained from NMFS fishery-dependent trips were greater than those obtained from TPWD fishery-independent trips. This observation was consistent for most species during most months.

Linear Regression

For data collected by TPWD, ratios of finfish to shrimp and invertebrates to shrimp (number of organisms by area and month) are provided in Table 21 and Figures 36-37. During most months, in each area, finfish catches in TPWD trawl samples outnumbered shrimp catches. Ratios varied from 42 times greater number of fish (compared to shrimp) in August Lower Bay samples, to about half (0.632) during September Upper Bay samples. During most months there were more shrimp than

invertebrates collected in trawl samples. Exceptions were during August and October in the Lower Bay, October in Trinity Bay, and March in the Upper Bay.

NMFS and TPWD ratio data were compared using NMFS ratios as the dependent and TPWD ratios as the independent during linear regression analysis (Table 22). Results indicated that TPWD fish and invertebrate ratios are not comparable with NMFS fish and invertebrate ratios for each of the three bay areas.

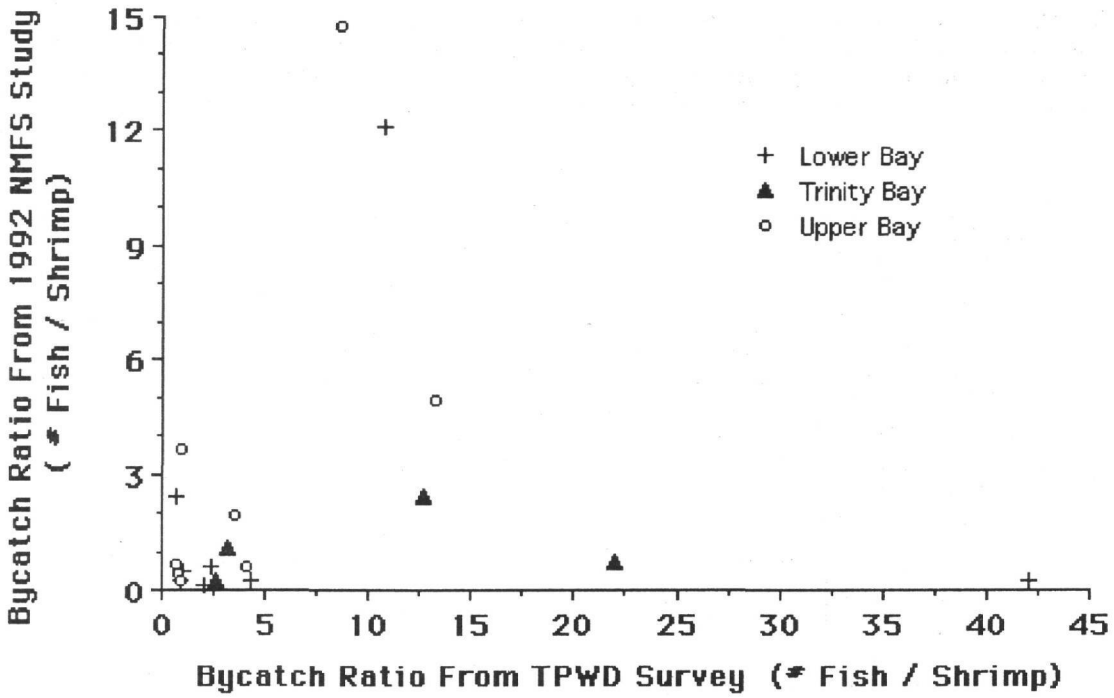

Figure 37. Plot of finfish : shrimp ratios for the three fishing zones sampled during May - November 1992 (Lower Bay, Trinity Bay, Upper Bay).

