Estimated Number of Dredge Tows Required to Detect Changes in Oyster Abundance in Galveston Bay
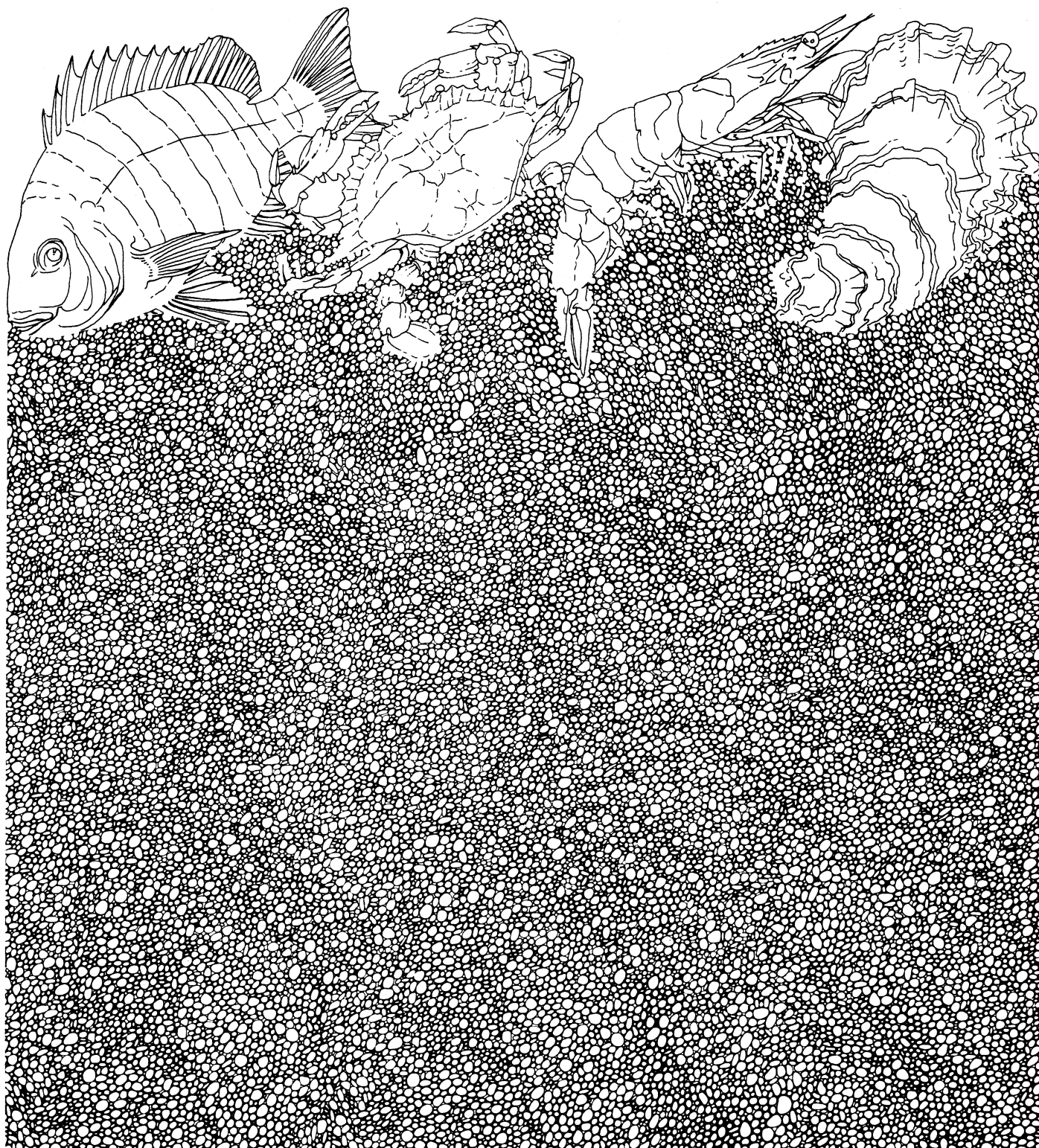
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The number of collections at different sites and replications at each site necessary to detect most changes in oyster abundance in the Galveston Bay system and at a single site therein were estimated using variances measured during December 1984 at 14 sites. Changes of >50% in total oyster abundance within the system could be detected with one tow at seven different, randomly selected sites. To detect similar changes in each of market (> 76mm), small (25-75 mm) or spat « 25 mm) oysters, 20 sites would have-to be sampled. Ten to thirty-four replicate tows would be needed to detect 50% changes in each category at a site. At least 55 sites should be sampled using one tow per site to maximize the probability of collecting data from as many reefs in the system as possible within present (1986) budgetary constraints.

