REDUCING THE BYCATCH IN A COMMERCIAL TROTLINE FISHERY

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ABSTRACT

Reducing the bycatch of red drum, *Sciaenops ocellatus*, and spotted seatrout, *Cynoscion nebulosus*, in the Texas commercial trotline fishery is desirable. Hook placement within the water column was examined as a means of accomplishing this objective. The commercial trotline fishery was simulated in the Laguna Madre during February 1985 through January 1986. Requiring placement of trotline hooks on bottom will reduce bycatch of red drum, spotted seatrout, and other nonmarketable fishes and improve operational efficiency of commercial fishermen without significantly reducing catch of black drum, *Pogonias cromis*, a target commercial species. Other than crab and shrimp being more effective baits than oleander leaves, no other generalization could be made concerning baits and seasons.

Longlines catch species unwanted or legally nonretainable by fishermen and have been regulated to reduce the bycatch of nontargeted species (South Atlantic Fishery Management Council 1985). Trotlines (Figs. 1, 2) are a specialized longline used in shallow (<4 m) Texas estuaries to catch fish (Simmons and Breuer 1962; Breuer 1973, 1974, 1975; Matlock 1980). Red drum, *Sciaenops ocellatus*, and spotted seatrout, *Cynoscion nebulosus*, were the primary targets until 1981 when their sale was prohibited because of overfishing (Matlock et al. 1979; Anonymous 1979, 1981, 1983). The effort has since been redirected toward black drum, *Pogonias cromis*. Regulations requiring the use of circle hooks and placement of the mainline under water were enacted to reduce the bycatch of red drum and spotted seatrout. However, a bycatch still occurs. This study was conducted to determine if the bycatch could be further reduced by additional regulation of where in the water column hooks are fished and bait types.

MATERIALS AND METHODS

The catch on trotlines with hooks placed on the bottom or in the top of the water column was compared by simulating commercial fishing techniques in the Laguna Madre, TX (Fig. 3). Bottom trotlines were set with the mainline on the bottom. Top trotlines had the mainline floated with the hooks suspended in water ≥0.6 m deep to insure hooks fished in the water column. Texas Parks and Wildlife Department (TPWD) trotlines were set in the same area as commercial trotlines. Commercial fishermen were contacted by telephone within 24 hours prior to TPWD sets to determine areas of commercial activity. All TPWD trotlines were at least 15 m apart.

Trotlines with 100 hooks each were built according to commercial fishermen specifications (McEachron et al. 1985). The mainline (182.9 m long) consisted of #36 nylon twine, knotted twice every 1.8 m for swivel (1/0 black brass barrel) placement (Figs. 1, 2). Hooks (#8 Mustad 39960ST) were attached by a 610–686 mm long staging (56.7 kg test monofiliament) to the swivel at 1.8 m intervals. Stakes (51 cm × 76 mm) and/or anchors were placed on each end to stretch the mainline. Floats (3.8 L) were attached to the mainline every 15 hooks for navigation identification.

Eighteen trotlines were set overnight each month in both the upper and lower Laguna Madre during 1 February 1985 through 31 January 1986. Six (3 top; 3 bottom) were set during each of two monthly sampling periods (first and last 15 days of the month). Another six sets were made in either the first or last half of each month; the period was randomly selected each month. Each trotline was baited completely with one of three bait types—cut portions of blue crab, *Callinectes sapidus*; dead shrimp, *Penaeus* sp.; or oleander, *Nerium* sp. leaves—so that all bait types were used on both top and bottom trotlines during every period. These baits represented the most

