Comparison Of Random And Nonrandom Bag Seine Station Selection Methods

by Hal R. Osburn

Management Data Series Number 117
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Texas Parks and Wildlife Department
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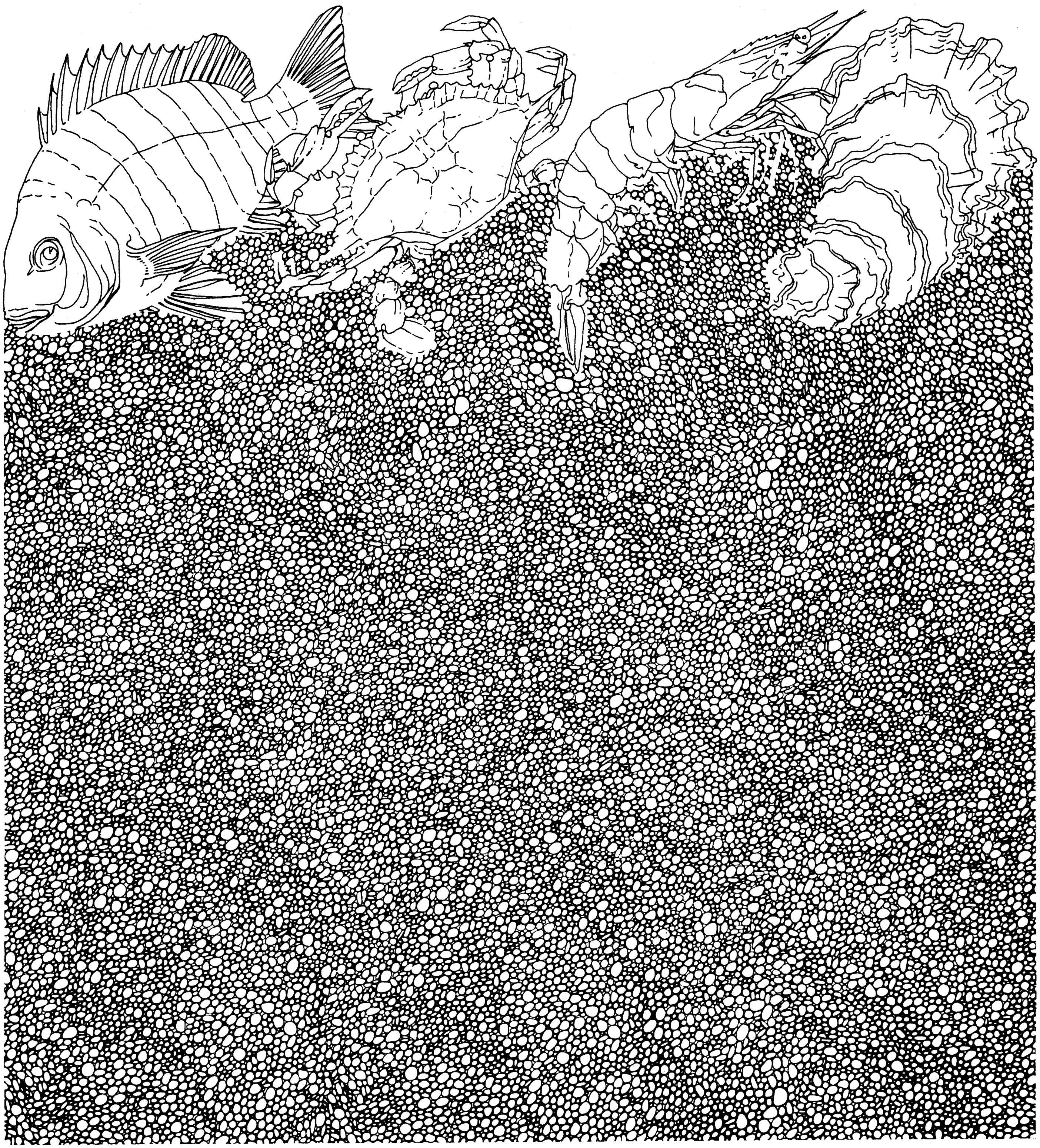

