

FLORIDA DEPARTMENT OF NATURAL RESOURCES

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**CONSTRUCTION AND REHABILITATION OF COMMERCIAL OYSTER REEFS IN FLORIDA
FROM 1949 THROUGH 1971 WITH EMPHASIS ON ECONOMIC IMPACT IN FRANKLIN COUNTY**

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ABSTRACT

Reef construction and rehabilitation are described and mapped. Over 4.2 million bushels of oyster shell and other cultch materials have been planted in 10 Florida counties since 1949, including 1.9 million bushels planted in three counties from 1967 to 1971. Planting costs were 9.5 cents per bushel of cultch material, and the unamortized planting expenditures are less than 1% of the estimated value of the oysters expected to be produced from these reefs over a 20 year period. The recently planted reefs comprise up to 12% of the local reef acreage used by oystermen. Additional pertinent historical, statistical, and biological data are included. [*Crassostrea virginica*; commercial fisheries; estuarine development and production].

INTRODUCTION

Man has successfully planted cultch materials for oyster cultivation for centuries — long before the biological importance of this practice was fully understood.

During the past hundred years, increased demand for oysters has led to over-exploitation and depletion of many natural oyster bars. Increased pollution has further limited areas suitable for oyster harvesting, resulting in a substantial decline in United States oyster production, while demand has steadily increased. Consequently, the oyster industry has turned more toward rehabilitation of natural bars and creation of new ones. Use of modern scientific techniques has greatly improved chances of success.

In 1949, the Florida Department of Natural Resources (FDNR) (then the Florida State Board of Conservation) began rehabilitation of depleted natural oyster bars and construction of new beds. From 1949 through May 1972 approximately 4.2 million bushels of cultch materials were planted on selected areas in Franklin, Bay, Wakulla, Lee, Levy, Citrus, and Walton Counties with efforts concentrated in Franklin County, center of the Florida oyster industry (Appendix 1 and Figures 3-36).

Planting prior to 1967 was limited by lack of adequate support and funding. Interest gradually increased as oyster reef values became apparent. The Commercial Fisheries Research and Development Act of 1964 (Public Law 88-309) authorized the U.S. Secretary of the Interior to cooperate with the 50 states, Puerto Rico, and the U.S. territories in sponsoring research, development, construction, and coordination programs (U.S. Fish & Wildlife Service, 1968). Accordingly, this federal program provided about 50% of the funds used from 7 May 1967 to 30 June 1971 by the Bureau of Marine Science & Technology of the FDNR to rehabilitate and construct oyster reefs.

Florida law contains provisions to facilitate such oyster reef development. All water bottoms and natural oyster reefs within Florida are State property unless specifically alienated (Chapter 370.03, Florida Statutes), and oysters may be taken from such bottoms by the public, subject to certain regulations (Chapter 370.10). Mechanized equipment, for example, may not be used to harvest oysters from public bottoms (Chapter 370.16 [15]) and oysters under the three-inch legal size must be culled and returned to the reef (Chapter 370.16 [16]). In addition, oyster shells remain the property of the State when such shells are needed for public reef planting projects (Chapter 370.16 [35]). All oyster reefs developed under State programs remain public property.

This paper describes procedures and results of the jointly supported Federal-State oyster reef, construction and rehabilitation project conducted in Florida from 1967 through 1971. All other State oyster planting since 1949 is represented in maps, tables, and appendices. Methods used in these other efforts have been similar to those described herein. A conversion table and glossary are presented in Appendices 3 and 4.

Contribution No. 219

Effective July 1, 1969, agencies of the State of Florida underwent legislative reorganization and the Florida Board of Conservation was renamed the Florida Department of Natural Resources.

This study was conducted in cooperation with the U.S. Department of Commerce, NOAA, National Marine Fisheries Service, under PL 88-309, Project No. 2-52-D.