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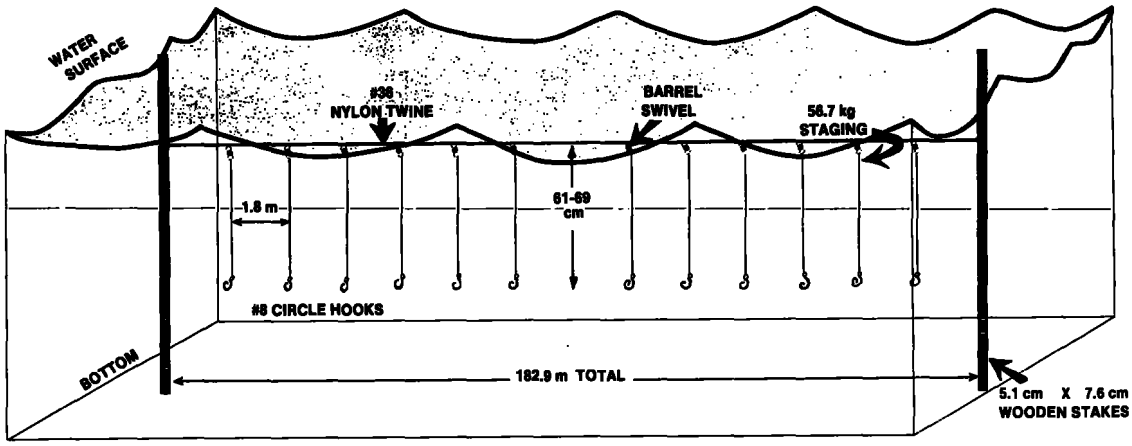

FIGURE 1.—Top trotline.

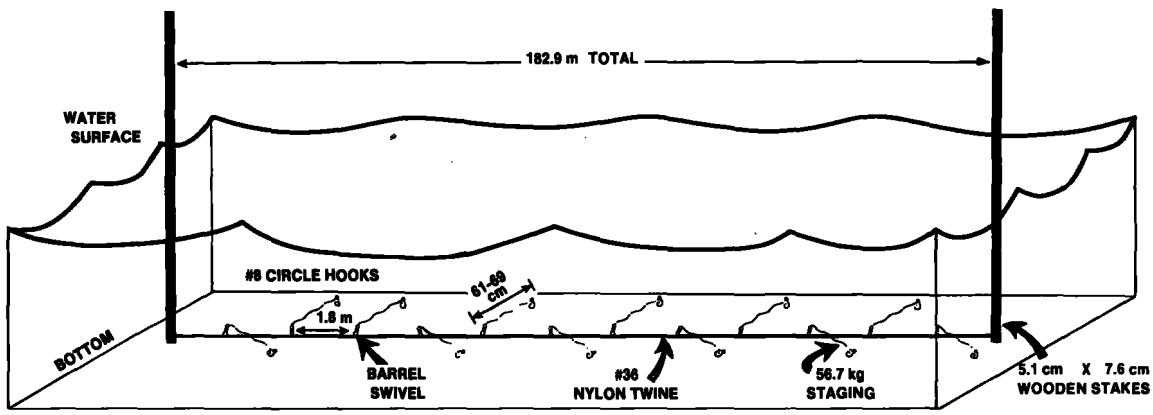

FIGURE 2.—Bottom trotline.

commonly used baits by commercial trotline fishermen (McEachron et al. 1980, 1986).

Fishes caught were identified (Hoese and Moore 1977; Robins et al. 1980), counted (Table 1), and total length (TL) was measured to the nearest 1 mm. Data were pooled into fall (September–November), winter (December–February), spring (March–May), and summer (June–August) to examine seasonal variation.

A catch rate (No./line · h) for black drum; red drum; spotted seatrout; hardhead catfish *Arius felis*; and total fishes was computed for each trotline set by dividing the number caught by the number of hours fished. Catch rates were transformed to log (catch rate + 1) and analyzed using a four-factor fixed-effects model analysis of variance (AOV). The four factors were 1) hook placement, at two levels—top and bottom; 2) bait, at three levels—crab, shimp, and leaves; 3) bay, at two levels—upper Laguna Madre and lower Laguna Madre; 4) season, at four levels—fall, winter, spring, and summer.