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INTRODUCTION

The American oyster (<u>Crassostrea virginica</u>) supports the second most valuable commercial fishery in Texas. Over 3.6 million kg worth $11.3 million at the dock were landed in Texas in 1983 with 75% of this weight harvested from public reefs in the Galveston Bay system (Hamilton and Saul 1984). The fishery is regulated by seasons, size and bag limits, and gear restrictions. The Texas Parks and Wildlife Commission (TPWC) may close an area to the taking of oysters when it finds that the area is being overworked or damaged. The Texas Parks and Wildlife Department (TPWD) has monitored relative abundance and size of oysters on selected reefs in Galveston Bay since 1956 (Hofstetter 1983). A standard dredge was pulled at each site until 35.2 L of oysters were collected. This design was changed in 1984 to sampling 80 randomly selected sites on reefs throughout the bay system and towing the dredge for 30 seconds at each site. However, 1 tow at each site does not enable detection of changes in oyster abundance at that site because no variance estimate is obtained. This study was conducted to determine if this design was sufficient to detect most changes in oyster abundance in the Galveston Bay system and to determine the number of replicate tows necessary to detect changes in abundance at a site.

MATERIALS AND METHODS

An eight-tooth "Biloxi style" dredge (35.2 L capacity) was towed five times for 1 minute each at each of 14 sites in the Galveston Bay system (Fig. 1) during December 1984. All live oysters were counted and measured along the dorso-ventral axis of the right valve. For analysis each tow's catch was partitioned into spat (< 25mm), small (25-75mm) and market ($\geq$ 76mm) categories. Analysis of variance (Appendix B) was used to estimate the variance associated with catches of each group and all groups combined at each site (among replicate tows) and among sites (Sokal and Rohlf 1969). These variance estimates were used in standard sample size determination procedures (Sokal and Rohlf 1969) to estimate the number of replicate tows and number of sites necessary to be 80 and 90% certain of detecting 10, 25, 50, 75 and 100% differences in mean catches of each of total oysters and the size groups with the smallest and largest variance at the 1 and 5% levels of significance. All data (Appendix A) were transformed to common logarithm before analysis. The coefficients of variation (CV) for each size group at each site were also calculated from transformed data (Appendix C). The mean CV for each size group was calculated for comparison to the estimated mean CV obtained from analyses of variance.

The mean time required for 30-second collections (including preparation, tow time, retrieval, data recording, and travel to next site) at each site during October 1984 through June 1985 was used to estimate the number of sites that could be sampled with each of 1, 2, 3, and 4 replicates.

RESULTS

Changes of $\geq 50\%$ in total oyster abundance within the Galveston Bay system could be detected with one tow at seven different sites (Table 1). However, 20 sites would have to be sampled (one replicate each) to detect this change in market oysters. Twenty tows would also detect similar changes in spat and small oyster abundance because the coefficients of variation (CV) were 27 and 24% for these two categories, respectively and the CV for market oysters was 39% (see Appendix B, Table 1 for mean square errors).

Changes of $\geq 50\%$ in total oyster abundance at a site could be detected with three replicate dredge tows (Table 2). However, 34 replicates would be required to detect these changes in spat abundance and 12 would be required for small or market oysters (CV for small and market oysters were similar).

If three replicates were collected at each site only seven sites could be visited each day whereas 14 sites/day could be visited with only one collection per site (Table 3).