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Texas Parks and Wildlife Department
Coastal Fisheries Branch
4200 Smith School Road
Austin, Texas 78744

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ABSTRACT

One random and two nonrandom but potentially more cost effective station selection methods were used to collect bag seine samples in seven Texas bay systems during October 1980-March 1981. Three-way analyses of variance were used to compare mean catch rates of five juvenile fishes among station selection methods, months and bay systems. Station selection method significantly affected the catch rates of Atlantic croaker (*Micropogonias undulatus*), southern flounder (*Paralichthys lethostigma*) and striped mullet (*Mugil cephalus*) but not those of red drum (*Sciaenops ocellatus*) and spotted seatrout (*Cynoscion nebulosus*). Significant differences were found among months and among bay systems for all species tested. Highly variable catch rates caused by changes in gear efficiency and patchy distribution of captured organisms may have obscured the ability to detect meaningful differences among the selection methods. Successful monitoring of juvenile fish should include year-round random sampling in each bay system. Utilization of nonrandom station selection methods, if economically necessary, should be done with caution and the data segregated from those collected randomly.

INTRODUCTION

The juveniles (first assumption of adult body form)(Johnson 1978) of any species represent the potential recruitment stock to the adult populations. Theoretically, fisheries managers can gain predictive insight into future relative abundance by monitoring the population densities of juveniles. Any monitoring program, however, must address the questions of appropriate sampling techniques, adequate sample size, randomness of the sample stations, fish population distribution and fish catchability. Additionally, the cost effectiveness of the sampling must be considered, particularly for long-term monitoring programs.

The Coastal Fisheries Branch of the Texas Parks and Wildlife Department (TPWD) began monitoring the relative abundance of juvenile finfish with bag seines in Texas bay systems in 1961 (Stevens 1963). Bag seine samples were collected at a limited number of fixed stations (3-7 per bay system). Monthly bag seining was initiated in October 1977 utilizing standardized gear and techniques at six randomly selected stations in seven major Texas bay systems (Matlock and Weaver 1979). Data from this fishery independent monitoring program have been used to test for significant differences in annual coastwide catch rates among years for six economically important species of juvenile fish (McEachron and Green 1986).

Random station selection sampling is expensive primarily due to the necessity of field personnel boating to remote areas. Nonrandom station selection sampling could provide more cost effective sampling by reducing personnel time and/or equipment needs in the field. Nonrandom sampling schemes, however, must also be judged on their ability to consistently provide the same relative abundance information on juvenile fish stocks as does random sampling. King et al. (1981), testing a modification of this principle, found that catch rates of electroshocked reservoir fish did not differ significantly between random stations and fixed stations that were originally randomly selected. They also discussed the statistical bias potentially associated with nonrandom fish sampling procedures and the necessity of having comparison data from randomly selected stations when estimating any parameter of a fish population. Weinstein and Davis (1980), however, emphasize the need for a large number of different stations whether they are randomly or nonrandomly selected, concluding that "variation among sites must transcend that associated with the collection methodology".

If nonrandom station selection methods do not produce bias in juvenile finfish catch rates, then economic considerations may dictate their use to supplement random sampling, thereby increasing sample size. The purpose of this study is to determine if catch rates of selected species by bay system and month from two nonrandom station selection methods are the same as those from random station selection.

MATERIALS AND METHODS

Bag seine samples were collected from October 1980 through March 1981 in the Galveston Bay, Matagorda Bay, San Antonio Bay, Aransas Bay, Corpus Christi Bay and the upper and lower Laguna Madre systems (Figure 1). Bag seines were 18.3 m long and 1.8 m deep with 1.9-cm stretched nylon multifilament mesh in the lateral wings and 1.3-cm stretched nylon multifilament mesh in the central bag (horizontal diameter of 1.8 m). Each seine was pulled parallel to shore for a distance of not less than 15.2 m and no more than 30.5 m. The rectangular surface area sampled was determined using the distance pulled and the length of extension of the bag seine.