Differences in main effect means were evaluated with Ducan's multiple range test. However, when significant first-order interactions were found, comparisons were made within levels of the interacting factors using the mean square error (MSE) from the AOV.

Total lengths of each species were analyzed in a nested AOV to investigate differences among the four factors. However, because fish were not caught in all factor level combinations, factors and/or factor levels for each species were eliminated from analyses. Spotted seatrout lengths

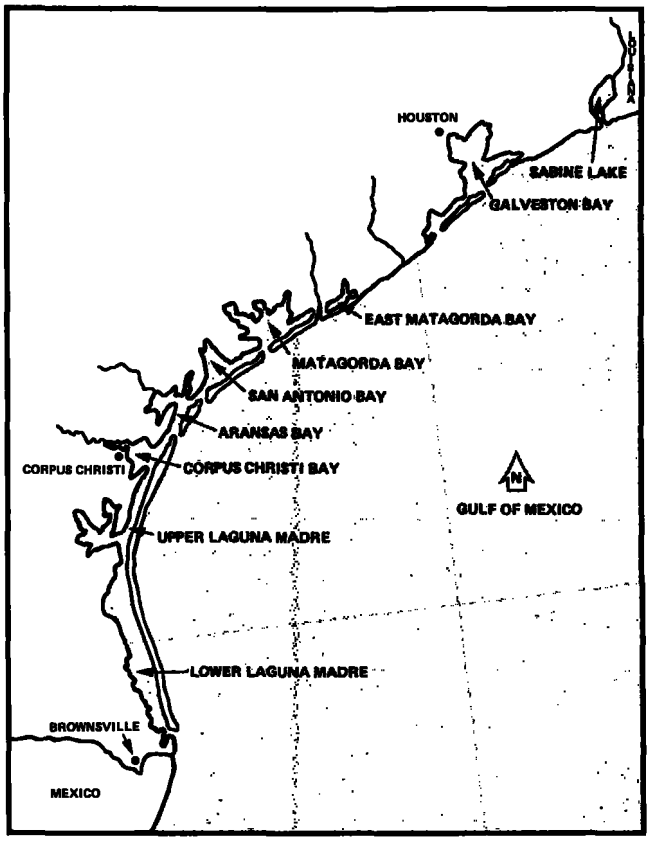

FIGURE 3.—Texas coast.

TABLE 1.—Number of fishes caught on trotlines in the upper and lower Laguna Madre during February 1985-January 1986.

Species	Upper Laguna Madre	Lower Laguna Madre	Total
Arius felis	977	1,652	2,629
Sciaenops ocellatus	352	658	1,010
Pogonias cromis	67	265	332
Cynoscion nebulosus	29	103	132
Micropogonias undulatus	36	51	87
Opsanus beta	34	1	35
Archosargus probatocephalus	1	24	25
Dasyatis americana	0	17	17
Dasyatis sabina	6	7	13
Elops saurus	4	4	8
Orthopristis chrysoptera	1	7	8
Bagre marinus	1	4	5
Lagodon rhomboides	0	5	5
Paralichthys lethostigma	1	3	4
Rhinoptera bonasus	0	4	4
Chilomycterus schoepfi	0	3	3
Ophichthus gomesi	3	0	3
Cynoscion arenarius	0	2	2
Negaprion brevirostris	0	1	1
Trachinotus carolinus	0	1	1
All species	1,512	2,812	4,324

were pooled for both bay systems because an insufficient number of spotted seatrout were caught for individual bay analyses. Factor levels eliminated from length analyses were leaves and winter from hardhead catfish, leaves and crab from spotted seatrout, and fall, spring, and summer from black drum. Spring and winter red drum lengths were pooled. Lower Laguna Madre data only were used for red drum, black drum, and hardhead catfish length analyses. Each measured fish length was an observational unit of a trotline set. Sets were a random factor nested within fixed main effect combinations. The nested set effect mean square was used for testing other effects when the set effect was significant. However, the AOV yields approximate F values because unequal numbers of fish were caught among sets.