DISCUSSION

The primary objective of the current TPWD oyster abundance monitoring program is to detect fluctuations in the size and abundance of oysters in the Galveston Bay system. Eighty randomly selected sites on reefs are currently visited each month. This effort detects at least a 25% difference in each oyster category 90% of the time at $P = 0.01$. The number of sites visited could be reduced to 55 without a large reduction in precision. The probability level of detecting a 25% change in market oysters (the size group with the largest CV) would be 0.05 instead of 0.01. However, a secondary objective of the current program is to monitor fluctuations on as many reefs as possible. If the number of sampled sites was decreased from 80 to 55, the mean proportion of reefs sampled monthly would be reduced from 65.6% to 45.1% with a time savings of 2 days (from 6 to 4 days). These estimates are based on one tow per site. If three tows were collected at each of the 55 sites, then 8 days (7 sites/day) would be required. This design would not allow monitoring on a monthly basis of fluctuations at each site because the same sites would not be visited each month. Additionally, this design would detect changes of 100% or greater for each size group. Although monitoring abundance fluctuations at each site is a desirable goal, it is not currently attainable within the current primary objective or existing budget ($60,000/year).

The number of sites and replicates required to detect changes in spat are probably underestimates. The number of spat in the bay during December is low compared to other months (Hofstetter 1983), and associated variances are probably also low. If so, more samples may be needed during periods when abundance is highest. This study should be repeated during

spring to determine the amount of underestimation. Additional research
is also needed to determine the impacts of tow time (30 versus 60 seconds)
on the results of this study since December collections involved 60 second
tows and the current design involves 30 second tows. Analysis of seasonal
abundance of each size category is also needed. If sample results for
2 or more similar months could be combined, the sampling variance may
be reduced. This would allow the option to reduce sampling without losing
the ability to detect differences at the selected level or to continue
sampling at the same effort and increase precision.

LITERATURE CITED

Hamilton, C.L. and G.E. Saul. 1984. Texas commercial harvest statistics, 1977-1983. Tex. Pks. Wildl. Dep., Coast. Fish. Branch, Mngmnt. Data Ser. No. 64. 66 p.

Hofstetter, R.P. 1983. Oyster population trends in Galveston Bay, 1973-1978. Tex. Pks. Wildl. Dep., Coast. Fish. Branch, Mngmnt. Data Ser. No. 51. 33 p.

Sokal, R.R. and F.J. Rohlf. 1969. Biometry. W.H. Freeman and Co. San Francisco, California. 776 p.

Table 1. Number of sites in Galveston Bay sampled with one oyster dredge tow each required for 80 and 90% certainty of detecting selected percentage differences in mean total oysters and mean market oysters at the 1 and 5% levels of significance. Coefficients of variation for log transformed data were 21 and 39%, respectively.

Difference in means (%)	Total oysters					Market oysters			
	P=0.90		P=0.80			P=0.90		P=0.80	
	0.01	0.05	0.01	0.05		0.01	0.05	0.01	0.05
10	131	92	103	72		452	316	355	248
25	22	15	18	13		78	55	56	39
50	7	5	6	4		20	14	16	11
75	4	3	3	2		10	7	8	6
100	3	2	2	2		9	6	7	5

Table 2. Number of replicate oyster dredge tows required at a site in Galveston Bay in December 1984 for 80 and 90% certainty of detecting selected percentage differences in mean total oysters, mean small oysters, and mean spat at the 1 and 5% levels of significance. Coefficients of variation for log transformed data were 0.13, 0.30, and 0.55 for total, small, and spat oysters respectively.

Difference in means (%)	Total oysters				Small oysters				Spat			
	P=0.90		P=0.80		P=0.90		P=0.80		P=0.90		P=0.80	
	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05	0.01	0.05
10	53	37	42	29	268	188	210	147	893	625	701	491
25	9	7	7	5	45	32	35	24	144	101	113	79
50	3	2	2	2	12	9	10	7	34	24	27	19
75	2	2	2	2	6	4	5	4	18	12	14	10
100	2	2	2	2	4	3	4	3	10	7	8	6

Table 3. Mean number of different sites that could be visited in an 8-hour day with 1, 2, 3, and 4 replicates based on 5.4 hours required for collections and data recording.

