Texas Game, Fish and Oyster Commission

Oyster Investigation

For the Fiscal Year 1949 - 1950

Submitted to the Marine Laboratory, Rockport, Texas

by

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Introduction

This investigation is a study of the environmental features which will determine the suitability of areas for production of market oysters. During the past three years emphasis has been placed upon studies of the effects of environment and ecological relationships involved in the transplanting of seed oysters. Five bays, (Aransas, Copano, Mesquite, Carlos, and Redfish) in the vicinity of Rockport have been utilized in the establishment of one acre test plots.

This period emphasis has been mainly on a preliminary survey of the spawning and setting activities in the area, including some data on spat size and growth.

Data was obtained on oyster quality and a monthly series of the three quality factors was begun at the close of the period.

Routine collection of data on hydrography and plankton for correlation with oyster quality and productivity was continued.

Methods and Equipment

The study of seed oyster transplanting utilized the placement of partitioned test baskets containing individual specimens on the plots. Prior to March, 1950 monthly size was accumulated similarly to that of previous years. After consideration of the results this procedure was modified to include quarterly examination of lengths only. Shell lengths were recorded as the maximum distance from the umbo of the right valve to the lip by vernier caliper in centimeters. Weighing was discontinued as being too inaccurate an index of growth.

Seed oysters for the planting at Bird Reef, Aransas Bay were obtained from the previously used stock in mid-Copano Bay by means of the dredging barge "Manta".

The Commission acquired the boat "Narwhale" which was assigned to the oyster investigation program in March of this year.

Plankton samples were no longer obtained by net towing but by pumping one hundred liters of water through a water meter into #20 mesh silk bolting cloth. Samples were then concentrated to ten milliliters and a one milliliter sample was examined in a Sedgwick-Rafter cell.

Oyster quality was generally determined by physical observations and the percent of solids. Future analysis should be made through the use of the condition factor, per cent of solids, and per cent of glycogen (dry weight).

Previous experimental plots were visited at intervals, however, the main effort of investigation was restricted to Long and Bird Reefs, Aransas Bay; and the reef south of McDowell Point, San Antonio Bay.

New data sheets were devised to include additional hydrographical data and reef composition.

Resume of Previous Investigation

During the period 1948-1949* three additional seed test plots were planted. Cost of planting was materially reduced over the previous year due to the use of a specially constructed dredging barge.

Growth rates on the new plots showed a slight average increase over a five month period. Monthly average mortality ranged slightly above ten per cent for the three plots with highest mortalities caused generally through sinkage of the oysters into the bottom and resultant smothering. No drill, Thais floridana floridana, depredation was observed.

Per cent of glycogen present in the oysters sampled ranged from 8.14 to 0.25 (wet weight), with the maximum during November, 1948.

Test spat collectors of shell bags were used to determine setting rates during August, 1949. Results were satisfactory with an average set per shell up to 16.1 spat. Glass slides and lead plates used as collectors at the laboratory did not prove satisfactory.

Larvae were present in the plankton tows as early as March with indications of a possible spawning as late as November. No quantitative data was obtained on larvae although on a percentage basis, larvae were present in the greatest quantities in April and July.

Fouling organisms were present in varying concentration throughout all the areas but Copano Bay appeared to have the

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* Baker, B. B., Jr.--1949--Oyster investigation. Unpub. report to the Texas Game, Fish and Oyster Commission.

highest incidence of Polydora and Martesia. Proven stone crab (Menippe mercenaria) kills in test basket oysters amounted to an average of 6.88 per cent for plots A, B, and C from April to August, 1949.

Seed Planting and Observations

One new seed oyster experimental plot was established at Bird Reef by early May, 1950. This reef is located in the northern part of Aransas Bay extending into the bay from the St. Joseph Island shore. Bird Reef covers about fifty acres with water depths ranging from three to five feet, the bottom is made up of broken shell supporting a very few live oysters.

One thousand barrels of seed oysters were transferred from Copano Bay to Bird Reef at an average cost per barrel of $.31 (includes wages and fuel only). This cost was slightly lower than last year's transplanting which averaged $.37 per barrel.