SAS procedures (SAS Institute, Inc. 1980, 1982) were used for all analyses. The significance level for each AOV test was $\alpha = 0.01$ because the AOV used to examine catch rates of each species had 15 potential F tests. This alpha value assured that

the family level of significance would not exceed 0.15. All other tests were made with a significance level of $\alpha = 0.05$. Mean catch rates and confidence intervals computed from transformed data were back-transformed for tabular and graphic presentation (Elliott 1979).

RESULTS

Fishing trotlines on the bottom reduces bycatch without affecting catches of black drum, the target species. A significant difference could not be detected between black drum catch rates on top and bottom trotlines regardless of bait, season, or bay (Tables 2, 3). Catch rates for hardhead catfish, red drum, spotted seatrout and total fishes were significantly lower on bottom trotlines than on top trotlines (Tables 2, 3). Differences in catch rates between top and bottom trotlines for hardhead catfish, red drum, and total fishes did not vary significantly among seasons and baits but did vary between bays based on the first-order interactions (Tables 4, 5). A significant second-order interaction of position × bay × bait for spotted seatrout revealed that differences between top and bottom trotlines were affected by both bait and bay but not by season (Fig. 4).

No significant difference was found in red drum catch rates among baits nor in spotted seatrout catch rates among seasons (Tables 2, 3). All other main effects were significant for catch rates of all species and total fishes. Of the possible first-order interactions involving bait, season, and bay, only season × bait for hardhead catfish, red drum, and total fishes, bait × bay for black drum and total fishes, and season × bay for black drum, hardhead catfish, and total fishes were significant (Tables 4, 5). The second-order interaction of bait × bay × season for total fishes was significant (Fig. 5).

No significant differences were found in mean lengths of black drum, hardhead catfish, red drum, and spotted seatrout between top and bottom trotlines (Tables 6–8). Significant differences in mean length of hardhead catfish were detected for main effects of bait and season (Table 7).

DISCUSSION

Management objectives could be better met by requiring placement of trotline hooks on bottom than by allowing hooks to be fished from the surface. Red drum and spotted seatrout mortality would be reduced without significantly affecting

TABLE 2.—Mean back-transformed catch rate (No./line·h) and associated 95% confidence interval of black drum, hardhead catfish, red drum, spotted seatrout, and total fish caught on top and bottom trotlines by bait, bay, and season during February 1985–January 1986. Numbers in parentheses are the lower and upper values for the 95% confidence interval.

Species	Position[1]		Bait[2]			Bay[1]		Season[3]			
	Top	Bottom	Crab	Shrimp	Leaves	Upper Laguna Madre	Lower Laguna Madre	Fall	Winter	Spring	Summer
Black drum	0.049 (0.033-0.066)	0.039 (0.025-0.053)	0.072 (0.046-0.099)	0.044 (0.027-0.061)	0.017 (0.007-0.027)	0.017 (0.010-0.024)	0.071 (0.051-0.092)	0.019 (0.010-0.028)	0.113 (0.073-0.153)	0.037 (0.021-0.052)	0.010 (0.004-0.016)
Hardhead catfish	0.486 (0.411-0.566)	0.207 (0.165-0.249)	0.674 (0.563-0.793)	0.288 (0.233-0.345)	0.090 (0.055-0.126)	0.265 (0.216-0.316)	0.424 (0.355-0.498)	0.312 (0.246-0.381)	0.213 (0.136-0.295)	0.530 (0.418-0.651)	0.326 (0.250-0.407)
Red drum	0.209 (0.167-0.253)	0.047 (0.031-0.062)	0.123 (0.087-0.162)	0.155 (0.112-0.199)	0.103 (0.064-0.140)	0.089 (0.067-0.114)	0.166 (0.129-0.204)	0.072 (0.048-0.096)	0.299 (0.215-0.388)	0.062 (0.041-0.084)	0.084 (0.057-0.112)
Spotted seatrout	0.031 (0.022-0.041)	0.005 (0.001-0.009)	0.007 (0.003-0.011)	0.037 (0.023-0.051)	0.010 (0.004-0.016)	0.008 (0.003-0.012)	0.028 (0.019-0.038)	0.014 (0.007-0.022)	0.028 (0.014-0.042)	0.009 (0.004-0.015)	0.020 (0.008-0.033)
Total fish	0.839 (0.739-0.945)	0.319 (0.268-0.372)	0.925 (0.795-1.064)	0.578 (0.493-0.667)	0.234 (0.176-0.295)	0.408 (0.346-0.472)	0.745 (0.649-0.846)	0.452 (0.370-0.540)	0.717 (0.571-0.876)	0.677 (0.553-0.811)	0.460 (0.367-0.559)