Following the routine bag seine procedures, six stations were randomly selected every month from a list of ≤100 sample stations compiled for each bay system (Hegen 1982). Each station was at least 1.6 km of continuous shoreline from any other station. Three different stations were sampled during daylight hours in each of the first two and last two fullest weeks of each month.

The second tested procedure was to select ten stations accessible by vehicle (drive-to) in each bay system from the original list of ≤100 sample stations. These same ten fixed stations were repeated every month with five different stations sampled during daylight hours in each of the first two and last two fullest weeks of each month. Because of the lack of vehicle accessible stations, only eight samples were taken monthly in the San Antonio Bay system. One drive-to station was not sampled in January in the Corpus Christi Bay system.

The third tested procedure was to select four stations (convenience) from the original list of ≤100 sample stations in each bay system based on time-saving convenience of the field personnel. This generally resulted in the convenience bag seine stations being associated temporally and spatially with randomly selected stations of other gear type monitoring programs. Two different stations were sampled during daylight hours in each of the first two and last two fullest weeks of each month.

A Model I three-way analysis of variance ($P = 0.05$)(Sokal and Rohlf 1969) was used to test for differences in catch rates (no./ha) among the three station selection methods, the six months and the seven bay systems for species with a total catch of >100 individuals (red drum (Sciaenops ocellatus), Atlantic croaker (Micropogonias undulatus), spotted seatrout (Cynoscion nebulosus), southern flounder (Paralichthys lethostigma) and striped mullet (Mugil cephalus)). To provide proportional sample sizes for the analyses, the reduced samples in the San Antonio and Corpus Christi Bay systems were treated as missing data; these values, which did not influence the analyses, were estimated according to iterative procedures in Steel and Torrie (1960). Inequality of variances was detected among samples and was corrected prior to analyses by transforming each catch rate to common logarithms ($\log_1(X + 1)$).

RESULTS

The bag seine station selection method significantly affected the catch rate of Atlantic croaker and, through interactions, the catch rates of southern flounder and striped mullet; it did not significantly affect the catch rates of red drum and spotted seatrout (Table 1). Catch rates differed significantly among months and among bay systems for each species tested but were not consistently higher for any one station selection method (Appendix A).

The total coastwide catch for all five species was 11,395 (Table 2). The catch by bay system was highest in the Galveston Bay system (2,886) and lowest in the San Antonio Bay system (570). Striped mullet had the highest catch (8,167) of any species while southern flounder had the lowest (158).

DISCUSSION

The nonrandom bag seine station selection methods utilized in this study failed to provide the same relative abundance information for all juvenile fish species as did the random selection method. Based on these results, neither nonrandom station selection method should be used in a comprehensive juvenile fish abundance monitoring program. However, the sensitivity of the current study's sample size for detecting differences in catch rates is unknown. The high variability in catch rates noted among and within selection methods would adversely affect that statistical sensitivity. Principal among the causes for such variability among samples would be changes in gear efficiency and patchy distribution of captured organisms (Gullard 1977).

The effectiveness of juvenile fish capture gear, including small-mesh seines, varies with the habitat being sampled (Burch 1983). Within each bay system biased comparisons of catch rates may have occurred if the proportions of various habitats sampled by each station selection method had not been the same. In addition, Shenker and Dean (1979) reported that juvenile fish nets were often biased against benthic species. Juvenile southern flounder, as benthic-dwellers (Hoese and Moore 1977), may have been differentially affected in the present study by reductions in bag seine efficiency, depending on bottom types sampled.