Four test baskets containing individually measured oysters were placed upon the plot for examination quarterly.

Only small populations were maintained upon the previously located experimental plots to observe any changes in environment.

Growth rate data on the Copano, Carlos, and Redfish Bay plots for the latter part of 1949 were considered to be unreliable due to the generally heavy spatfall. The average monthly shell increase ranged somewhere around one millimeter for the three plots, to date this year the average shell growth for these plots was very slightly greater. The Bird Reef plot showed an average shell increase of one millimeter during the summer months.

Mortality rates remained fairly high for the previous year's plots. The latter part of 1949 mortality for the plots averaged 5.1 per cent, this year the mortality ranged from 13 per cent to 84 per cent. The new plot at Bird Reef had a 25 per cent mortality over a three month period. The main causative factor appeared to be smothering by sinkage of the oysters in the bottom for the old plots.

After three years of observation of seed oyster transplanting it is apparent to the author that on most bottoms tested strengthening was necessary as generally high mortality rates were due primarily to sinkage of the oysters

into the bottom. Other factors such as food supply and pests are agents but with the exception of the drill appear to only exert a secondary influence. The author's present opinion is that transplanting of seed oysters to areas where no reefs are present is only practical where considerable strengthening of the bottom can be done and that if existing natural reefs could be utilized this type of culture should be considered as the primary method of oyster producing on the Texas coast.

Spawning and Setting

Small wire bags containing clean shell cultch were placed in the water near Cedar Dugout as spat collectors. These bags were replaced and examined frequently into the month of October. Table 1 presents the set per ten shells; bag #1 was in about two feet of water and bag #2 was located in about four feet of water.

Table 1
Spatfall at Cedar Dugout

Date	Bag #1	Bag #2	Larvae in plankton tow	Temp. (°C.)	Salinity (o/oo)
9/2/49	27	39	Very few	28.4	26.9
9/5/49	51	33	Very few	32.2	26.4
9/7/49	21	15	None	31.4	25.7
9/9/49	24	3	None	30.3	26.5
9/12/49	5	6	None	27.0	25.6
9/14/49	3	0	Few	28.1	26.8
9/16/49	14	34	Very few	28.5	26.3
9/19/49	21	19	Very few	26.9	24.6
9/26/49	6	8	Very few	26.0	17.4
9/28/49	19	21	Very few	27.2	21.9
9/30/49	0	0	Very few	23.9	22.1
10/5/49	7	10	Very few	26.2	24.8

On October 11, 1949 a total of ninety-six cultch bags were placed at the junction of Long Reef and St. Joseph Island. Sixty-five shells were examined on November 23, having an average set per shell of 0.8 spat. Eighty-eight shells were examined on April 18, having an average set per shell of 0.9 spat, the spat size ranged from 7-27 mm. with 16 mm. as the average size. Fall set survival appeared to

be good in this instance with the numbers per shell not being excessive.

After conferring with Dr. Philip A. Butler, it was considered that a more extensive study should be initiated upon spawning and spatfall in the Rockport area.

Three primary stations were established supplimented by plankton samples from all existing experimental plots. These stations were located at Long Reef (eastern end), Bird Reef and a reef south of McDowell Point in San Antonio Bay.

Quantitative plankton samples were taken at regular intervals at these stations and the examination conducted as outlined earlier in this report. Six shell bag collectors containing approximately one-half bushel were placed at each of the three stations with a bag being picked up monthly. All spat were counted and random measurements made upon spat shell lengths. Additionally, oysters were opened to determine their general sexual condition.

Results of all plankton tows made March, 1950 to September, 1950 are shown in Table 2.

This table includes positive larvae counts per one milliliter of sample for the three stations.

Copano, Carlos, and Redfish Bays showed a comparable incidence of larvae. The two observations of larvae taken at below 20°C. may be questionable due to the difficulty in identification of the straight hinge stage.

As previously stated six shell cultch bags were placed at three locations. Four of each set of bags were picked up in consecutive months for spat counts and measurements, all shells in each bag were examined and only live spat were considered.