[1] N = 216 for each species.
[2] N = 144 for each species.
[3] N = 108 for each species.

TABLE 3.—Summary of results of four-way AOV's of the mean transformed catch rate on top and bottom trotlines in the Laguna Madre during February 1985-January 1986.

Source of variation	df	Black drum			Red drum			Spotted seatrout			Hardhead catfish			Total		
		Sum of squares	*F*	*PR* > *F*	Sum of squares	*F*	*PR* > *F*	Sum of squares	*F*	*PR* > *F*	Sum of squares	*F*	*PR* > *F*	Sum of squares	*F*	*PR* > *F*
Total	431	0.9803			3.5951			0.2369			9.4078			12.3038		
Position	1	0.0015	0.82	0.37	0.2736	43.12	<0.01	0.0115	25.88	<0.01	0.5652	41.23	<0.01	1.7030	121.71	<0.01
Bait	2	0.0252	6.90	<0.01	0.0217	1.71	0.18	0.0113	12.68	<0.01	1.7919	65.36	<0.01	2.1632	77.30	<0.01
Season	3	0.0789	14.41	<0.01	0.2932	15.41	<0.01	0.0028	2.11	0.10	0.4590	11.16	<0.01	0.2515	5.99	<0.01
Bay system	1	0.0380	20.81	<0.01	0.0611	9.63	<0.01	0.0070	15.67	<0.01	0.1716	12.51	<0.01	0.6792	48.54	<0.01
Position × bait	2	0.0005	0.13	0.88	0.0091	0.72	0.49	0.0026	2.89	0.06	0.0380	1.39	0.25	0.0149	0.53	0.59
Position × season	3	0.0008	0.15	0.93	0.0664	3.49	0.02	0.0010	0.77	0.51	0.0393	0.96	0.41	0.0326	0.78	0.51
Position × bay systems	1	0.0006	0.33	0.57	0.0430	6.77	0.01	0.0118	26.60	<0.01	0.2229	16.26	<0.01	0.5231	37.38	<0.01
Bait × bay systems	2	0.0265	7.27	<0.01	0.0434	3.42	0.03	0.0012	1.40	0.25	0.0135	0.49	0.61	0.1366	4.88	0.01
Bait × season	6	0.0179	1.63	0.14	0.2014	5.29	<0.01	0.0050	1.86	0.09	0.3355	4.08	<0.01	0.4950	5.90	<0.01
Bay systems × season	3	0.0588	10.74	<0.01	0.0045	0.23	0.87	0.0011	0.82	0.48	0.2675	6.50	<0.01	0.4854	11.56	<0.01
Position × bait × bay systems	2	0.0004	0.13	0.87	0.0152	1.20	0.30	0.0050	5.66	<0.01	0.0026	0.10	0.91	0.0006	0.02	0.98
Position × bait × season	6	0.0018	0.16	0.99	0.0078	0.20	0.98	0.0008	0.30	0.94	0.0499	0.61	0.72	0.0390	0.46	0.83
Position × bay systems × season	3	0.0003	0.06	0.98	0.0153	0.80	0.49	0.0011	0.83	0.48	0.0720	1.75	0.16	0.0904	2.15	0.09
Bait × bay systems × season	6	0.0264	2.41	0.03	0.0806	2.12	0.05	0.0009	0.34	0.91	0.0761	0.93	0.48	0.2381	2.84	0.01
Position × bait × bay systems × season	6	0.0013	0.12	0.99	0.0227	0.60	0.73	0.0026	0.96	0.45	0.0384	0.47	0.83	0.0781	0.93	0.47
Error	384	0.7012			2.4363			0.1711			5.2641			5.3731		