MATERIALS AND METHODS

Equipment

Heavy equipment was purchased with both State and project funds for year-round use in Franklin County. Equipment was rented and planting personnel were hired temporarily for similar work in other counties. The heavy equipment was typical of that used for oyster reef planting in most states and included diesel end loaders—two with a 3/4 cubic yard bucket and one with a 1 cubic yard bucket; three 2-ton dump trucks of 7 cubic yard capacity; a 100 ft x 26 ft x 6 ft steel-hulled barge powered by a G.M. 671 (165HP) diesel engine and a Murray & Tregurtha stern-mounted outboard propelling unit; a 6 in. x 6 in. Hale water pump; and a 38 ft general pullboat used as an auxiliary vessel.

Planting Procedures

Areas suitable for reef construction and rehabilitation were selected on the basis of water quality, hydrography, physiography, and biological considerations. Specific planting areas were determined by potential oyster growth and production and by local economic need. Corners of all selected sites were marked by heavy pilings for subsequent planting. Only subtidal locations were chosen since intertidal oyster growth and quality are poor (Ingle and Whitfield, 1968), disease problems are more severe (Quick and Mackin, 1971), and planting is more difficult. Almost all oysters are taken subtidally in Florida.

In Franklin County, thousands of bushels of oyster shell were collected regularly from shucking houses and stockpile for seasoning or immediately planted in Apalachicola Bay. Since quantities of shucked shell are scarce outside Franklin County, dredged mud (fossil) shell, holite rock (phosphate slag), oolitic limestone, railroad slag and other materials were used as cultch. All cultch materials were tested on trial plantings prior to extensive use.

Studies have shown that continuous spat set occurs from April through November in northern Florida (Ingle, 1951a,b; Ingle and Dawson, 1953) and year-round in southern Florida (Quick and Mackin, 1971). An oyster strike is usually commercially inadequate if cultch becomes fouled prior to oyster setting (Shaw, 1968), but oysters can become established when fouling organisms are setting simultaneously. Very little fouling has been observed during winter in northern Florida and cultch laid during this period remains sufficiently clean for adequate setting in spring. Thus, artificial reef planting has been successful year-round.

Cultch was planted by "blowing" shell off both sides of the stationary barge with a high-pressure water stream, thereby forming parallel ridges resembling natural oyster reefs. Cultch was planted at least two feet thick on hard bottoms and up to ten feet thick on soft bottoms. Studies have shown greatest oyster growth and least sedimentation on reefs planted in this form, and oyster production continues indefinitely without further investment—reefs planted by the State in 1949 are still thriving.

Economic Evaluation of Oyster Plantings

Unreliable sources hindered collection of information and statistics on production, value, and use of planted reefs. These difficulties arise from the scattered nature of the fishery, a preponderance of self-employed oystermen, the presence of numerous small shucking houses and wholesalers, and inadequate bookkeeping. Therefore, some statistics represented in this and many other such reports are estimates based on familiarity with the industry and on interviews. Other numerical data came from periodic inspections of the reefs for oyster recruitment, growth, mortality, and harvesting (Appendix 2).

The project has had an impact on the oyster industry of Florida, particularly in Franklin County where more than 80% of Florida oysters are produced and where 97.2 percent of the project effort was concentrated (Tables 1 and 2). Evaluation of economic impact of oyster plantings was not developed as extensively for areas other than Franklin County since the oyster industry and the project plantings are relatively insignificant to those local economies (Table 3).

TABLE 1. OYSTER PLANTING PROJECT DATA

Project Segment Number	Dates Inclusive	Bushels of Shell Collected	Bushels of Shell Planted	Number of Acres Planted	Total Annual Expenditures	Unamortized Average Cost/Acre	Unamortized Average Cost/Bushel	Average Number of Bushels/Acre
1	7 May 1967 to 31 Mar. 1968	326,592 ¹	464,080	74	\$25,773.76	\$348.39	\$.055	6,271
2	1 Apr. 1968 to 31 Mar. 1969	389,424	431,264	66.5	57,436.56 ²	863.71	.133	6,485
3	1 Apr. 1969 to 31 Mar. 1970	353,808	475,440	82	41,884.41	510.79	.088	5,798
4	1 Apr. 1970 to 30 June 1971	357,168	533,904	86	56,710.40	659.42	.106	6,208
Total	7 May 1967 to 30 June 1971	1,426,992	1,904,688	308.5	181,805.13 ³	595.55	.095	6,174

¹ The Department of Natural Resources had stockpiled approximately 500,000 bushels of shell in Apalachicola prior to the start of project segment No. 1.