From the data on hand it is apparent that spawning is more or less regular in Aransas Bay during the summer months although the relative small increase in spat per shell between June and July may indicate a decline in setting. The author can not account for the absence of spat in San Antonio Bay as the largest quantity of larvae was recorded for that area.

Random measurements were made on spat which had set on the test cultch. Measurements were made with vernier calipers on total length of the right valve, in millimeters. Table 4 presents the frequency of sizes by month and location.

Table 2

Quantitative Larvae Samples

Location	Date	Water temp.	Salinity	Straight Hinge Larvae	Umbo Larvae
Bird	Mar. 20	18.1	24.3	1	-
Bird	Mar. 22	18.4	25.9	1	-
Long	Apr. 12	22.2	24.2	-	1
Bird	Apr. 18	21.5	24.3	7	-
Bird	May 1	26.5	25.5	19	35
Long	May 1	25.9	24.1	-	1
Bird	May 15	26.0	26.2	4	2
Long	May 15	26.5	24.9	4	9
San Antonio	May 17	27.8	18.3	87	-
Bird	May 18	27.1	24.8	25	-
Bird	June 5	29.3	25.2	2	-
Long	June 16	28.5	24.7	-	3
San Antonio	June 27	28.6	13.1	527	-
Bird	June 28	29.4	25.7	24	16
Long	July 7	28.7	28.1	43	-
Bird	July 7	28.9	28.4	-	1
Bird	Aug. 7	28.8	33.2	-	1
Long	Aug. 7	29.3	35.3	1	1
San Antonio	Aug. 9	29.0	24.4	6	5

Number of samples without larvae - 14

Table 3

Frequency of Spat Per Shell

Numbers per shell	May			June			July			August		
	1	2	3	1	2	3	1	2	3	1	2	3
0	9		70			77			65			16
1-5	23	6		2							1	49
6-10	6	13		1	1		4	1			2	1
11-15		15		8	7		6	3		1	3	
16-20		11		8	6		12	6			7	
21-25		6		8	13		11	8			8	
26-30		4		6	10		4	10		2	9	
31-35				6	11		4	7		5	5	
36-40				3	11		6	6		8	8	
41-45				5	6		2	3		6	7	
46-50					1		2	6		5	2	
51-55				1				2		3	4	
56-60					2		1	1		3	4	
61-65					1		1	1		2		
66-70				1				2		1		
71-75										2	4	
76-80								1		1	1	
81 or above										4		

Legend Table #3

#1----------Bird Reef, Aransas Bay
#2----------Long Reef, Aransas Bay
#3----------Reef south of McDowell Point, San Antonio Bay

Table 4

Frequency of Spat Sizes

Shell Lengths of Spat	May			June			July			August		
	1	2	3	1	2	3	1	2	3	1	2	3
1												
2				2								
3				3						37		
4		1		8	2			1		9	1	
5	3	3		14	10		1	8		11		1
6	3	4		12	10		1	3		4	2	3
7	5	12		23	18		4	11		4	1	4
8	3	15		18	9		7	8		4	6	2
9	6	9		17	12		5	10		6	8	4
10	14	23		17	7		7	18		7	15	3
11	6	14		6	8		7	11		9	6	2
12	3	13		2	11		7	9		7	13	4
13		12		3	4		8	11		11	10	3
14	1	11		1	7		3	8		7	10	2
15	1	14			12		5	7		18	13	4
16		6		1	7		4	4		5	15	2
17		5		2	6		5	4		7	10	2
18		2			11		3	2		10	6	2
19		1			5		2			6	6	
20		1			8		1	3		5	5	
21		1						3		3	4	2
22				1	3			5		5	5	
23					4			1		1	2	
24					3			3		3	1	
25					1			3			3	1
26								1		1	1	
27								2		2	1	

Legend Table 4

#1----------Bird Reef, Aransas Bay
#2----------Long Reef, Aransas Bay
#3----------Reef south of McDowell Point, San Antonio Bay

The size groupings of the spat indicate that there is a fairly constant spatfall in Aransas Bay with exception of a decided addition of new spat in August at Bird Reef. The modal sizes of spat at San Antonio Bay apparently show a considerable variation in growth rates of the spatfall during August.