Atlantic croaker and striped mullet exhibited extreme fluctuations in catch rates. Shenker and Dean (1979) point to this as evidence of schooling behavior, with the number and size of schools at a locale probably being a random event. Miller and Dunn (1980) suggest that the movement patterns of juvenile fishes are influenced by the patchy concentrations of their prey. Weinstein and Davis (1980) found a wide range in juvenile fish seine efficiencies (19.9-83.8% of available fish) and concluded "the effect of a patchy distribution...might be a major contributing factor to the observed seine efficiency results." Shenker and Dean (1979) noted that "sample-to-sample variation is greatly affected by the continual movement of the fish." Significant differences in Atlantic croaker and striped mullet catch rates noted in the present study could be the result of a widely fluctuating distribution of fish schools rather than true differences among station selection methods.

Bay system differences noted in juvenile fish availability could be expected given the vast range in quantities and types of bottom sediments, vegetations and hydrological parameters evident along the Texas coast (Diener 1975; Matlock and Weaver 1979). Monthly differences are also understandable due to temporally influenced parameters such as spawning peaks, mortality, environmentally induced movement, and growth. Fish growth is particularly problematic when monitoring relative abundance with bag seines since the catchability of a species changes with fish size (Ricker 1971). Comparisons between widely spaced sample periods within a year would thus be subject to bias. Year-round sampling would monitor the widest size range of fish and the greatest number of species catchable by the gear. Detection of changes in relative abundance would be improved, however, if catch rate comparisons for a species were made based on the season when that particular species was most available to the gear. Determination of the appropriate seasonality of bag seined species is a subject for future study. The present study would have been enhanced with a full year of sampling. Due to their particular spawning times and growth patterns, a number of economically important species were not in abundance or available to the gear during October-March.

The present study also suffers from a lack of quantified differences in cost effectiveness per sample among the station selection methods. Other nonrandom station selective methods, which might provide greater cost effectiveness without creating sampling bias, remain to be examined: for example, replicate bag seine samples adjacent to each randomly selected sample.

Diversity of habitats coupled with fluctuating fish distributions would seem to dictate the use of only randomly selected stations. Because they may not adequately represent a bay system's sampleable habitats, fixed stations may produce trends for specialized areas which are not true for the whole area. Convenience stations such as those sampled in this study probably suffice as a subset of random stations because they generally coincide with randomly chosen stations of another sampling gear. However, using such a sampling scheme, care must be taken that all possible bag seine stations coincide with other sample gear stations and, thus, each retains an equal chance of being selected. Bag seine samples collected using any economically dictated nonrandom station selection method should be recorded as such to allow for comparison to randomly selected samples.

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Table 1. Summary of results of three-way analysis of variance of bag seine catch rates for selected species in seven Texas bays from three station selection methods during 6 consecutive months. (df = degrees of freedom).

Species	No. caught	Source of variation	Mean square (df)	F
Atlantic croaker	2278	Total	0.51 (826)	
		Station selection method	2.88 (2)	8.84 *
		Bay system	8.10 (6)	24.83 *
		Month	7.44 (5)	22.80 *
		Method X Bay	1.18 (12)	3.62 *
		Method X Month	0.67 (10)	2.06 *
		Bay X Month	1.47 (30)	4.49 *
		Method X Bay X Month	0.76 (60)	2.33 *
		Error	0.33 (701)	
Red drum	489	Total	0.43 (826)	
		Station selection method	0.01 (2)	0.01
		Bay system	1.09 (6)	2.66 *
		Month	1.12 (5)	2.72 *
		Method X Bay	0.53 (12)	1.29
		Method X Month	0.33 (10)	0.80
		Bay X Month	0.56 (30)	1.35
		Method X Bay X Month	0.36 (60)	0.88
		Error	0.41 (701)	
Southern flounder	158	Total	0.20 (826)	
		Station selection method	0.07 (2)	0.45
		Bay system	0.80 (6)	5.44 *
		Month	3.75 (5)	25.60 *
		Method X Bay	0.49 (12)	3.33 *
		Method X Month	0.12 (10)	0.84
		Bay X Month	0.51 (30)	3.50 *
		Method X Bay X Month	0.27 (60)	1.87 *
		Error	0.15 (701)	

Table 1. (Cont'd.)