² Increase in expenditures and project unit costs in project segment No. 2 reflects purchase of heavy equipment during that period.

³ U.S. share \$87,547.36. State of Florida share \$94,257.77.

The last project year lasted 15 months and State funds were used to supplement exhausted project funds.

TABLE 2. RECENT OYSTER PRODUCTION ¹

Year	STATE		BAY COUNTY ⁴		BREVARD COUNTY		FRANKLIN COUNTY	
	Weight (lb) ²	Value (\$) ³	Weight (lb)	Value (\$)	Weight (lb)	Value (\$)	Weight (lb)	Value (\$)
1960	1,975,400	496,082	89,458	22,365	—	—	1,744,760	436,190
1961	3,326,601	1,052,864	127,367	40,343	18,477	5,432	2,947,132	934,242
1962	5,019,771	1,435,762	259,664	74,004	6,759	2,028	4,366,700	1,244,510
1963	4,362,848	1,248,906	204,400	58,455	22,900	6,870	3,810,500	1,089,804
1964	2,885,123	808,844	70,119	19,612	32,913	9,874	2,252,377	629,990
1965	2,954,745	987,392	79,998	28,479	94,404	28,321	2,337,530	784,475
▶ 1966	4,291,925	1,343,034	55,046	21,743	32,307	11,307	3,809,941	1,171,194
1967	4,761,130	1,501,187	61,475	27,221	88,607	35,443	4,195,905	1,274,716
1968	5,568,773	1,853,634	88,859	41,666	143,171	56,868	4,825,668	1,542,801
1969	5,152,742	1,963,531	85,337	39,690	132,378	52,951	4,350,370	1,613,102
1970	3,786,519	1,593,873	70,856	30,454	139,000	83,400	3,044,401	1,229,025
1971	3,710,542	1,641,076	58,078	29,306	103,825	41,530	3,180,085	1,392,241

¹ From Florida Landings.

² Oyster data are collected as gallons and converted to pounds as meats by multiplying by 8.75.

³ Values shown are those paid to tongers. A weighted average of 25% has been calculated as the tongers' share of the final value.

⁴ Bay and Gulf Counties reported together 1960-1963.

TABLE 3. ECONOMIC COMPARISON BY COUNTY — 1969

	Bay Co.	Brevard Co.	Franklin Co.	State of Florida
Per capita income ¹	\$ 2,801	3,959	1,884	3,372
Total personal income ¹	\$211,400,000	928,000,000	13,400,000	22,396,000,000
Final retail value of oysters ²	\$ 158,760	211,804	6,452,408	7,854,124
Ratio of oyster retail value to total personal income	0.00075	0.00023	0.481	0.00035

¹ Florida Department of Commerce, personal communication.

² FDNR (1969). Florida Landings gives dockside values. Colberg and Windham (1965) and May (1971) stated that a weighted average of 25% has been calculated as the tongers' share of final retail value.

RESULTS AND CONCLUSIONS

Oyster beds planted in Florida can be harvested around the edges 18 months after construction and reach full commercial productivity in 24 to 30 months (Ingle and Dawson, 1952, 1953). More than 300 acres of reefs were constructed under this project from 1967 to 1971. About 70 acres of these were mature during the 1969-70 season and 120 acres for the 1970-71 season. An estimated 190-200 acres were available for the 1971-72 season as the most recently planted reefs matured.