A physical examination of the general sexual condition was made from time to time. In mid-April about twenty percent of the oysters at Long Reef had sex products present. The percentage was about the same in May at Bird Reef and San Antonio Bay. During August this percentage had risen to about eighty in all areas.

The data obtained during this period is definitely only of a preliminary nature. More detailed analysis of spawning and setting is necessary as a part of future investigations. A commercial grower's greatest need is replacement of his stock. The natural oyster setting is his primary source of supply. Therefore, as much information as possible should be gathered on this phase of the investigation.

Bottom Improvement

No specific effort was placed upon this part of the investigation during the period. At Dr. Butler's and Mr. Baughman's suggestion expansion of existing reefs and stiffening of the bottom could best be accomplished by the use of "fines" from mudshell dredging operations.

During 1948 the bottom at the experimental plot at Spaulding Reef was stiffened with eighty yards of mudshell. After the seed stock was placed on the plot mortality thru sinkage into the bottom appeared to be no more reduced than other plots with a medium soft mud bottom. Therefore, it appears that strengthening a bottom for cultivation requires a considerable quantity of material. Due to the cost of mudshell the use of "fines" might be a much more economical method for this operation.

Reef Survey

Only preliminary work has been done in evaluating the existing and potential oyster resources of this area. Population samples have been made of six reefs in the area based upon examination of a random sample by tonging one bushel in quantity. A percentage breakdown of the sampling is shown by Table 5.

It is the author's opinion that the area around Ayres Dugout and Long Reef are probably at present the only

commercially productive oyster locations in the bays adjacent to Rockport. One small leased oyster claim is being operated satisfactorily by Mr. Harvey at Fulton.

In January, 1950 a survey was made in cooperation with Dr. Butler of fifty six reefs in Copano, Aransas, Redfish, Carlos, San Antonio, Espiritus Santo, Lavaca and Tres Palacios Bays. Dr. Butler's report on this survey is included as an appendix to this investigational report.

Hydrographic Data

At all stations physical and hydrographical data was obtained regarding water temperature, salinity, pH, turbidity, wind, weather, and current. Water samples were collected at the bottom. Temperature is recorded in degrees Centigrade and salinity in parts per thousand. Salinities were determined by titration except prior to 1950 hydrometers were used. Turbidity was determined by a photo-electric colorimeter using distilled water as a blank at a maximum light penetration of ten, pH was determined on a Beckman meter.

Table 6 represents the consolidated monthly data for the bags under investigation; figures denote average reading, based on the samples obtained each month.

As water temperatures remained fairly high during the winter of 1949-1950, it appears to the author that this season might be considered atypical thus accounting for irregularities in oyster behavior in this area.

Recommendations

1. Considering the importance of oyster spawning and spatfall to the maintenance of a commercial or natural bed it is felt that a more exhaustive study should be made next year on this phase of oyster biology.

2. A permanent station should be established adjacent to the laboratory where comparable data on temperature, salinity, growth and mortality, spatfall, and the effects of fouling organisms and pests may be collected over long periods. The main advantage to this project is that data could be accumulated regularly independant of weather conditions.

3. Surveys should be continued of reef populations to determine their composition.

4. Monthly data should be secured on glycogen, percent solids, and condition factor as a means of observing changes in oyster quality. Long Reef may be suggested as the specimen

Table 5

Reef Population Composition – %

Component	"A" California Hole	"B" Spaulding Carlos Bay	"C" N. Copano Bay	2x4 Aransas Bay	Bird Aransas Bay	McDowell Point San Antonio Bay
Market Oysters	6	5	3	4	1	7
(Small oysters less than 3 1/2 in.)	22	20	21	19	3	25
Spat	Large quantity	24	35	42	71	49
Market boxes	2	2	4	1	1	1
Spat boxes	Many	6	20	21	21	3
Drilled boxes	-	-	-	-	-	-
Blanks (Empty valves 3 1/2 in. plus)	16	3	1	1	1	1
Trash	54	40	16	12	2	14