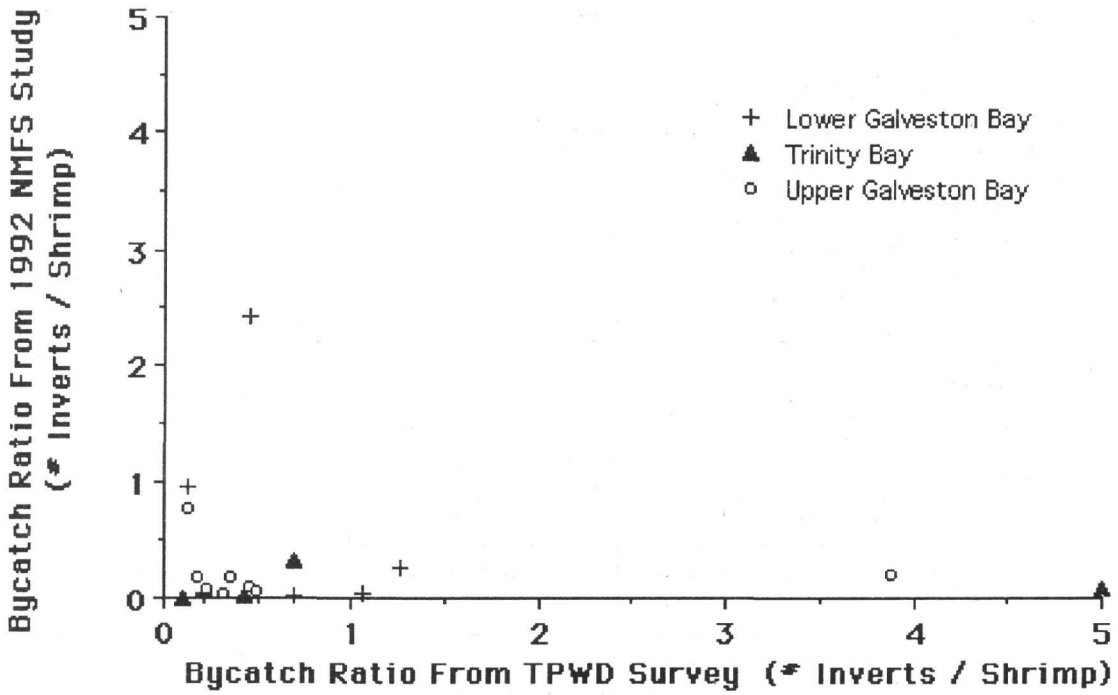

Figure 38. Plot of invertebrate : shrimp ratios for the three fishing zones sampled during May - November 1992 (Lower Bay, Trinity Bay, Upper Bay)

Table 18. Listing of individual species captured in fishery independent trawl surveys conducted by the Texas Parks and Wildlife Department (79 species total). Plus (+) symbols indicate presence in Galveston Bay during specified month. Monthly total are provided at bottom of table. Common names follow American Fisheries Society guidelines (Turgeonet al. 1988, Williams et al. 1988, Robins et al. 1991).

COMMON NAME	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
American Oyster		+	+	+	+	+	+	+
Atlantic Brief Squid			+	+	+	+	+	+
Atlantic Bumper			+	+	+	+	+	+
Atlantic Croaker	+	+	+	+	+	+	+	+
Atlantic Midshipman	+	+	+	+	+		+	
Atlantic Rangia					+	+	+	+
Atlantic Spadefish	+	+	+		+	+	+	+
Atlantic Stingray	+	+	+	+		+	+	+
Atlantic Threadfin			+	+				
Bay Anchovy	+	+	+	+	+	+	+	+
Bay Whiff		+	+	+	+		+	+
Bigeye Searobin			+	+	+		+	
Bighead Searobin	+	+	+	+	+	+	+	
Black Drum	+		+					
Blue Catfish	+	+	+	+				
Blue Crab	+	+	+	+	+	+	+	+
Bluntnose Jack						+	+	+
Bluntnose Stingray				+				
Brown Rangia			+	+	+	+	+	
Brown Shrimp	+	+	+	+	+	+	+	+
Cannonball Jellyfish							+	
Chain Pipefish			+					
Comb Jellyfish			+				+	
Common carp				+				
Crevalle Jack						+	+	
Cutlassfish		+	+	+	+	+	+	+
Daggerblade Grass Shrimp	+	+	+					
Flatback Mud Crab	+		+			+		
Flatclaw Hermit Crab				+	+			
Florida Rocksnail		+	+		+			
Fringed Flounder	+	+	+	+	+	+	+	+
Gafftopsail Catfish	+	+	+		+	+		+
Gizzard Shad	+		+	+	+	+	+	
Gray Snapper								+
Gulf Butterfish		+			+			
Gulf Menhaden	+	+	+	+	+	+	+	+
Gulf Stone Crab			+	+				
Gulf Toadfish			+		+			+
Hardhead Catfish	+	+	+	+	+	+	+	+
Harris Mud Crab	+							
Harvestfish			+	+	+	+	+	+
Hogchoker			+	+	+			+
Inshore Lizardfish			+	+		+	+	+
Iridescent Swimming Crab						+		
Ladyfish						+		
Least Puffer	+	+	+	+	+	+	+	+
Lesser Blue Crab		+	+	+			+	+
Lookdown					+		+	+
Mantis Shrimp				+	+		+	+
Moonfish						+	+	+

Table 18 (continued):

COMMON NAME	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
Ocellated Flounder		+		+	+			
Ohio Shrimp	+	+	+	+				
Pigfish		+	+					
Pinfish	+	+	+	+	+	+	+	+
Pink Shrimp								+
Portly Spider Crab			+		+			
Red Drum				+				
Roughback Shrimp							+	+
Sand Seatrout	+	+	+	+	+	+	+	+
Sargassum Shrimp	+							
Sea Nettle				+		+	+	+
Shark Eye Mollusk		+						+
Sheephead	+							+
Silver Jenny								+
Silver Perch	+	+	+					+
Silver Seatrout				+			+	+
Smooth Mud Crab			+					
Southern Flounder	+	+	+	+	+	+		+
Southern Hake		+						
Southern Kingfish			+					
Spanish Mackerel					+	+		+
Spot	+	+	+	+	+	+	+	+
Spotted Gar				+				
Spotted Seatrout	+		+					
Star Drum								+
Striped Mullet	+		+	+	+		+	
Thinstripe Hermit Crab		+	+	+	+	+	+	+
Threadfin Shad	+	+	+	+	+	+	+	+
White Shrimp	+	+	+	+	+	+	+	+
TOTALS:	31	34	50	44	40	36	41	44

Table 19. Comparison and statistical analysis of length-frequency distributions for NMFS and TPWD bycatch data. Min., max., mean and std. dev. values refer to total length (mm). P-values from Kolmogorov-Smirnov analyses on length-frequency distributions of NMFS and TPWD data. Significant differences are observed among length-frequency distributions from both datasets if p-value is ≤0.05.