Interviews, observations, and reports indicated tongers used the project plants in Franklin County 4 to 8% of the time during the 1969-70 season and 8 to 12% during the 1970-71 season (Table 4 Figures 12, 13, and 14). This percentage of use is expected to increase as more planted beds mature. In addition to the greater area of planted beds ready for harvest in 1970-71, the increased use may have partially resulted from damage to nearby large natural reefs by low salinity. Reefs constructed by the Department between 1949 and 1966 are used extensively and are now considered to be "natural" bars by many oystermen. Many tongers have said that Franklin County artificial reefs now account for a significant portion of the county's production.

The Brevard County reefs (Figure 36) matured rapidly, possibly due to their more southerly location. Oysters of legal size were observed after six months; after one year (just prior to the 1969-70 season), the beds were covered with oysters 3 to 5 in. long. Samples taken in the summer of 1971 indicated a satisfactory spat catch. The economic impact of these reefs is of minor significance, however, because they are small in relation to natural and leased oyster beds.

Reefs were constructed in Bay County (Figures 23 and 24) to partially offset closure of some natural bars due to coliform contamination. Initially, the two artificial beds in North Bay were used more than the small one near California Bayou because of proximity to shucking houses at Southport. This latter bed was used more toward the end of the 1969-70 season, and was harvested heavily during the 1970-71 season. Although local oystermen traditionally obtain most of their oysters from Franklin County, harvest reports indicated individual oystermen harvested the Bay County artificial reefs an average of 20% of the 1970-71 season.

The 1970 census revealed Franklin County to have only 6,862 residents while Bay and Brevard Counties had 73,153 and 224,672. Approximately 1,084 individuals (15.8% of the population) are directly associated with the Franklin County oyster industry (P. Thompson, National Oceanic & Atmospheric Administration, pers. comm., 1971; Table 5). This made up

TABLE 4. FRANKLIN COUNTY PLANTED REEF VALUE ANALYSIS

Date	Values Based on Acreage Planted				Total Oyster Landings		Values Based on Reported Harvest from Plants		
	No. of Matured Planted Acres	Expected Bushels Available at 400 Bu/Acre	Value to Tongsers at \$2/Bu	Estimated Final Retail Value ¹	Value to Tongsers ²	Calculated Final Retail Value ¹	Proportion of Harvesting Effort on Planted Reefs	Estimated Return from Plants ³	
								Value to Tongsers	Final Retail Value ¹
1969-70 season	70	28,000	56,000	\$220,000	\$1,385,896	\$ 5,500,000	4-8%	\$ 55,000	\$220,000
1970-71 season	120	48,000	96,000	\$380,000	\$1,206,081	\$ 4,800,000	8-12%	\$ 96,000	\$390,000
Two-year total	—	76,000	152,000	\$600,000	\$2,591,977	\$10,400,000	—	\$152,000	\$608,000

¹ The tonger received approximately 25% of the final retail value (Colberg and Windham, 1965.)

² Data taken from Florida Landings based on a seasonal, not calendar, basis.

³ Figures based on lowest reported percent of harvesting effort, assuming harvesting efficiency on planted reefs was equal to that on all other harvested reefs.

TABLE 5. FRANKLIN COUNTY OYSTER INDUSTRY DATA — 1970¹

Number of tongers	471
Number of oyster boats	386
Number of shuckers	519
Number of house men, skim board operators, etc.	94
Number of shucking houses	51
Number of packers	53
Number of repacking houses	17

¹P. Thompson, National Oceanic & Atmospheric Administration, Apalachicola (personal communication).

about 46% of the county employment (Colberg and Windham, 1965). The final retail value of oysters produced in Franklin County accounted for approximately 48.1% of the total personal income there. The industry in Bay and Brevard Counties is small compared to that of Franklin County and information on oyster production, individual income, and population demonstrates that the economic base of Bay and Brevard Counties, and Florida as a whole, is not dependent on the oyster industry as is Franklin County (Table 3).