Table 6

	Sept. '49	Oct. '49	Nov. '49	Dec. '49	Jan. '50	Feb. '50	Mar. '50	Apr. '50	May '50	June '50	July '50	Aug. '50
Redfish Bay												
Salinity	35.5	27.3	23.7	26.0	21.7	24.0	23.1	25.5	25.1	29.5	38.4	39.8
Temperature	30.1	27.1	16.6	19.2	15.6	16.5	15.2	23.0	26.7	28.3	28.3	29.1
Turbidity	-	-	-	-	-	-	6	-	-	6	8	6
pH	-	-	-	-	-	-	8.5	-	-	8.3	8.5	8.1
Aransas Bay												
Salinity	29.0	23.9	20.9	22.0	23.8	21.7	23.2	25.2	24.9	25.2	28.7	34.3
Temperature	29.0	26.2	16.6	20.1	18.3	18.8	18.5	22.3	26.9	28.9	29.3	29.1
Turbidity	-	-	-	-	-	-	5	7	8	4	6	5
pH	-	-	-	-	-	-	8.4	8.5	8.9	8.1	8.2	8.1
Carlos Bay												
Salinity	28.5	24.1	21.7	23.2	-	-	24.1	-	27.1	26.2	-	34.5
Temperature	29.4	24.8	15.3	21.7	-	-	14.3	-	28.3	28.5	-	29.2
Turbidity	-	-	-	-	-	-	2	-	6	-10	-	5
pH	-	-	-	-	-	-	8.7	-	8.7	8.3	-	8.2
Copano Bay												
Salinity	20.5	23.1	14.3	18.5	19.2	19.6	20.1	-	24.0	23.9	27.4	32.3
Temperature	29.9	26.4	15.5	19.1	12.4	18.1	16.8	-	27.2	28.4	28.6	28.8
Turbidity	-	-	-	-	-	-	5	-	-	4	4	6
pH	-	-	-	-	-	-	8.7	-	-	8.4	8.2	8.1
San Antonio Bay												
Salinity	-	-	-	-	16.4	-	-	-	18.3	13.1	17.3	24.4
Temperature	-	-	-	-	-	-	-	-	27.8	28.6	28.7	29.0
Turbidity	-	-	-	-	-	-	-	-	8	4	3	6
pH	-	-	-	-	-	-	-	-	9.1	8.2	8.5	8.1

source.

5. Quarterly examination of the experimental plots should be added to the Bird Reef plot in order to establish a more adequate population for observation.

Acknowledgements

The author is deeply indebted to Dr. Philip A. Butler of the U. S. Fish and Wildlife Service for invaluable assistance in the formulation of investigational objectives and in developing field and laboratory techniques.

Summary

1. Seed oyster transplanting observations were continued and one new plot was established at Bird Reef, Aransas Bay. Emphasis was placed upon spawning and setting activities.

2. A resume of the previous activities is presented. Growth rates and mortality on experimental plots were generally unsatisfactory from a cultivation standpoint. Spat collectors showed an adequate strike in fall months at Cedar Dugout.

3. Cost of transplanting seed to the Bird Reef plot was less than any previous transplantings. Initial growth was slight as might be expected during summer months. Mortality was around twenty-five percent.

4. Cultch bags for spat collection and counts were placed at three stations. Quantitative tows were made for larvae. Tables are presented showing larvae counts, spat per shell counts, and size frequency of spat.

5. No definite program was begun on bottom improvement. The results from strengthening the bottom at Plot "B" with mudshell did not apparently warrant the expense of this operation.

6. Preliminary data is presented in regard to reef surveys.

7. Hydrographical and physical data was collected for all stations.

8. Recommendations are presented for the future investigational program.

Appendix

Survey of Texas Oyster Reefs

By
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And
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INTRODUCTION

The purpose of this survey was to determine the most suitable location for expanding a system of oyster culture. Since hydrographic conditions will vary from year to year, as well as seasonally, a single survey is inadequate for this stated purpose. However, the attempt has been made to analyze existing populations and conditions in terms of the probable production potential of each area.

The isolated data on salinity and pH are given only for the record and have little value for interpreting reef conditions on a long-range basis. During the time of the survey, water temperatures ranged from 19 to 22° C., but no attempt was made to correlate these data with tidal stages.