TABLE 4.—Mean transformed catch rate of position × bay and bait × bay in significant two-way interactions. Means followed by the same letter in a row under a species heading are not significantly ($P > 0.05$) different.

	Position × bay				Bait × bay		
	Hardhead catfish		Red drum		Black drum		
Bay system	Top	Bottom	Top	Bottom	Crab	Shrimp	Leaves
Upper Laguna Madre	0.315 A	0.216 A	0.135 A	0.044 B	0.012 A	0.036 A	0.003 A
Lower Laguna Madre	0.665 A	0.197 B	0.286 A	0.050 B	0.133 A	0.052 B	0.031 B

TABLE 5.—Mean transformed catch rate of season × bait and season × bay in significant two-way interactions. Means followed by the same letter in a row under a species heading are not significantly ($P > 0.05$) different. ULM = upper Laguna Madre; LLM = Lower Laguna Madre.

	Season × bait						Season × bay			
	Hardhead catfish			Red drum			Black drum		Hardhead catfish	
Season	Crab	Shrimp	Leaves	Crab	Shrimp	Leaves	ULM	LLM	ULM	LLM
Fall	0.614 A	0.310 B	0.212 C	0.100 A	0.068 A	0.047 A	0.008 A	0.030 A	0.326 A	0.298 A
Winter	0.329 A	0.200 A	0.119 A	0.224 A	0.494 B	0.183 B	0.023 A	0.205 B	0.001 A	0.444 B
Spring	1.006 A	0.444 B	0.178 C	0.076 A	0.035 A	0.077 A	0.038 A	0.035 A	0.445 A	0.617 B
Summer	0.757 A	0.201 B	0.045 C	0.100 A	0.044 A	0.109 A	0.000 A	0.019 A	0.305 A	0.349 A

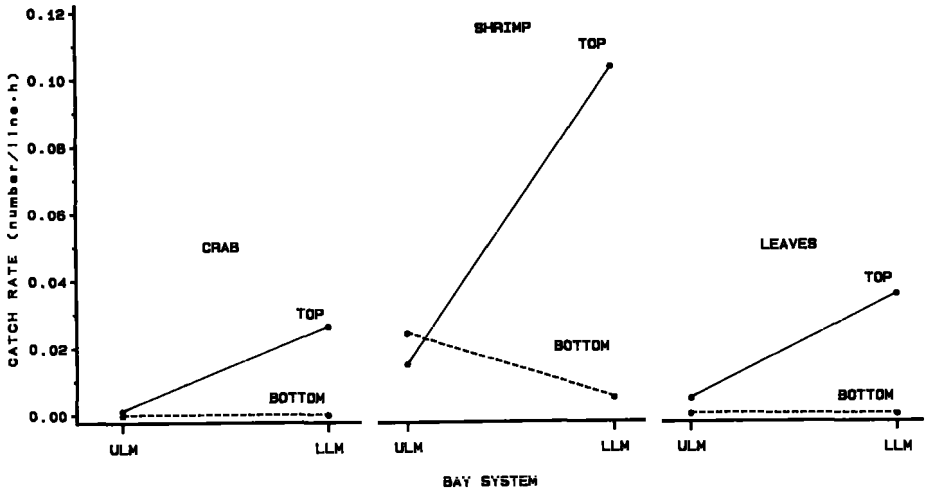

FIGURE 4.—Significant second-order interaction among positions, baits, and bay system for spotted seatrout catch rates. LLM = lower Laguna Madre, ULM = upper Laguna Madre.