Oyster production and value vary with supply and demand, particularly with fluctuations in oyster quality, size, and weather conditions during harvest. Only dockside values of oysters are reflected in the fishery statistics of Florida Landings (Table 2) but this represents only a portion of the final retail value which varies with the form in which oysters are marketed (Table 6). According to Colberg and Windham (1965) and May (1971), the dockside value paid to tongers averages 25% of the final retail sales value. Thus, Franklin County oysters having an average dockside value of \$2 a bushel (P. Thompson, National Oceanic & Atmospheric Administration, pers. comm., 1971) would average \$8 per bushel retail.

TABLE 6. OYSTERS LANDED: PROPORTION OF USE AND TONGERS' PROPORTION OF FINAL RETAIL VALUE, FRANKLIN COUNTY*

Processing Method	Percentage of Total Oysters Landed	Tongers' Percentage or Share of Landed Oysters
Shucked	54	32
Half-shell	32	14
Frozen or breaded	14	25
Frozen oyster stew	<1	22

*From Colberg and Windham (1965) and P. Thompson, National Oceanic & Atmospheric Administration (personal communication).

Thompson (1961) reported that maximum yield from oyster reefs under optimum conditions would not exceed 750 bushels per acre. Ingle (1956; pers. comm., 1972) calculated that annual production of marketable oysters from planted reefs, under ideal biological and market conditions, could be up to 1,500 bushels per acre, worth \$20,000 retail. Unfortunately, these conditions are seldom, if ever, met. Ingle further estimated consistent annual production to be 400 to 600 bushels per acre from planted reefs. May (1971), Menzel et al. (1966), and others have made similar studies on natural and leased bars, finding a wide variation in expected production because of reef conditions. These findings indicate that oysters are, per acre, among our most valuable "crops."

I have chosen to use 400 bushels per acre at the final retail price of \$8 per bushel to illustrate the value of the oyster plants to the economy of the area and state. This figure is based on the literature mentioned above, and on observations of at least two to four marketable oysters per square foot from random sampling by tonging on the plants. These figures, based on projected harvest rates and present return values, are subject to wide variations with time and place. In particular, actual harvest rates by independent oystermen may include only a portion of the oysters available some years.

During the 1969-70 season, approximately 70 acres of matured planted reefs were available to tongers. This represented, using chosen values, a final retail value of \$224,000 (Table 4). An estimated total of 120 acres of matured planted reefs were available to tongers during the 1970-71 season, thus giving a final value of \$384,000 or over 2% of the total personal income for Franklin County. Further, these projected values of the plants represent approximately 4% of the total Florida oyster production in 1969-70 and nearly 8% for 1970-71 (Table 4).

Total combined final retail value estimate for the reef harvest from the 1969-70 and 1970-71 oyster seasons exceed the unamortized planting costs (Appendix 2). This does not include expected return from many future oyster seasons. The full 308.5 acres planted under this project are expected to be mature by 1973-74 and to produce near 120,000 bushels of oysters annually thereafter at a final retail value of about \$960,000. It would require a long-term capital investment of \$19,200,000 at 5% annual interest to earn this final retail value each year. Total expenditures for this project were approximately \$182,000, or less than 1% of the capital investment required to provide, through interest, the return available from harvesting the oyster plants.

Oyster rehabilitation has resulted in cost-to-benefit ratios as high as 1 to 20 in Louisiana, where oysters and cultch are generally scattered over water bottoms and then harvested mechanically. Such plantings must therefore be replenished frequently (H. E. Schafer, Jr., Louisiana Wildl. Fish. Comm., pers. comm., 1972). The 308.5 acres planted under this project in Florida had an estimated cost-to-benefit (final retail value) ratio of 1 to 5 for the first oyster season following maturity. Cultch on these reefs was planted thickly and will last indefinitely without the need for further replanting or other investment. A reef that produces 20 years, as some already have, will result in an estimated cost-to-benefit ratio of 1 to 100.

Monetary values for various water bottoms have been estimated for many purposes by different methods. Some estimates include only the value of bottoms as sites for landfill development or the value of the marine harvest from an area for only one year (Woodburn, 1965). More realistic estimates also include the value of such areas as nursery grounds, as sites of biological productivity, and as sources of recreation and aesthetic appeal (McQuigg, 1971). It is unfortunate that some bottoms have been sold by the State for less than annual production value alone.