		NMFS DATA					TPWD DATA					
COMMON NAME	MONTH	CASES	MIN.	MAX.	MEAN	STD. DEV.	CASES	MIN.	MAX.	MEAN	STD. DEV.	P-VALUES
Atlantic Brief Squid	MAY	237	11	80	47.86	13.04	54	18	76	54.65	10.08	0.00
	JUN	162	12	80	43.94	14.08	62	34	82	60.55	12.04	0.00
	JUL	399	12	86	36.28	14.38	12	22	47	35.00	8.49	0.82
	AUG	231	11	78	36.03	11.75	23	14	76	43.91	13.38	0.01
	SEP	573	13	99	43.43	14.65	16	15	70	50.81	15.78	0.03
	OCT	827	15	95	44.59	14.40	165	15	96	50.03	16.81	0.00
Atlantic Croaker	MAR	125	25	190	79.36	25.81	364	22	212	116.57	43.04	0.00
	APR	742	26	197	85.23	30.94	308	30	215	112.25	40.75	0.00
	MAY	913	40	218	107.55	34.18	314	33	198	105.91	33.34	0.10
	JUN	927	48	244	98.40	28.20	321	42	225	104.60	37.40	0.00
	JUL	1021	47	225	100.42	27.66	171	64	248	103.49	33.03	0.01
	AUG	626	73	231	100.18	20.81	89	76	246	110.21	34.29	0.00
	SEP	735	81	257	115.74	23.65	123	38	229	112.98	24.51	0.00
	OCT	818	83	227	124.19	22.28	142	96	182	132.60	15.33	0.00
Bay Anchovy	MAR	110	30	91	56.95	13.68	16	27	76	45.69	14.53	0.00
	APR	382	28	91	62.40	17.91	21	26	87	44.67	14.92	0.00
	MAY	328	23	87	49.81	12.37	54	33	82	48.52	10.78	0.66
	JUN	360	20	85	44.53	12.31	33	23	75	43.55	10.96	0.75
	JUL	470	23	85	39.62	12.37	32	25	71	34.72	9.24	0.02
	AUG	370	23	72	40.44	7.27	21	33	63	40.52	6.52	0.12
	SEP	455	25	70	43.28	9.14	4	38	70	50.25	13.77	0.51
	OCT	530	26	78	52.13	9.47	30	38	71	52.17	8.05	0.42
Blue Crab	MAR	110	17	180	60.26	36.69	143	20	170	66.83	28.30	0.00
	APR	347	19	178	59.62	31.98	47	21	161	62.09	32.97	0.57
	MAY	347	17	197	74.29	38.34	146	16	159	74.74	31.14	0.02
	JUN	479	17	187	70.89	33.94	173	26	182	84.86	38.00	0.00
	JUL	506	22	185	83.70	38.16	68	25	195	94.49	43.71	0.01
	AUG	173	29	191	80.14	35.95	3	60	150	119.00	51.12	0.33
	SEP	257	32	183	78.34	31.23	42	33	171	77.33	33.64	0.78
	OCT	231	34	167	78.87	30.97	18	33	159	76.00	39.91	0.21

Table 19 (continued):

COMMON NAME	MONTH	NMFS DATA CASES	NMFS DATA MIN.	NMFS DATA MAX.	NMFS DATA MEAN	NMFS DATA STD. DEV.	TPWD DATA CASES	TPWD DATA MIN.	TPWD DATA MAX.	TPWD DATA MEAN	TPWD DATA STD. DEV.	P-VALUES
Brown Shrimp	MAR	53	46	70	58.04	5.80	5	64	96	81.80	13.61	0.00
	APR	228	18	80	44.88	18.10	149	39	141	85.11	19.65	0.00
	MAY	921	22	75	43.39	8.15	263	42	119	79.08	14.08	0.00
	JUN	928	27	86	43.85	6.79	651	42	140	80.38	15.05	0.00
	JUL	1002	22	87	46.99	7.36	280	28	135	85.76	12.74	0.00
	AUG	520	25	86	44.95	7.53	4	61	105	81.50	18.50	0.00
	SEP	758	22	74	45.21	6.35	348	55	157	81.95	10.11	0.00
	OCT	587	28	69	50.68	5.53	72	35	115	85.96	16.48	0.00
Cutlassfish	APR	357	159	447	318.00	38.17	11	269	370	298.82	27.08	0.02
	MAY	684	180	585	389.56	45.48	5	378	415	395.40	15.47	0.45
	JUN	459	160	625	443.87	75.43	4	222	428	373.00	100.72	0.62
	JUL	550	98	605	303.03	94.56	8	120	311	225.75	53.81	0.02
	AUG	88	253	626	373.19	78.74	3	178	505	352.33	164.57	0.94
Gulf Menhaden	MAR	105	43	249	109.81	31.69	78	33	237	121.90	43.36	0.00
	APR	604	25	258	120.11	39.84	96	32	242	103.74	40.93	0.00
	MAY	563	27	258	101.66	32.10	28	33	144	82.61	37.47	0.00
	JUN	495	43	239	101.83	30.62	81	33	256	109.85	34.58	0.00
	JUL	691	42	206	95.21	22.79	67	50	147	90.22	20.88	0.22
	AUG	581	54	165	92.94	17.15	41	74	164	109.27	16.78	0.00
	SEP	359	65	176	104.23	16.97	59	75	208	104.09	19.72	0.53
	OCT	585	71	204	108.47	19.71	20	87	216	114.50	27.45	0.75
Hardhead Catfish	MAR	26	89	275	130.15	48.71	50	95	378	171.00	52.60	0.00
	APR	366	81	353	130.98	48.37	30	101	345	192.87	56.42	0.00
	MAY	249	45	377	143.17	49.68	5	102	172	134.00	28.82	0.98
	JUN	278	100	393	143.95	49.86	51	112	391	190.92	64.94	0.00
	JUL	351	25	354	110.04	57.96	90	50	322	185.49	80.86	0.00
	AUG	378	56	284	98.74	42.39	29	60	345	215.28	81.37	0.00
	SEP	415	64	347	92.55	32.73	26	71	251	158.65	51.08	0.00
	OCT	316	55	328	118.39	39.51	72	80	352	150.21	80.29	0.00
Pink Shrimp	OCT	4	53	70	59.25	7.59	2	50	56	53.00	4.24	1.00