Number of replicates	Number of sites
1	14
2	9
3	7
4	6

Figure 1. Location of sample sites on oyster reefs in the Galveston Bay
system (1 = Eagle Point, 2 = Todds Dump, 3 = Switchover, 4 =
Experimental, 5 = North Redfish, 6 = South Redfish, 7 = Central
Redfish, 8 = East Redfish, 9 = Gaspipe, 10 = Barts Pass, 11 =
Confederate, 12 = Greens Cut, 13 = Carancahua (N), 14 = Carancahua
(S)).

HOUSTON

N

TRINITY

1   3
2
4   5   10
6 7   8
9

GALVESTÖN

EAST

12
13   WEST   11
14

GULF   OF   MEXICO
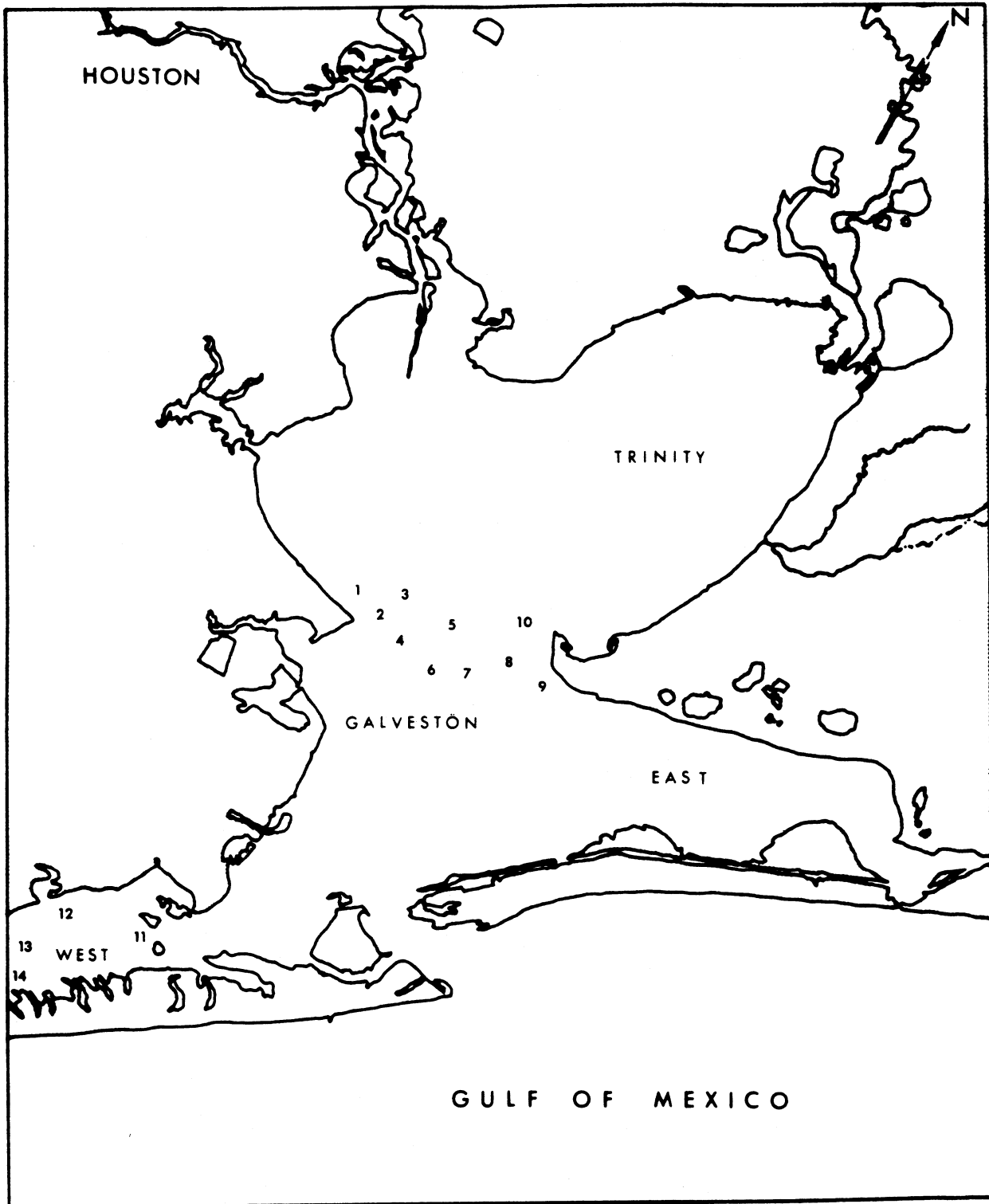
Appendix A. Oyster catches in each tow at each site.