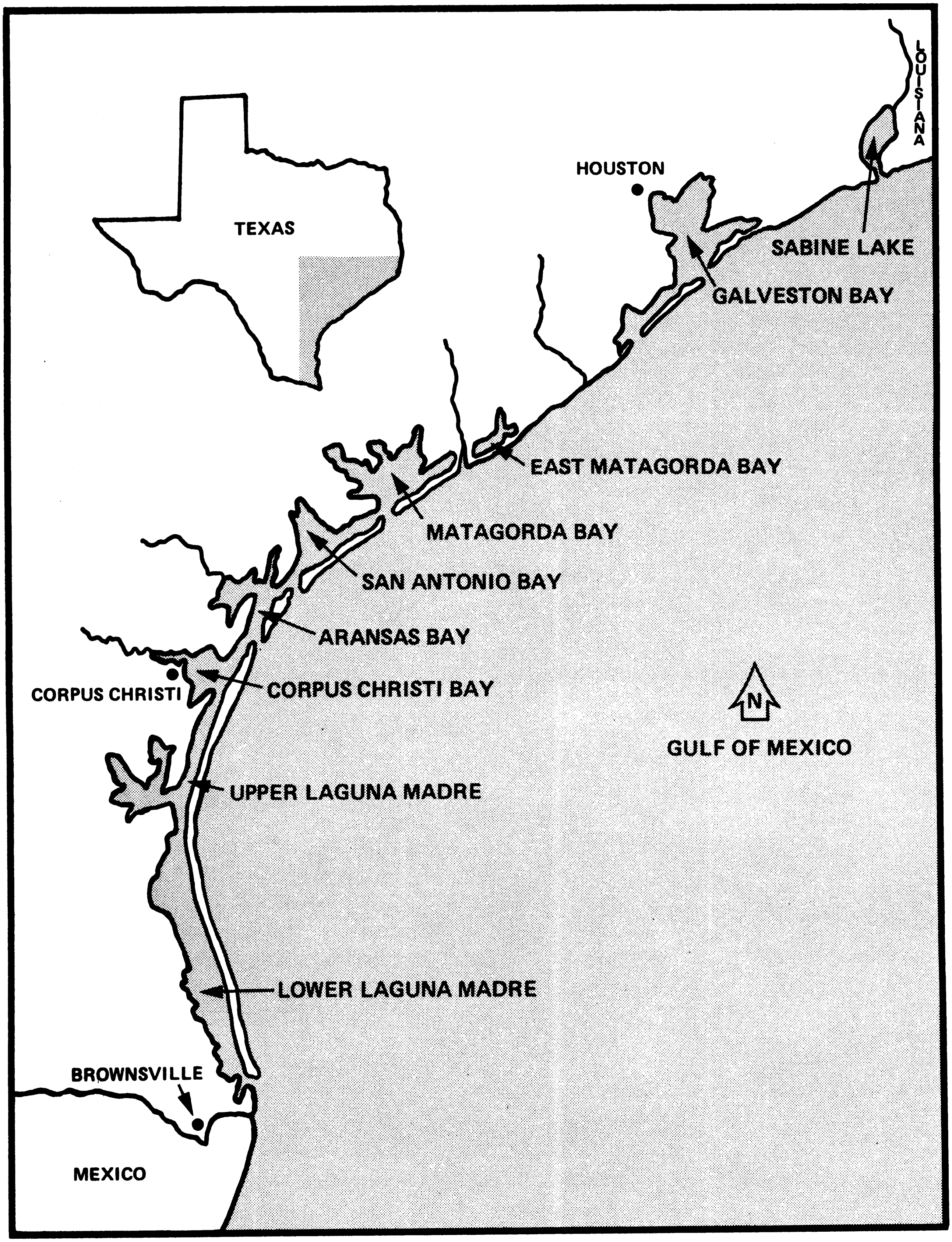
Species	No. caught	Source of variation	Mean square (df)	F
Spotted seatrout	303	Total	0.31 (826)	
		Station selection method	0.27 (2)	1.13
		Bay system	0.84 (6)	3.47 *
		Month	7.87 (5)	32.59 *
		Method X Bay	0.27 (12)	1.12
		Method X Month	0.24 (10)	0.98
		Bay X Month	0.47 (30)	1.95 *
		Method X Bay X Month	0.26 (60)	1.08
		Error	0.24 (701)	
Striped mullet	8167	Total	1.20 (826)	
		Station selection method	0.17 (2)	0.21
		Bay system	5.74 (6)	6.73 *
		Month	23.60 (5)	27.69 *
		Method X Bay	2.36 (12)	2.77 *
		Method X Month	1.23 (10)	1.44
		Bay X Month	3.16 (30)	3.70 *
		Method X Bay X Month	1.33 (60)	1.56 *
		Error	0.85 (701)	