Table 19 (continued):

COMMON NAME	MONTH	NMFS DATA CASES	NMFS DATA MIN.	NMFS DATA MAX.	NMFS DATA MEAN	NMFS DATA STD. DEV.	TPWD DATA CASES	TPWD DATA MIN.	TPWD DATA MAX.	TPWD DATA MEAN	TPWD DATA STD. DEV.	P-VALUES
Sand Seatrout	MAR	105	75	177	112.12	16.03	2	105	157	131.00	36.77	1.00
	APR	460	22	210	115.18	35.01	10	37	162	120.00	39.74	0.36
	MAY	522	21	210	92.02	37.81	63	44	184	120.86	42.26	0.00
	JUN	744	26	238	103.51	25.03	142	29	221	106.75	37.63	0.06
	JUL	836	20	252	97.39	33.40	41	56	230	115.73	35.04	0.02
	AUG	442	39	219	117.65	31.22	16	84	230	123.50	38.75	0.53
	SEP	587	25	253	116.87	39.66	18	79	210	142.61	32.05	0.00
	OCT	659	33	269	130.74	45.68	41	47	265	136.68	52.48	0.60
Spot	MAR	16	114	192	134.88	19.95	58	122	248	146.12	18.04	0.01
	APR	208	54	240	105.58	38.22	47	54	208	125.09	43.86	0.00
	MAY	199	59	230	88.16	21.36	57	59	211	93.67	25.62	0.01
	JUN	428	57	170	91.66	11.60	139	76	182	98.55	15.31	0.00
	JUL	626	52	207	96.45	16.91	58	73	148	103.79	12.90	0.00
	AUG	385	26	187	105.47	17.04	47	99	172	114.55	11.64	0.00
	SEP	262	84	196	116.56	14.79	75	105	147	122.79	9.82	0.00
	OCT	184	92	228	128.46	16.19	54	105	225	136.50	27.42	0.00
Spotted Seatrout	MAR	7	111	150	129.57	16.52	15	109	200	150.20	24.97	0.14
	MAY	11	159	246	200.82	23.12	3	184	211	195.67	13.87	0.98
Roughback Shrimp	SEP	107	13	39	30.62	5.96	3	50	60	55.00	5.00	0.00
White Shrimp	MAR	125	33	86	53.96	11.24	127	62	131	85.66	10.92	0.00
	APR	728	34	91	61.55	8.66	182	37	145	98.63	14.05	0.00
	MAY	707	43	97	75.56	7.30	76	54	142	117.07	17.42	0.00
	JUN	376	25	105	66.80	23.86	28	39	159	99.21	38.57	0.00
	JUL	909	27	97	50.77	10.39	225	57	135	96.49	13.56	0.00
	AUG	696	35	87	59.69	9.74	102	66	140	109.09	14.69	0.00
	SEP	901	21	110	59.48	11.89	213	62	151	99.54	16.06	0.00
	OCT	999	28	96	62.92	10.85	250	68	153	105.96	15.68	0.00

Table 20. Catch per unit effort for each species during 1992 NMFS sampling and TPWD fishery independent surveys. P-values are from Student's t-test comparing numerical CPUE from NMFS vs. TPWD data. Values less than 0.05 are significantly different at the 95% level of significance.

DATA FOR MARCH 1992

COMMON NAME	NUMBER OF CASES	NMFS MEAN	NMFS STD. DEV.	NUMBER OF CASES	TPWD MEAN	TPWD STD. DEV.	P-VALUE
Atlantic Croaker	5	3396.27	3835.48	26	611.08	1011.91	0.00
Atlantic Spadefish	5	55.67	69.93	26	2.22	5.64	0.00
Bay Anchovy	5	234.57	275.09	26	5.91	9.04	0.00
Bighead Searobin	5	113.84	144.00	26	2.59	5.12	0.00
Blue Crab	5	149.42	70.15	26	143.26	361.93	0.97
Brown Shrimp	5	57.66	47.31	26	2.22	5.64	0.00
Daggerblade Grass Shrimp	5	0.61	1.36	26	1.11	3.13	0.73
Fringed Flounder	5	4.53	6.81	26	0.37	1.88	0.01
Gafftopsail Catfish	5	1.26	2.82	26	0.37	1.88	0.38
Gizzard Shad	5	0.73	1.63	26	0.37	1.88	0.69
Gulf Menhaden	5	840.71	517.74	26	36.55	75.35	0.00
Hardhead Catfish	5	33.12	35.28	26	18.46	24.73	0.27
Least Puffer	5	1.99	2.88	26	4.06	10.58	0.67
Sand Seatrout	5	232.48	317.04	26	0.74	3.77	0.00
Silver Perch	5	3.45	5.01	26	0.74	3.77	0.17
Spot	5	16.07	11.20	26	25.85	63.84	0.74
Spotted Seatrout	5	4.27	9.55	26	5.54	11.25	0.82
Threadfin Shad	5	1300.67	2704.36	26	0.37	1.88	0.01
White Shrimp	5	560.05	245.12	26	55.39	112.75	0.00