Submerged lands will obviously vary in annual value not only from one bay or area to the next but also over short distances within a body of water. However, it is impractical to evaluate each unit of bottom separately; average values are usually drawn (Woodburn, 1965).

Studies have shown the Laguna Madre in Texas to have an average annual productive value of \$370 per acre and other states have values ranging from \$200 to \$380 (McQuigg, 1971). May (1971) valued the annual contribution of natural oyster reefs of Mobile Bay, Alabama at \$542 per acre.

Florida has not made a detailed evaluation of submerged land but values are probably comparable to those of other states with an annual average productive value between \$250 and \$400 per acre.

In this project, reefs were constructed in areas where no oysters of commercial quality or quantity were present and where reef construction did not permanently reduce value of the sites for other uses. In fact, biological importance was no doubt enhanced due to increased diversity and higher productivity of oyster habitats as compared with original sand or mud bottom.

Potential annual value of the plants is approximately \$3,200 per acre for the oyster production alone at 400 bushels per acre. This does not take into account the additional use as nursery grounds, recreation, and other functions. Thus, value of the planted water bottoms nearly doubled the statewide productive value of submerged lands. Oyster reef planting therefore can be expected to increase the annual productive value of water bottoms by ten times or more.

SUMMARY

1. More than 1.9 million bushels of cultch materials were planted during construction or over 300 acres of new public oyster reefs in three Florida counties from 1967 to 1971.
2. Seventy acres of planted bottoms were estimated to be available for harvest by oystermen during the 1969-70 oyster season, 120 acres for the 1970-71 season, and the remaining acreage in succeeding season.
3. In 1969-70 these oyster plants accounted for nearly 4% of the total oyster production of Florida and provided nearly 2% of total personal income for Franklin County.
4. Unamortized expenditures for the four-year project were \$182,000 compared to an estimated potential final retail value return of the resultant plants of \$608,000 for the 1969-70 and 1970-71 oyster season.
5. An additional 2.3 million bushels of oysters and cultch have been planted by the State in other projects since 1949, most of which still produce commercially.

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APPENDIX 1. DEPARTMENT OF NATURAL RESOURCES CULTCH AND OYSTER PLANTINGS
IN FLORIDA, 1949 THROUGH MAY 1972

1949	52 2,000	"Army pontoons" of miscellaneous cultch in Franklin County. Bushels of shell in Franklin County.
1950	88,000 8,576	Bushels of shell in Franklin County. Bushels of oysters in Franklin County.
1951	50,500	Bushels of shell in Franklin County.
1952	63,700	Bushels of shell in Franklin County.
1953	13,288 6,510	Bushels of shell in Franklin County Bushels of shell in Levy County.
1954	27,720 5,389	Bushels of shell in Franklin County. Bushels of oysters in Franklin County.
1955	2,170	Bushels of oysters in Levy County.
1956	125,950 25,300 100 6,510	Bushels of shell in Franklin County. Bushels of shell in Bay County. Bushels of oysters in Citrus County. Bushels of shell in Lee County
1957	3,400 600 1,943 1,396 31,992 43,400	Bushels of oysters in Citrus County. Bushels of shell in Citrus County. Bushels of oysters in Wakulla County Bushels of oysters in Franklin County. Bushels of shell in Bay County. Bushels of shell in Walton County.
1958	183,700 3,460	Bushels of shell in Franklin County. Bushels of oysters in Wakulla County.
1959	None	
1960	229,174 1,760 65,100 7,595	Bushels of shell in Franklin County. Bushels of concrete rock in Bay County. Bushels of shell in Walton County Bushels of shell in Lee County.
1961	4,032 167,420 6,072 117,180 1,980	Bushels of oysters in Wakulla County. Bushels of shell in Franklin County. Bushels of shell in Walton County. Bushels of shell in Hillsborough County. Bushels of shell in Citrus County.
1962	320,826	Bushels of shell in Franklin County
1963	10,000 21,700 6,510	Bushels of shell in Franklin County Bushels of shell in Walton County Bushels of shell in Lee County
1964	201,500 22,000	Bushels of shell in Franklin County Bushels of shell in Bay County