* = Significant at $P<0.05$

Table 2. Total number of selected species captured by bag seines in Texas bay systems during October 1980-March 1981.

Species	Galveston	Matagorda	San Antonio	Aransas	Corpus Christi	Upper Laguna Madre	Lower Laguna Madre	Coastwide
Atlantic croaker	1,408	318	4	3	42	10	493	2,278
Red drum	105	38	109	78	114	19	26	489
Southern flounder	23	5	3	65	7	9	46	158
Spotted seatrout	41	20	42	70	72	55	3	303
Striped mullet	1,309	189	2,393	1,593	1,387	860	436	8,167

Figure 1. Major bay systems sampled on the Texas coast.


TEXAS
HOUSTON
LOUISIANA
SABINE LAKE
GALVESTON BAY
EAST MATAGORDA BAY
MATAGORDA BAY
SAN ANTONIO BAY
ARANSAS BAY
CORPUS CHRISTI
CORPUS CHRISTI BAY
N
GULF OF MEXICO
UPPER LAGUNA MADRE
LOWER LAGUNA MADRE
BROWNSVILLE
MEXICO

Appendix A

Table A.1. Mean catch rates (no./ha) ± 1SE of selected species caught at convenience, drive-to and random bag seine stations in Texas bay systems during October 1980-March 1981.

Species Month Method	Galveston	Matagorda	San Antonio	Aransas	Corpus Christi	Upper Laguna Madre	Lower Laguna Madre
Atlantic croaker							
October							
Convenience	17 ± 10	0	0	5 ± 5	0	0	0
Drive-to	3 ± 3	0	0	0	0	0	0
Random	0	0	0	0	0	0	0
November							
Convenience	0	0	0	0	0	0	0
Drive-to	0	0	0	0	0	0	0
Random	0	0	0	0	0	0	0
December							
Convenience	0	42 ± 32	0	0	0	0	58 ± 27
Drive-to	10 ± 10	0	0	0	0	0	0
Random	0	5 ± 5	0	0	0	0	0
January							
Convenience	116 ± 106	29 ± 29	0	0	0	0	94 ± 65
Drive-to	130 ± 100	58 ± 51	0	0	0	12 ± 12	1 ± 1
Random	450 ± 443	17 ± 14	0	0	3 ± 3	0	168 ± 65
February							
Convenience	8 ± 8	304 ± 104	16 ± 10	0	5 ± 5	0	250 ± 203
Drive-to	53 ± 53	27 ± 17	0	0	62 ± 59	5 ± 5	44 ± 43
Random	1144 ± 537	75 ± 19	0	3 ± 3	43 ± 43	0	8 ± 8
March							
Convenience	3,300 ± 3,300	308 ± 199	0	0	0	12 ± 12	79 ± 29
Drive-to	217 ± 91	100 ± 84	12 ± 12	2 ± 2	0	0	109 ± 102
Random	3,244 ± 2,494	20 ± 16	0	0	0	4 ± 4	130 ± 126

Table A.1. (Cont'd.)