Table 20 (continued):

DATA FOR APRIL 1992

COMMON NAME	NUMBER OF CASES	NMFS MEAN	NMFS STD. DEV.	NUMBER OF CASES	TPWD MEAN	TPWD STD. DEV.	P-VALUE
Atlantic Croaker	30	3818.68	6122.64	26	203.45	279.95	0.00
Atlantic Midshipman	30	3.88	11.41	26	1.11	3.13	0.24
Atlantic Spadefish	30	2.04	5.54	26	6.28	24.43	0.36
Bay Anchovy	30	351.14	547.53	26	8.12	19.52	0.00
Bay Whiff	30	0.79	2.82	26	0.74	2.61	0.95
Bighead Searobin	30	11.73	28.61	26	1.11	4.14	0.07
Blue Catfish	30	123.97	214.48	26	193.48	573.70	0.54
Blue Crab	30	82.74	109.89	26	17.72	24.54	0.01
Brown Shrimp	30	61.86	97.48	26	103.02	309.41	0.49
Cutlassfish	30	331.80	609.80	26	4.06	15.16	0.01
Daggerblade Grass Shrimp	30	0.37	2.05	26	1.85	6.08	0.22
Fringed Flounder	30	0.55	1.87	26	0.37	1.88	0.73
Gafftopsail Catfish	30	7.51	19.80	26	0.74	3.77	0.09
Gulf Butterfish	30	3.96	14.68	26	2.59	10.00	0.69
Gulf Menhaden	30	3422.26	10338.04	26	50.95	101.44	0.10
Hardhead Catfish	30	93.73	127.37	26	11.08	19.90	0.00
Least Puffer	30	1.35	4.94	26	1.11	3.13	0.83
Ohio Shrimp	30	52.30	66.85	26	13.66	34.04	0.01
Pigfish	30	0.47	2.58	26	0.37	1.88	0.87
Pinfish	30	0.64	2.27	26	0.37	1.88	0.64
Sand Seatrout	30	171.61	217.28	26	3.69	13.32	0.00
Silver Perch	30	2.08	6.78	26	2.59	9.23	0.82
Southern Hake	30	9.64	26.92	26	1.48	4.46	0.13
Spot	30	78.22	166.20	26	18.09	47.60	0.81
Threadfin Shad	30	122.89	291.69	26	1.85	3.86	0.04
White Shrimp	30	685.06	610.33	26	67.94	114.56	0.00

Table 20 (continued):

DATA FOR MAY 1992

COMMON NAME	NUMBER OF CASES	NMFS MEAN	NMFS STD. DEV.	NUMBER OF CASES	TPWD MEAN	TPWD STD. DEV.	P-VALUE
Atlantic Brief Squid	36	190.93	513.84	26	19.94	46.23	0.10
Atlantic Croaker	36	1487.79	2344.18	26	292.06	375.09	0.01
Atlantic Midshipman	36	4.85	14.27	26	5.17	14.68	0.93
Atlantic Spadefish	36	20.16	77.92	26	5.91	15.85	0.36
Atlantic Threadfin	36	0.13	0.79	26	0.37	1.88	0.50
Bay Anchovy	36	66.33	89.66	26	21.42	35.02	0.02
Bay Whiff	36	2.13	6.61	26	13.29	42.07	0.12
Bighead Searobin	36	5.34	12.15	26	0.74	2.61	0.06
Black Drum	36	0.06	0.38	26	0.37	1.88	0.34
Blue Catfish	36	118.84	291.88	26	3.32	8.98	0.05
Blue Crab	36	102.18	151.55	26	67.57	142.40	0.37
Brown Shrimp	36	7813.45	9822.45	26	444.19	1368.46	0.00
Cutlassfish	36	1210.32	2495.05	26	1.85	4.72	0.02
Fringed Flounder	36	0.56	1.97	26	29.54	112.28	0.13
Gafftopsail Catfish	36	0.46	2.10	26	6.28	22.38	0.13
Gizzard Shad	36	29.50	54.48	26	0.37	1.88	0.01
Gulf Menhaden	36	689.74	1097.08	26	10.71	20.20	0.00
Gulf Toadfish	36	0.98	4.15	26	1.85	4.72	0.45
Hardhead Catfish	36	75.62	209.26	26	1.85	3.86	0.08
Harvestfish	36	4.61	10.81	26	0.37	1.88	0.05
Hogchoker	36	0.70	3.09	26	0.74	3.77	0.96
Inshore Lizardfish	36	6.38	25.42	26	0.37	1.88	0.23
Least Puffer	36	2.13	6.07	26	1.85	5.44	0.85
Lesser Blue Crab	36	1.26	4.53	26	1.11	4.14	0.89
Ohio Shrimp	36	7.05	17.88	26	1.48	3.53	0.12
Pigfish	36	3.21	10.29	26	0.37	1.88	0.17
Pinfish	36	11.72	38.37	26	0.37	1.88	0.14
Sand Seatrout	36	128.76	140.01	26	23.26	44.47	0.00
Silver Perch	36	0.49	2.16	26	2.59	13.18	0.35
Southern Kingfish	36	0.82	4.90	26	0.37	1.88	0.66
Spot	36	54.24	120.26	26	88.62	292.92	0.53
Spotted Seatrout	36	0.98	2.48	26	1.11	3.13	0.85
Striped Mullet	36	0.54	2.01	26	0.37	1.88	0.74
Threadfin Shad	36	21.49	59.03	26	1.11	3.13	0.08
White Shrimp	36	260.72	312.70	26	28.43	52.19	0.00