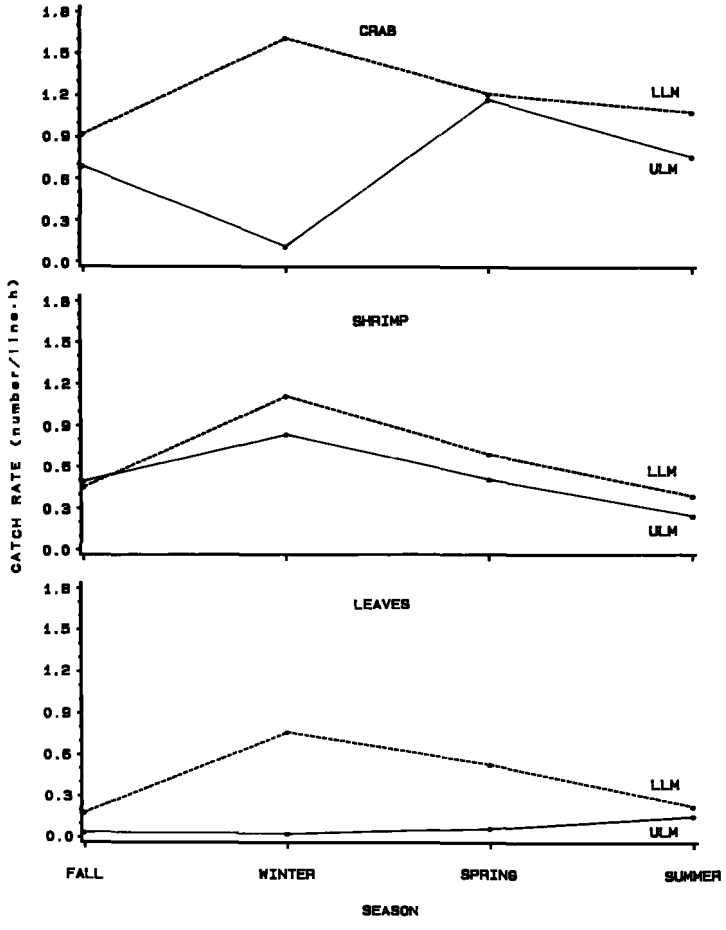

FIGURE 5.—Significant second-order interaction among bait types, bay system, and seasons for total fishes catch rates. LLM = lower Laguna Madre, ULM = upper Laguna Madre.

TABLE 6.—Mean length (mm ± 1SE) of black drum, hardhead catfish, red drum, and spotted seatrout caught on top and bottom trotlines by bait, bay and season during February 1985–January 1986. Number in parentheses is number of fish measured.

Species	Position		Bait		
	Top	Bottom	Crab	Shrimp	Leaves
Black drum	539 ± 10 (177)	550 ± 13 (146)	566 ± 11 (172)	493 ± 12 (108)	588 ± 21 (43)
Hardhead catfish	338 ± 1 (1,363)	343 ± 2 (675)	346 ± 1 (1,201)	328 ± 2 (651)	337 ± 3 (186)
Red drum	521 ± 4 (657)	504 ± 9 (173)	540 ± 6 (260)	481 ± 6 (336)	542 ± 7 (234)
Spotted seatrout	439 ± 9 (111)	420 ± 24 (18)	471 ± 23 (17)	426 ± 10 (86)	445 ± 19 (26)

Species	Bay		Season			
	Upper Laguna Madre	Lower Laguna Madre	Fall	Winter	Spring	Summer
Black drum	484 ± 19 (67)	560 ± 8 (256)	464 ± 20 (35)	538 ± 8 (201)	630 ± 21 (71)	416 ± 19 (16)
Hardhead catfish	327 ± 1 (824)	348 ± 1 (1,214)	329 ± 2 (538)	368 ± 2 (277)	333 ± 2 (724)	345 ± 2 (499)
Red drum	506 ± 7 (308)	523 ± 5 (522)	493 ± 11 (133)	506 ± 5 (427)	546 ± 9 (114)	551 ± 10 (146)
Spotted seatrout	411 ± 15 (29)	443 ± 10 (100)	410 ± 21 (25)	404 ± 12 (51)	482 ± 25 (16)	478 ± 13 (37)