Species Month Method	Galveston	Matagorda	San Antonio	Aransas	Corpus Christi	Upper Laguna Madre	Lower Laguna Madre
Red drum							
October							
Convenience	0	8 ± 8	25 ± 25	0	0	0	0
Drive-to	0	0	6 ± 6	10 ± 8	57 ± 57	0	0
Random	39 ± 39	3 ± 3	0	0	10 ± 10	0	0
November							
Convenience	0	0	8 ± 8	44 ± 44	0	38 ± 38	0
Drive-to	0	5 ± 3	35 ± 21	40 ± 25	3 ± 3	5 ± 5	0
Random	0	6 ± 6	33 ± 33	0	30 ± 23	0	0
December							
Convenience	58 ± 58	25 ± 25	117 ± 117	12 ± 12	0	0	6 ± 6
Drive-to	33 ± 33	0	44 ± 37	4 ± 4	63 ± 55	0	0
Random	0	39 ± 20	222 ± 185	17 ± 17	47 ± 28	0	0
January							
Convenience	0	0	0	5 ± 5	25 ± 25	6 ± 6	0
Drive-to	7 ± 7	3 ± 3	44 ± 31	6 ± 6	0	5 ± 5	2 ± 2
Random	11 ± 11	3 ± 3	0	0	0	0	12 ± 6
February							
Convenience	0	0	8 ± 8	19 ± 19	15 ± 8	6 ± 6	12 ± 7
Drive-to	10 ± 10	5 ± 5	25 ± 16	30 ± 12	53 ± 46	12 ± 12	1 ± 1
Random	6 ± 6	8 ± 8	33 ± 27	20 ± 16	17 ± 13	4 ± 4	0
March							
Convenience	25 ± 16	5 ± 4	17 ± 17	0	0	0	25 ± 14
Drive-to	230 ± 114	0	12 ± 12	18 ± 14	61 ± 45	2 ± 2	5 ± 3
Random	6 ± 6	0	6 ± 6	0	17 ± 13	0	17 ± 11

Table A.1. (Cont'd.).

Species Month Method	Galveston	Matagorda	San Antonio	Aransas	Corpus Christi	Upper Laguna Madre	Lower Laguna Madre
Southern flounder							
October							
Convenience	8 ± 8	0	0	0	0	0	0
Drive-to	3 ± 3	3 ± 2	0	4 ± 3	0	0	0
Random	0	6 ± 4	0	0	0	0	0
November							
Convenience	0	0	0	0	0	0	0
Drive-to	0	0	0	0	0	5 ± 5	0
Random	0	0	0	0	0	0	0
December							
Convenience	0	0	0	0	0	0	0
Drive-to	0	0	0	0	0	0	0
Random	0	0	0	0	0	0	0
January							
Convenience	0	0	0	0	0	0	0
Drive-to	0	0	6 ± 6	0	0	0	0
Random	0	0	0	0	0	0	0
February							
Convenience	0	0	0	0	0	6 ± 6	50 ± 29
Drive-to	7 ± 4	0	0	94 ± 52	2 ± 2	12 ± 7	1 ± 1
Random	0	0	11 ± 11	3 ± 3	3 ± 3	0	25 ± 16
March							
Convenience	50 ± 32	0	0	29 ± 16	10 ± 6	0	54 ± 29
Drive-to	23 ± 11	0	0	12 ± 5	0	52 ± 26	3 ± 2
Random	33 ± 17	3 ± 3	0	0	0	4 ± 4	63 ± 35

Table A.1. (Cont'd.).