Table A.1. Number of market oysters ($\geq$ 76mm) collected in each drag at each site in the Galveston Bay system during December 1984.

Site	Drag					Mean number ± 1 SD
	1	2	3	4	5	
Carancahua (N)	6	2	1	4	7	4.0 ± 2.6
Carancahua (S)	7	2	5	1	4	3.8 ± 2.4
Green's Cut	3	2	4	8	5	4.4 ± 2.3
Confederate (N)	9	1	0	4	13	5.4 ± 5.5
Eagle Point	26	16	19	26	42	25.8 ± 10.1
Todd's Dump	5	4	8	14	17	9.6 ± 5.7
Switchover	13	14	20	19	22	17.6 ± 3.9
Experimental	9	7	2	3	2	4.6 ± 3.2
N. Redfish	3	3	1	6	5	3.6 ± 2.0
S. Redfish	3	5	2	2	2	2.8 ± 1.3
C. Redfish	3	3	1	0	2	1.8 ± 1.3
E. Redfish	4	6	7	13	12	8.4 ± 3.9
Gaspipe	14	28	14	20	15	18.2 ± 6.0
Bart's Pass	4	13	6	14	12	9.8 ± 4.5
Mean ± 1 SD	7.8 ± 6.4	7.6 ± 7.6	6.4 ± 6.7	9.6 ± 8.1	11.4 ± 10.8	

Table A.2. Number of small oysters (25-75mm) collected in each drag at each site in the Galveston Bay system during December 1984.

Site	Drag					Mean number ± 1 SD
	1	2	3	4	5	
Carancahua (N)	36	36	12	17	40	28.2 ± 12.7
Carancahua (S)	8	8	12	2	9	7.8 ± 3.6
Green's Cut	16	14	33	29	8	20.0 ± 10.5
Confederate (N)	19	7	5	24	49	20.8 ± 17.7
Eagle Point	54	88	98	93	70	80.6 ± 18.2
Todd's Dump	75	41	21	53	30	44.0 ± 21.1
Switchover	39	66	56	66	86	62.6 ± 17.1
Experimental	12	1	0	0	0	2.6 ± 5.3
N. Redfish	25	21	3	23	54	25.2 ± 18.3
S. Redfish	0	2	0	1	2	1.0 ± 1.0
C. Redfish	1	2	0	0	0	0.6 ± 0.9
E. Redfish	33	30	46	32	40	36.2 ± 6.6
Gaspipe	80	104	67	115	58	84.8 ± 24.2
Bart's Pass	61	99	49	76	48	66.6 ± 21.4
Mean ± 1 SD	32.8 ± 26.3	37.1 ± 37.3	28.7 ± 30.4	37.9 ± 37.2	35.3 ± 27.9	

Table A.3. Number of oyster spat (< 25mm) collected in each drag at each site in the Galveston Bay system during December 1984.

Site	Drag					Mean number ± 1 SD
	1	2	3	4	5	
Carancahua (N)	2	5	0	1	6	2.8 ± 2.6
Carancahua (S)	3	0	1	1	0	1.0 ± 1.2
Green's Cut	1	1	4	1	2	1.8 ± 1.3
Confederate (N)	1	3	2	5	3	2.8 ± 1.5
Eagle Point	0	14	19	7	11	10.2 ± 7.2
Todd's Dump	13	7	5	0	1	5.2 ± 5.2
Switchover	8	9	2	5	15	7.8 ± 4.9
Experimental	4	1	0	0	1	1.2 ± 1.6
N. Redfish	14	17	7	17	28	16.6 ± 7.6
S. Redfish	1	1	1	1	1	1.0 ± 0.0
C. Redfish	0	2	1	0	0	0.6 ± 0.9
E. Redfish	25	5	7	5	4	9.2 ± 8.9
Gaspipe	1	1	9	6	3	4.0 ± 3.5
Bart's Pass	0	2	0	4	1	1.4 ± 1.7
Mean ± 1 SD	5.2 ± 7.4	4.9 ± 5.2	4.1 ± 5.2	3.8 ± 4.5	5.4 ± 7.8	

Table A.4. Number of total oysters collected in each drag at each site in the Galveston Bay system during December 1984.