Table 20 (continued):

DATA FOR JUNE 1992

COMMON NAME	NUMBER OF CASES	NMFS MEAN	NMFS STD. DEV.	NUMBER OF CASES	TPWD MEAN	TPWD STD. DEV.	P-VALUE
Atlantic Brief Squid	37	60.53	105.73	26	24.37	51.82	0.11
Atlantic Bumper	37	5.90	19.91	26	1.48	7.53	0.29
Atlantic Croaker	37	988.05	1018.01	26	308.68	535.56	0.00
Atlantic Midshipman	37	11.18	27.89	26	1.11	3.13	0.07
Atlantic Stingray	37	2.29	8.27	26	0.37	1.88	0.25
Atlantic Threadfin	37	3.87	10.53	26	0.37	1.88	0.10
Bay Anchovy	37	98.96	124.01	26	12.55	22.52	0.00
Bay Whiff	37	27.77	47.43	26	8.12	16.45	0.05
Bighead Searobin	37	6.24	10.81	26	1.85	4.72	0.06
Blue Catfish	37	0.95	4.29	26	10.71	35.33	0.10
Blue Crab	37	148.56	193.20	26	63.88	73.96	0.04
Brown Shrimp	37	13113.70	12864.81	26	548.68	899.88	0.00
Cutlassfish	37	306.54	479.80	26	1.48	3.53	0.00
Fringed Flounder	37	3.60	7.94	26	16.62	38.45	0.05
Gizzard Shad	37	3.79	9.06	26	0.74	2.61	0.10
Gulf Menhaden	37	504.09	880.59	26	29.91	37.36	0.01
Hardhead Catfish	37	53.18	66.97	26	18.83	29.93	0.02
Harvestfish	37	42.06	76.89	26	16.25	26.57	0.11
Hogchoker	37	2.82	10.63	26	1.85	6.66	0.68
Inshore Lizardfish	37	15.21	32.67	26	0.37	1.88	0.02
Least Puffer	37	14.36	25.12	26	1.11	4.14	0.01
Lesser Blue Crab	37	19.34	58.51	26	1.48	4.46	0.13
Mantis Shrimp	37	1.69	5.31	26	2.22	6.26	0.72
Ohio Shrimp	37	1.67	7.88	26	1.85	4.72	0.92
Pinfish	37	18.04	77.90	26	4.80	20.90	0.40
Sand Seatrout	37	447.41	540.20	26	54.65	70.74	0.00
Silver Seatrout	37	14.67	38.69	26	0.37	1.88	0.07
Spot	37	1507.79	3056.75	26	60.55	92.83	0.02
Striped Mullet	37	1.41	4.21	26	1.48	5.88	0.96
Threadfin Shad	37	21.75	52.62	26	3.32	5.39	0.08
White Shrimp	37	352.21	1006.00	26	10.34	16.50	0.09

Table 20 (continued):

DATA FOR JULY 1992

COMMON NAME	NUMBER OF CASES	NMFS MEAN	NMFS STD. DEV.	NUMBER OF CASES	TPWD MEAN	TPWD STD. DEV.	P-VALUE
Atlantic Brief Squid	42	119.76	189.41	20	5.76	16.89	0.01
Atlantic Bumper	42	1.81	5.67	20	0.48	2.15	0.32
Atlantic Croaker	42	504.95	717.86	20	134.88	211.44	0.03
Atlantic Midshipman	42	29.92	80.78	20	0.96	2.96	0.12
Atlantic Spadefish	42	6.76	11.43	20	0.96	4.29	0.03
Bay Anchovy	42	197.85	316.89	20	15.36	23.18	0.01
Bay Whiff	42	65.45	141.98	20	1.44	3.52	0.05
Bighead Searobin	42	11.61	23.09	20	0.48	2.15	0.04
Blue Crab	42	160.40	216.36	20	32.64	53.17	0.01
Brown Shrimp	42	1853.50	3530.64	20	159.84	251.85	0.04
Cutlassfish	42	171.12	187.96	20	3.84	9.03	0.00
Fringed Flounder	42	26.53	45.67	20	2.40	6.13	0.02
Gafftopsail Catfish	42	99.84	120.94	20	1.44	3.52	0.00
Gizzard Shad	42	15.46	49.24	20	0.48	2.15	0.18
Gulf Butterfish	42	0.33	1.73	20	0.96	4.29	0.41
Gulf Menhaden	42	290.81	429.20	20	39.84	81.18	0.01
Gulf Toadfish	42	3.03	10.63	20	0.96	2.96	0.40
Hardhead Catfish	42	89.01	103.64	20	81.12	172.42	0.82
Harvestfish	42	47.22	65.31	20	1.44	3.52	0.00
Hogchoker	42	6.39	20.03	20	0.48	2.15	0.20
Least Puffer	42	36.73	64.56	20	2.40	5.28	0.02
Lookdown	42	1.52	4.12	20	0.48	2.15	0.30
Mantis Shrimp	42	19.14	49.88	20	0.48	2.15	0.10
Pinfish	42	3.43	8.19	20	12.00	39.01	0.18
Sand Seatrout	42	277.37	233.79	20	19.68	21.00	0.00
Spanish Mackerel	42	4.68	11.79	20	1.44	3.52	0.24
Spot	42	200.86	226.04	20	28.32	53.72	0.00
Striped Mullet	42	5.51	17.92	20	0.48	2.15	0.22
Threadfin Shad	42	28.35	52.26	20	9.60	40.73	0.16
White Shrimp	42	952.12	1880.41	20	133.44	236.03	0.06