This report is not complete in itself but provides the data on which was based the oyster culture program previously presented.

Description of Sampling Stations, Survey of Texas Oyster Reefs January 9 to 17, 1950

Station Number	Name	Sal.	pH	
1.	California Hole,	22.5		Bottom only fair; oysters showed recent growth up to 6 mms and were feeding, but meat quality was poor. The shells were riddled with sponge and had many polydora. There were many spat, either recent or slow growing. 72% of sample consisted of old boxes.
2.	Trout Bayou			These three stations were visited on the clam survey; bottom was made up of sticky
3.	Mud Island			
4.	Allyns Bight			

Station Number	Name	Sal.	pH	
				mud containing scattered shells covered with recent and older spat. There are possibilities here for oyster culture if sufficient cultch, or seed, is planted.
5.	Old Ship Yard			A small area having only scattered old oysters riddled with sponge; rocks and trash on the bottom would probably prevent cultivating oysters here without extensive clean-up operations.
6.	Southeast of Laboratory			This area consists of sticky mud changing to softer mud on the outside and at various places having hard shelly tow-heads. The few oysters present were mostly small and of fair meat quality. Fouling with clams and sponge was moderate. Suitable bottom in this area can be extended by the planting of cultch and seed. Very heavy recent spatfall.
7.	Two-by-Four			
8.	Un-named Towhead			
9.	Grass Island Towheads			Scattered clusters of oysters on a mostly too-soft bottom; oysters of very poor quality.
10.	Copano Bay Exp. Plot, 19.2, 7.6			Bottom in this area is a soft sand-mud. The oysters were extremely poor with glassy meats; showed no recent growth and were not feeding. The shells were heavily fouled with martesia, serpulids and polydora. The reason for the poor condition of the oysters was not obvious but the small amount of plankton indicates that the food supply may have been inadequate.
11.	Bartel, Blackjack Islands			This area is now covered with mud.

Station Number	Name	Sal.	pH	
7. 12.	Long Reef			These areas are characterized by a good bottom made up of gravel, sand, and shelly mud. Quality of the meat was fair; moderate recent growth on shells; fouling was not too heavy. The oysters at Long Reef had fair shape, were not badly clustered and were feeding. These areas would probably be satisfactory for commercial cultivation if sufficient cultch and seed is planted. Oysters at Dunham point were rare and not of as good quality.
8. 13.	Bird Reef			
14.	Dunham Point			
9. 15.	Spaulding Exp. Plot			Bottom in this area is a soft mud-sand and would require a great deal of strengthening to support a population of oysters. The poor quality of the meats indicate that it would not be worthwhile to improve the bottom here. Oysters were not feeding; fouling was moderately heavy.
16.	Cape Carlos Dugout			A good hard bottom here with oysters in fair condition. All oysters were feeding; those in deeper water were better quality than in shallow areas. There is some market stock and, although the area is small, it could be made self-maintaining if culling were enforced.
13. 17.	Cedar Dugout			
18.	Mesquite Bay			This entire area has a too-soft mud bottom; not suitable for the cultivation of oysters.
17. 19.	Ayres			This area is made up of small wild reefs and towheads, some of which are exposed at low tide having for the most part a hard shell bottom. The oyster meats were of fair-to-good quality; showed some
20.	Belden			
21.	Ayers Bay-North 21.2, 8.1			
22.	Second Chain of Islands,			
23.	22.7			

Station Number	Name	Sal.	pH	
				recent growth. Many of the oysters were singles, and there was a small percentage of market size. The setting rate was low; only moderate. This area could probably maintain itself if culling were strictly enforced, but the chances are that it will soon be fished out if seed plantings are not made. However, occasional drilled spat were found and the conch may prevent oyster cultivation here.
24.	False Liveoak Point,	20.8,	8.1	These areas had oysters of fair quality with some recent growth. The oyster shells appeared relatively clean and were not clustered. All of the oysters were small but there were no recent spat. This area would appear to have a single spring spatfall, and for this reason (seed would all be approximately same size) would be a good area for dredging seed which could be planted in a better growing location.
25.	Panther Reef-South,	22.1		
20 26.	Panther Reef-North,	21.2		
27.	Dagger Point,	18.0		This area is under the influence of the Guadeloupe River, and at the time of the survey hydrographic conditions were suitable for the production of a very good quality oyster, although they tasted somewhat fresh. Oysters are located on reefs and towheads of shell elevated above a softer sand-mud bottom. The oysters showed good growth and good shape. Fouling was light. At some points were dredges were working, the oysters were not badly clustered. This area is probably the best of all those surveyed and has possibilities for expanded
28.	Webb Point			
29.	Shark Point-South, (McDowell)	16.4		