Site	Drag					Mean number ± 1 SD
	1	2	3	4	5	
Carancahua (N)	44	43	13	22	53	35.0 ± 16.8
Carancahua (S)	18	10	18	4	13	12.6 ± 5.9
Green's Cut	20	17	41	38	15	26.2 ± 12.3
Confederate (N)	29	11	7	33	65	29.0 ± 23.0
Eagle Point	80	118	136	126	123	116.6 ± 21.5
Todd's Dump	93	52	34	67	48	58.8 ± 22.4
Switchover	60	89	78	90	123	88.0 ± 23.0
Experimental	25	9	2	3	3	8.4 ± 9.7
N. Redfish	42	41	11	46	87	45.4 ± 27.1
S. Redfish	4	8	3	4	5	4.8 ± 1.9
C. Redfish	4	7	2	0	2	3.0 ± 2.6
E. Redfish	62	41	60	50	56	53.8 ± 8.5
Gaspipe	95	133	90	141	76	107.0 ± 28.4
Bart's Pass	65	114	55	94	61	77.8 ± 25.2
Mean ± 1 SD	45.8 ± 30.8	49.5 ± 45.4	39.3 ± 40.4	51.3 ± 46.4	52.1 ± 41.3	

Appendix B. Results of analysis of variances of mean oyster catches
in replicate tows at each site in Galveston Bay.

Table B.1. Summary of analyses of variance of mean catches (no./tow) among 14 sites in Galveston Bay. Five replicate tows were made at each site.

Oyster category	Source of variation	Degrees of freedom	Sums of squares	Mean square	F
Total	Total	69	19.190		
	Sites	13	17.177	1.321	36.70**
	Error	56	2.013	0.036	
Spat	Total	69	11.730		
	Sites	13	6.391	0.492	5.18**
	Error	56	5.339	0.095	
Small	Total	69	32.494		
	Sites	13	25.004	1.923	14.35**
	Error	56	7.490	0.134	
Market	Total	69	9.125		
	Sites	13	6.098	0.469	8.68**
	Error	56	3.207	0.054	

Table B.2. Summary of analyses of variance of mean catches (no./tow) among five tows of total, spat, small and market oysters at 14 sites in Galveston Bay.

Oyster category	Source of variation	Degrees of freedom	Sums of squares	Mean square	F
Total	Total	69	19.190		
	Tows	4	0.360	0.090	0.31
	Error	65	18.830	0.290	
Spat	Total	69	11.730		
	Tows	4	0.094	0.023	0.13
	Error	65	11.636	0.179	
Small	Total	69	32.494		
	Tows	4	0.368	0.092	0.19
	Error	65	32.126	0.494	
Market	Total	69	9.125		
	Tows	4	0.441	0.110	0.82
	Error	65	8.684	0.134	

Appendix C. Coefficients of variation for each oyster size group
at each site.

Table C.1. Coefficients of variation of $\log_{10}$ transformation of oyster catches at each of 14 sites in Galveston Bay system based on five replicate dredge tows in December 1984.

Site	Spat	Small	Market	Total
Carancahua (N)	0.163	0.392	0.158	0.725
Carancahua (S)	0.220	0.381	0.272	1.046
Green's Cut	0.139	0.256	0.184	0.637
Confederate	0.270	0.760	0.308	0.320
Eagle Point	0.044	0.110	0.056	0.582
Todd's Dump	0.092	0.249	0.129	0.744
Switchover	0.058	0.075	0.069	0.309
Experimental	0.473	0.354	1.703	1.108
N. Redfish	0.198	0.337	0.323	0.167
S. Redfish	0.177	0.235	0.956	0.000
C. Redfish	0.658	0.641	1.423	1.423
E. Redfish	0.041	0.200	0.048	0.316
Gaspipe	0.056	0.098	0.065	0.518
Bart's Pass	0.071	0.213	0.072	1.031