Table 20 (continued):

DATA FOR AUGUST 1992

COMMON NAME	NUMBER OF CASES	NMFS MEAN	NMFS STD. DEV.	NUMBER OF CASES	TPWD MEAN	TPWD STD. DEV.	P-VALUE
Atlantic Brief Squid	28	115.47	163.76	20	15.18	25.44	0.01
Atlantic Bumper	28	17.92	84.20	20	7.26	29.51	0.59
Atlantic Croaker	28	527.97	427.02	20	77.22	140.63	0.00
Atlantic Spadefish	28	6.02	8.47	20	0.66	2.95	0.01
Atlantic Stingray	28	2.10	5.23	20	1.98	4.84	0.94
Bay Anchovy	28	214.99	411.03	20	13.86	24.41	0.03
Bighead Searobin	28	3.47	6.87	20	0.66	2.95	0.09
Blue Crab	28	46.04	64.28	20	1.98	6.46	0.00
Bluntnose Jack	28	4.66	9.28	20	4.62	14.38	0.99
Brown Shrimp	28	793.98	1170.55	20	2.64	6.91	0.00
Crevalle Jack	28	3.01	5.12	20	0.66	2.95	0.07
Cutlassfish	28	27.13	45.64	20	1.98	6.46	0.02
Fringed Flounder	28	21.64	45.65	20	1.32	4.06	0.05
Gafftopsail Catfish	28	64.76	111.63	20	8.58	18.31	0.03
Gizzard Shad	28	33.95	104.44	20	0.66	2.95	0.16
Gulf Menhaden	28	2619.09	4525.88	20	36.30	97.46	0.01
Hardhead Catfish	28	402.92	683.59	20	19.14	23.25	0.02
Harvestfish	28	8.47	10.69	20	3.30	10.38	0.10
Inshore Lizardfish	28	3.00	8.06	20	1.32	4.06	0.40
Ladyfish	28	1.13	3.31	20	0.66	2.95	0.61
Least Puffer	28	7.12	12.28	20	0.66	2.95	0.03
Pinfish	28	8.20	16.37	20	3.30	14.76	0.29
Sand Seatrout	28	212.79	337.32	20	10.56	16.36	0.01
Spanish Mackerel	28	7.93	12.64	20	0.66	2.95	0.02
Spot	28	282.20	593.07	20	31.02	59.23	0.07
Threadfin Shad	28	25.22	33.34	20	7.26	26.56	0.05
White Shrimp	28	5726.37	9436.09	20	67.32	111.09	0.01

Table 20 (continued):

DATA FOR SEPTEMBER 1992

COMMON NAME	NUMBER OF CASES	NMFS MEAN	NMFS STD. DEV.	NUMBER OF CASES	TPWD MEAN	TPWD STD. DEV.	P-VALUE
Atlantic Brief Squid	36	197.66	258.16	20	10.56	18.96	0.00
Atlantic Bumper	36	12.41	35.30	20	9.24	14.27	0.70
Atlantic Croaker	36	597.34	872.52	20	113.52	170.04	0.02
Atlantic Midshipman	36	4.40	12.09	20	1.98	6.46	0.41
Atlantic Spadefish	36	7.32	9.15	20	3.30	10.38	0.14
Atlantic Stingray	36	2.08	6.57	20	1.32	4.06	0.64
Bay Anchovy	36	110.13	141.48	20	2.64	5.42	0.00
Bay Whiff	36	364.94	684.83	20	9.90	15.37	0.03
Bighead Searobin	36	0.81	2.26	20	3.96	7.54	0.02
Blue Crab	36	42.03	46.87	20	27.72	38.52	0.25
Bluntnose Jack	36	8.23	9.40	20	4.62	9.84	0.18
Brown Shrimp	36	1030.85	1181.51	20	322.08	464.12	0.01
Crevalle Jack	36	1.22	6.36	20	1.32	4.06	0.95
Cutlassfish	36	28.28	60.18	20	1.32	5.90	0.05
Fringed Flounder	36	41.54	51.79	20	19.14	30.12	0.08
Gizzard Shad	36	0.88	3.00	20	3.30	8.43	0.13
Gulf Menhaden	36	328.98	975.69	20	38.94	64.73	0.19
Hardhead Catfish	36	206.99	280.81	20	17.16	17.18	0.00
Harvestfish	36	21.79	24.17	20	7.26	15.72	0.02
Inshore Lizardfish	36	14.67	28.98	20	1.32	4.06	0.05
Least Puffer	36	7.59	13.43	20	21.78	28.17	0.01
Lesser Blue Crab	36	28.47	35.76	20	28.38	64.71	0.99
Lookdown	36	3.98	20.88	20	0.66	2.95	0.48
Mantis Shrimp	36	17.78	23.73	20	5.94	13.18	0.05
Pinfish	36	1.87	4.83	20	1.32	4.06	0.67
Roughneck Shrimp	36	16.88	29.74	20	2.64	11.81	0.05
Sand Seatrout	36	268.33	387.61	20	12.54	20.30	0.01
Spot	36	66.68	139.91	20	80.52	196.53	0.76
Striped Mullet	36	0.23	0.95	20	4.62	15.01	0.08
Threadfin Shad	36	8.19	19.80	20	32.34	58.80	0.03
White Shrimp	36	9043.05	18141.25	20	200.64	401.17	0.03