TABLE 7.—Summary of results of the AOV's of mean length for black drum (winter season only), hardhead catfish (excludes leaves and winter season), and red drum (winter and spring seasons combined) on top and bottom trotlines in lower Laguna Madre during February 1985–January 1986. NA = not analyzed.

Source of variation	Black drum				Hardhead catfish				Red drum			
	df	Sum of squares	*F*	*PR* > *F*	df	Sum of squares	*F*	*PR* > *F*	df	Sum of squares	*F*	*PR* > *F*
Total	176	1,941,401			1,050	2,310,898			521	6,484,793		
Position	1	5,978	0.15	0.70	1	80	0.02	0.90	1	6,122	0.26	0.61
Bait	2	15,082	0.19	0.83	1	33,650	6.60	0.01	2	89,151	1.90	0.15
Season	NA				3	89,202	5.83	<0.01	2	133,190	2.85	0.06
Position × bait	2	49,063	0.69	0.55	1	8,242	1.62	0.21	2	10,913	0.23	0.79
Season × position	NA				3	1,517	0.10	0.96	2	789	0.02	0.98
Season × bait	NA				3	6,132	0.40	0.75	4	68,535	0.73	0.57
Season × position × bait	NA				3	10,269	0.67	0.57	4	63,388	0.68	0.61
Set (position × bait)	27	10,906,616	8.26	<0.01	NA				NA			
Set (season × position × bait)	NA				89	453,750	3.22	<0.01	91	2,129,491	2.61	<0.01
Error	144	704,611			946	1,499,474			413	3,706,235		

TABLE 8.—Summary of results of the AOV of mean length for spotted seatrout (shrimp bait only) on top and bottom trotlines in upper and lower Laguna Madre combined during February 1985–January 1986.

Source of variation	df	Sum of squares	*F*	*PR*>*F*
Total	85	750,362		
Position	1	601	0.04	0.84
Season	3	58,796	1.32	0.29
Position × season	3	58,462	1.31	0.29
Set (position × season)	28	416,855	3.42	<0.01
Error	50	217,744		

black drum catches. Operational efficiency of commercial fishermen should improve with less handling of nontarget species. Mortality of nontarget fishes would decrease because they would not be caught and subsequently handled. For red drum and spotted seatrout that are caught, survival would be high for those released back into the water. Survival of released red drum caught on trotlines in winter and summer and of spotted seatrout in winter was 100% (Martin et al. 1987). About 50% of the spotted seatrout died in summer cage studies; but few commercial trotlines are fished during this period (TPWD unpubl. data). Thus, the goal of reducing the catch of nontarget species and reducing mortality due to trotlines can be achieved with minimal impact on the commercial fishermen.

Interactions between bay system and the other three factors for some species probably reflect differences in relative abundance. Fewer fish were available to be caught in upper Laguna Madre than in lower Laguna Madre (Crowe et al. 1986). The effects of bait and season on trotline catches cannot be determined in bay systems where the fish abundance approaches zero.

No spotted seatrout were caught on crab bait on bottom in either bay; but they were caught on all baits on top in the lower Laguna Madre leading to the significant second-order interaction of position × bay × bait. This condition was not unexpected because spotted seatrout are predominately sight feeders (Vetter 1977), and might not take baits on bottom as readily as baits suspended in the water column.

Crab and shrimp were more effective baits than oleander leaves for all four species. No other generalizations could be made concerning baits and seasons. Selection of crab or shrimp as the bait of choice for reducing bycatch while maximizing black drum catch is unclear because catch rates for black drum and red drum were greater on crab than shrimp, especially in winter.

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