Station Number	Name	Sal.	pH	
				commercial development. By the addition of considerable quantities of strengthening material, a continuous bar could be developed along this shore. For sustained yield, the area would have to be planted with seed, as the spatfall was light.
30.	Shark Point,	16.2		This area is made up of scattered towheads with too-soft mud in between. There was evidence of siltation from the Guadalupe River. The oysters were of fair quality and showed rapid growth. The size of the spat indicated that the only significant set takes place in the spring. This is a marginal area, which in years of excessive run-off would probably have extensive mortality.
31.	Midway,	19.1		
32.	Swan Point,	20.2		
33.	Mesquite Pt.	Inshore		This area is similar to the west side of San Antonio Bay, but the population of oysters was much smaller. The oysters were more clustered. It could probably be developed into a good area with adequate cultivation.
34.	Mesquite Pt.	Offshore, 22.9		
35.	Turnstake Lagoon,	25.5,	7.8	This area is made up of towheads and reefs of wild stock. Majority of the oysters were small, not too badly clustered. The oysters were of good quality and clean looking, although sponge and martesia were moderate. Spatfall is moderate, but there were many spat scars and boxes. Drills were not found, but this is probably within their range. The area is probably self-maintaining, but would soon be cleaned out if harvesting
36.	South Pass			
37.	Old Pass			
38.	South Pass			
39.	South Pass Lagoon			
40.	Steamboat Pass,	27.0,	7.8	

Station Number	Name	Sal.	pH	
				was very intensive. It would probably be a fair source of seed for transplanting into San Antonio Bay.
41.	Deep Reef,	27.2,	7.6	This entire area is composed scattered clumps of oysters and old riddled shell on a sand-mud bottom. In some areas, such as Big Pocket and Mail Boat, there is evidence that the sand has shifted and buried most of the few oysters there. The area is characterized by heavy spatfall which was either recent or very slow growing. Many drills were recovered and the spat mortality from this cause varied from 25 to 95 per cent in the different locations. The high salinity combined with the drill population makes it probable that this area will have no commercial prospects for a long time to come. Oysters growing in the marsh ponds protected from drills and fouling organisms were of excellent quality. The pond near Whittaker's Bayou was noteworthy in that the oysters there were all heavily pigmented with green, apparently due to the diatom, Navicula ostrearum. There is the possibility that Deep Reef would respond to planting and cultivation. The fouling here was not quite so heavy, but the sample was too small to determine whether or not it was beyond the range of the drills.
42.	Army Canal, Spoil Bank			
43.	Farwell Island			
44.	Cross Reef-Farwell Is.,	27.9		
45.	Big Pocket			
46.	Cross Reef-Grass Island			
47.	Marsh Pond,	30.5,	8.0	
48.	Whittaker's Bayou,	29.6,	7.8 (Saluria)	
49.	Grass Island-South,	29.8		
50.	Grass Island-North			
51.	Dick Day's,	28.8		
52.	Everetts			
53.	Big Bayou			
54.	Mail Boat,	29.4		
55.	Cris's			
56.	Little Mary Bayou,	29.2		
57.	Sand Point,	15.8,	7.8	The bottom here was a mixture of sand and shell, the oysters were excellent quality; feeding and with only light fouling. About 20 per cent of the oysters