Table 20 (continued):

DATA FOR OCTOBER 1992

COMMON NAME	NUMBER OF CASES	NMFS MEAN	NMFS STD. DEV.	NUMBER OF CASES	TPWD MEAN	TPWD STD. DEV.	P-VALUE
Atlantic Brief Squid	40	277.23	450.38	26	106.62	150.31	0.07
Atlantic Bumper	40	18.37	50.05	26	18.79	80.35	0.98
Atlantic Croaker	40	211.50	195.10	26	76.66	97.86	0.00
Atlantic Spadefish	40	13.99	25.12	26	5.59	18.36	0.15
Atlantic Stingray	40	0.05	0.27	26	0.51	2.59	0.27
Bay Anchovy	40	58.80	46.23	26	15.23	31.39	0.00
Bay Whiff	40	26.26	46.05	26	7.62	16.77	0.05
Blue Crab	40	34.78	49.50	26	9.65	17.73	0.02
Bluntnose Jack	40	8.01	10.95	26	2.03	4.86	0.01
Brown Shrimp	40	773.45	1687.32	26	40.11	64.83	0.03
Cutlassfish	40	92.31	360.35	26	0.51	2.59	0.20
Fringed Flounder	40	15.87	28.05	26	35.54	68.31	0.11
Gafftopsail Catfish	40	7.18	17.13	26	0.51	2.59	0.05
Gray Snapper	40	0.09	0.54	26	0.51	2.59	0.32
Gulf Menhaden	40	548.71	1048.12	26	10.15	18.41	0.01
Gulf Toadfish	40	1.05	3.82	26	0.51	2.59	0.53
Hardhead Catfish	40	130.69	317.36	26	41.63	77.03	0.17
Harvestfish	40	42.69	49.62	26	9.14	14.35	0.00
Hogchoker	40	2.85	7.98	26	0.51	2.59	0.15
Inshore Lizardfish	40	14.56	24.21	26	4.06	8.97	0.04
Least Puffer	40	8.05	16.63	26	6.09	17.20	0.65
Lesser Blue Crab	40	20.28	36.94	26	28.94	56.62	0.45
Lookdown	40	7.89	32.84	26	4.06	13.85	0.58
Mantis Shrimp	40	28.02	90.14	26	9.65	19.60	0.31
Pinfish	40	1.99	5.22	26	1.52	7.77	0.77
Pink Shrimp	40	0.80	4.36	26	1.02	5.18	0.85
Roughback Shrimp	40	17.83	44.04	26	0.51	2.59	0.05
Sand Seatrout	40	155.68	274.31	26	20.82	30.37	0.02
Sheephead	40	0.08	0.48	26	1.02	5.18	0.26
Silver Jenny	40	0.35	1.32	26	16.25	80.19	0.21
Silver Perch	40	1.91	5.41	26	1.02	5.18	0.51
Spanish Mackerel	40	4.93	8.74	26	0.51	2.59	0.02
Spot	40	37.74	126.10	26	30.46	72.66	0.79
Star Drum	40	17.78	74.32	26	0.51	2.59	0.24
Threadfin Shad	40	36.34	82.97	26	6.09	28.49	0.08
White Shrimp	40	2255.19	3049.22	26	186.83	321.40	0.00

Table 21. Ratio of finfish and invertebrate catch to shrimp landings from Texas Parks and Wildlife Department fishery independent surveys. Data represent monthly ratios of numbers of individuals captured.

MONTH	FISH : SHRIMP	INVERT : SHRIMP
March	13.54 : 1	2.60 : 1
April	3.01 : 1	0.22 : 1
May	1.10 : 1	0.23 : 1
June	1.01 : 1	0.20 : 1
July	1.24 : 1	0.28 : 1
August	3.36 : 1	21.34 : 1
September	0.76 : 1	0.82 : 1
October	1.41 : 1	1.08 : 1

Table 22. Linear regression results for statistical (regression) comparison of NMFS and TPWD bycatch ratios. P-values less than 0.05 indicate a significant regression (correlation) among the NMFS and TPWD bycatch ratios.

Fishing Area	Finfish		Invertebrates	
	R-value	P-value	R-value	P-value
Lower Galveston Bay	0.032	0.940	0.228	0.586
Trinity Bay	0.228	0.772	0.534	0.466
Upper Galveston Bay	0.603	0.114	0.690	0.586