1965	153,000 19,530	Bushels of shell in Franklin County Bushels of shell in Hillsborough County
1966	2,170	Bushels of oysters in Levy County 4 gaps cut through coon reefs (1 acre total) and planted with 1,085 bushels of oysters in Levy County (Ingle, 1967)
1967	295,294	Bushels of shell in Franklin County
1968	332,813 347	Bushels of shell in Franklin County Bushels of rock in Brevard County
1969	463,295 47,740	Bushels of shell in Franklin County Bushels of shell in Bay County
1970	410,282	Bushels of shell in Franklin County
1971	37,105 222,989	Bushels of oysters in Levy County Bushels of shell in Franklin County
1972	43,704 42,275 62,735 195,300 2,659	Bushels of rock in Brevard County Bushels of oysters in Levy County Bushels of shell in Franklin County Bushels of shell in Santa Rosa County Bushels of oysters in Santa Rosa County

Approximately 4.2 million bushels of cultch and oysters have been planted in Florida since 1949.

All plantings listed were made by or under the supervision of the Florida Department of Natural Resources. Data were obtained from the Department biennial reports to the Governor and members of the State Cabinet, annual reports of the Gulf States Marine Fisheries Commission, shell dredge lease files, and records of the Bureau of Marine Science & Technology.

APPENDIX 2. DEPARTMENT OF NATURAL RESOURCES OYSTER PLANTINGS MAY 1967 THROUGH JUNE 1971

Date	Location	Area (acres)	Cultch Volume (bushels)	Evaluation
18 May 1967 to April 1968	6-Mile plant, Franklin County: 200 yd offshore 6-Mile on the north shore of St. Vincent's Sound. 4 - 5 ft. deep.	51	311,156	Shucked oyster shell was laid over an extinct oyster reef covered by 8 to 10 in. of silt and mud. Strike was evident by late summer 1967 and has continued. Oystermen have harvested this plant since the 1969-70 season. Observations during summer 1971 revealed an established and well-worked oyster bed with high densities of 3 to 6 in., rapidly growing oysters.
18 May 1967 to December 1967	Cabbage Lump No. 1 plant, Franklin County: 0.6 mi north of the easternmost extremity of St. Vincent Island. 5 ft. deep.	30	178,700	An artificial reef was built of shucked shell laid over an old reef buried under 2 to 3 in. of fine silt and mud. Spat was observed in late summer 1967. This bed has been harvested since the 1969-70 season. Samples taken in summer 1971 revealed large oysters some 6 in. long. There was an exceptionally large year class of oysters 1 to 2 inches long available to the oystermen in the 1971-72 season.
January 1968 to July 1968 and October 1968 to April 1969	Porter Bar plant, Franklin County: 1/2 mi east of the town of Eastpoint, 150 yd west of Porter Bar, 300 yd south of the mainland. 4 - 6 ft deep.	56	317,696	Nearly surrounded by existing natural oyster bars, this reef was constructed by laying shucked shell on bottom unsuitable for natural reef development because of several inches of mud over an extinct oyster bed. Spat fall was heavy from 1968 to mid-1969. Salinity variations in mid-1969 and mid-1970 killed smaller oysters and delayed spat fall, thus preventing harvest until 1971-72. Heavy strike and a dense growth of 1 to 2 in. oysters was observed.
January 1968 to June 1968	Main Channel plant, Franklin County: near No. 7 & 9 buoys 200 ft east of the main channel to Apalachicola, 5 to 7 ft deep.	8	59,040	Nearly 50% of shucked shell planted was lost in deep mud. 8 to 10 scattered beds remain, totaling about 4 acres. Excellent oysters were taken during 1970-71. Samples taken in summer 1971 indicated a dense growth of large commercial quality oysters. These small beds are harvested preferentially during periods of inclement weather because of their proximity to Apalachicola.
January 1968 to April 1968	8-Mile plant, Franklin County: 200 yd offshore from 8-Mile on the north side of St. Vincent Sound, 4 to 6 ft deep.	2	15,240	Using shucked shell, this reef was established near beds previously rehabilitated and on top of an extinct oyster bed overlain by 4 to 6 inches of mud and silt. Strike was evident in late summer 1968 and dense spatfalls have been observed annually since. Sampling revealed a well-developed oyster bed with a high density of oysters of commercial quality and quantity. Oysters were harvested here during the 1969-70 and 1970-71 season.