Station Number	Name	Sal.	pH	
				were market size. This area is probably suitable for oyster culture on an expanded scale.
58.	Carancahua-Middle Ground			All of these stations had firm hard bottom, but the oyster population had been wiped out by man and drills. The spatfall, while heavy in most places, remained alive only in partially closed boxes which the drills could not enter. None of the area at present is worth cultivating.
59.	Carancahua-Entrance, 19.9, 7.9			
60.	Well Point			
61.	Turtle Point, 20.9			
62.	Turtle Point-Offshore			
63.	Camp Hulen			
64.	Oliver Point, 22.8			
65.	Oyster Bayou-Entrance			
66.	Robinson			
67.	Trespalacios Bay, 1.4,7.2			This is an area of scattered small towheads, some of which had been planted. Oysters were of excellent quality; showed up to one-half inch recent growth. Fouling was very light. At the time of the survey the oysters were not feeding; probably because of the low salinity. This is a good marginal area which will at times produce good oysters and at other times will suffer heavy mortality.

Summary

Analysis of the data gathered on this survey leads to the following generalizations:

1. The oyster reefs of the entire area are characterized by their serious depletion resulting from either over-fishing, drill predation, or both.

2. With few exceptions, the oyster meats were of only fair to very poor quality.

3. The high incidence of boring sponge and boring clam are probably primary agents in causing poor oyster meat quality, since

a. Oysters living in marsh ponds cuts off from infection with sponges and clams were of excellent quality even though salinity levels were as high or higher than on adjacent reefs in open water.

b. Oysters exposed at low tides, which automatically controls sponges, were of better quality than adjacent oysters which were heavily fouled with sponges.

4. Oysters of satisfactory quality were found primarily in areas having salinity levels below 20 o/oo, such as Stations 67,57 and 28; these reefs are located near the junctions of primary and secondary bays; while fouling and predators are partially controlled at these levels, there is the possibility of mortality due to excessive run-off of fresh water in some years.

5. In the areas where commercial harvesting was observed, the rate of spatfall is insufficient to maintain the reefs.

6. The areas infested with drills are those having greatest access to waters of the Gulf and the drill population will probably fluctuate regularly with the rate of run-off from the several rivers.

7. There were indications that oysters growing in deeper waters were of better quality than those on shallow reefs.

8. The topography of the bottom, consisting of elevated ridges and towheads surrounded by soft mud, suggests caution in attempting to expand reefs so that natural siltation areas will be avoided.

9. The absence of feeding at many locations indicates that the plankton may be low quantitatively and that poor oyster quality may be due to a small food supply; this may be of importance in determining the density of seed plantings.

10. The presence of spat of less than 1/2" diameter at many stations suggests that either there is an important winter spatfall or else, that in these locations, the spat are extremely slow growing. These two possibilities should be investigated since other locations showed that there was a single important spatfall some months before this survey.

Recommendations for Oyster Culture Program

1. It is desirable to initiate an oyster culture program on a small scale and then with experience, to expand operations. Fortunately, there are more than enough reefs

in the area surveyed which show promise for economically good results. Areas suggested for development in the order of their probable commercial importance are:

San Antonio Bay	Stations	28 - 29 - 27
Lavaca Bay	"	57
Aransas Bay	"	12 - 13, maybe 14
Trespalacios Bay	"	67 possibly

2. In the above areas there will be a minimum amount of trouble from fouling and drills. However, in order to understand the biology of the oyster under conditions of higher salinity, with the ultimate purpose of expanding oyster culture operation it is strongly urged that a reef be created at the 10 foot level in front of the Rockport Laboratory. Such a location should have a stationary pier extending to the reef proper. This would provide a permanent station for the year round collection of hydrographic and biological samples over a period of years.

These data are essential, not only for the study of oysters in the area but also for the migratory forms which have commercial value. The absence of seasonal and annual records made it impossible, for example, to understand why the majority of oysters on the reefs surveyed were not feeding.

I believe the following categories represent the minimum number of records that should be kept on a permanent basis, in order to provide enough information for interpreting the environment in relation to the oyster:

Salinity
Temperature
Plankton - (quantitative and qualitative)
Spatfall
Spat Survival
Adult Oyster Growth
Adult Oyster Survival

3. In view of the limited number of investigators, studies on spatfall, larvae, plankton, oyster growth and mortality, drills, clams and sponges should be concentrated in an area adjacent to the laboratory.