Species Month Method	Galveston	Matagorda	San Antonio	Aransas	Corpus Christi	Upper Laguna Madre	Lower Laguna Madre
Spotted seatrout							
October							
Convenience	50 ± 22	16 ± 10	0	44 ± 26	0	19 ± 19	0
Drive-to	50 ± 22	8 ± 4	44 ± 18	66 ± 25	47 ± 26	35 ± 27	8 ± 4
Random	67 ± 41	20 ± 8	66 ± 33	10 ± 7	20 ± 16	25 ± 25	0
November							
Convenience	0	0	83 ± 63	12 ± 12	0	0	0
Drive-to	17 ± 13	5 ± 5	6 ± 6	30 ± 30	62 ± 41	8 ± 5	0
Random	17 ± 11	3 ± 3	39 ± 22	3 ± 3	73 ± 73	8 ± 5	0
December							
Convenience	0	0	0	6 ± 6	0	0	0
Drive-to	0	0	0	6 ± 4	0	2 ± 2	0
Random	0	0	22 ± 22	13 ± 13	7 ± 7	0	0
January							
Convenience	0	0	0	0	0	31 ± 19	0
Drive-to	0	0	0	0	0	0	0
Random	0	0	0	0	0	0	0
February							
Convenience	0	0	0	0	0	0	0
Drive-to	0	0	0	0	0	0	0
Random	0	0	6 ± 6	0	0	0	0
March							
Convenience	0	0	0	0	0	0	0
Drive-to	0	0	0	0	0	0	0
Random	0	0	0	0	0	0	0

Table A.1. (Cont'd.)

Species Month Method	Galveston	Matagorda	San Antonio	Aransas	Corpus Christi	Upper Laguna Madre	Lower Laguna Madre
Striped mullet							
October							
Convenience	75 ± 64	58 ± 42	17 ± 17	84 ± 37	90 ± 90	0	0
Drive-to	43 ± 19	83 ± 42	44 ± 22	124 ± 104	41 ± 34	2 ± 2	200 ± 112
Random	11 ± 7	61 ± 41	50 ± 27	22 ± 8	3 ± 3	0	129 ± 72
November							
Convenience	16 ± 10	17 ± 12	8 ± 8	16 ± 6	0	6 ± 6	0
Drive-to	31 ± 13	60 ± 31	4 ± 4	20 ± 18	8 ± 8	15 ± 12	4 ± 2
Random	28 ± 22	0	11 ± 7	30 ± 17	140 ± 114	8 ± 8	4 ± 4
December							
Convenience	75 ± 75	4 ± 4	0	599 ± 454	0	6 ± 6	19 ± 19
Drive-to	7 ± 4	13 ± 10	25 ± 25	10 ± 10	8 ± 4	0	1 ± 1
Random	0	0	100 ± 69	13 ± 13	7 ± 4	4 ± 4	50 ± 41
January							
Convenience	108 ± 44	0	42 ± 42	79 ± 66	10 ± 6	6 ± 6	269 ± 199
Drive-to	403 ± 248	2 ± 2	31 ± 13	0	0	440 ± 230	0
Random	22 ± 16	0	28 ± 18	37 ± 33	193 ± 182	12 ± 9	175 ± 63
February							
Convenience	433 ± 422	0	392 ± 214	496 ± 436	20 ± 0	700 ± 376	12 ± 7
Drive-to	117 ± 77	10 ± 8	1,384 ± 1,009	656 ± 345	539 ± 289	162 ± 106	23 ± 12
Random	233 ± 168	11 ± 8	328 ± 163	752 ± 352	43 ± 19	162 ± 143	438 ± 224
March							
Convenience	4,833 ± 4,189	0	15,316 ± 15,272	1,874 ± 1,440	780 ± 580	2,562 ± 2,521	0
Drive-to	127 ± 37	34 ± 28	753 ± 237	784 ± 464	942 ± 412	92 ± 20	6 ± 4
Random	2,072 ± 1,672	67 ± 38	128 ± 128	21 ± 16	197 ± 153	21 ± 16	48 ± 28

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