APPENDIX 2. DEPARTMENT OF NATURAL RESOURCES OYSTER PLANTINGS MAY 1967 THROUGH JUNE 1971

(CONTINUED)

Date	Location	Area (acres)	Cultch Volume (bushels)	Evaluation
April 1968 to July 1968	Big Bayou Flats plant, Franklin County: 1-1/4 mi NE from the mouth of Big Bayou on St. Vincents Island, 4 to 6 ft deep.	4	28,056	Shucked shell was planted on top of an extinct reef covered by 3 in. of mud and adjacent to producing beds on 3 sides. Strike was evident 6 months after planting and sampling since mid-1969 revealed quality oysters up to 6 in. long. Tongers harvested the reef during the 1970-71 season and thereafter.
July 1968 to October 1968	Paradise Flats plant, Franklin County: 1/2 mi north of St. Vincent Island in St. Vincent Sound. 4 to 6 ft deep.	12	81,312	This reef was planted by placing shucked shell on an extinct natural reef covered by 4 to 6 in. of mud and nearly surrounded by producing natural bars. Strike was evident from sampling in summer 1969. Samples taken in 1971 revealed oysters of all sizes up to 6 in. long. There was a good year class of oysters 1 to 2 in. long which became available for harvest during the 1971-72 season.
15 Aug. 1968	Brevard plants, Brevard County: 2 small sites south of Grant Farm Island. 5 ft deep.	.5	336	Two reefs were constructed, using 1-1/2 in. diameter grade Miami oolite (limestone) for cultch. Samples taken 2 months later revealed a very dense strike. Oysters 3 in. long were observed at the end of 6 months and up to 4 in. long by the end of 1 year. These plants indicated the feasibility of using mined limerock for cultch in areas lacking shell cultch and demonstrated the potential of southern Brevard County for oyster cultivation.
February 1969	California Bayou Flants plant, Bay County: 1/2 mi SW of California Bayou in East Bay. 6 ft deep.	2	15,665	Using dredged (mud) shell, this reef was constructed east of Panama City adjacent to producing natural reefs. Samples taken in late summer 1969 revealed a dense spat catch. Oysters were tonged from the bed during the 1970-71 oyster season and oysters up to 4 in. long were found in summer 1971.
February 1969	Newman Bayou plant, Bay County: 1/2 mi SE of Newman Bayou and 1-1/2 mi SW of Southport in North Bay. 6 ft deep.	6	37,663	This reef was constructed of dredged (mud) shell and located near a concentration of shucking houses in Southport. It is partially surrounded by producing natural beds. Strike was evident by summer 1969 and large concentrations of commercial-size oysters were harvested in 1970.

APPENDIX 2. DEPARTMENT OF NATURAL RESOURCES OYSTER PLANTINGS MAY 1967 THROUGH JUNE 1971

(CONTINUED)

Date	Location	Area (acres)	Cultch Volume (bushels)	Evaluation
May 1969 to June 1969	Redfish Creek Flats plant, Franklin County: 1/2 mi north of Redfish Creek on St. Vincents Island in St. Vincents Sound. 6 ft deep.	22	135,240	A reef was constructed of shucked shell placed on top of an extinct oyster bed covered by 6 to 8 inches of silt and mud. Strike was heavy by the end of summer 1969. Samples taken in 1970 indicated oysters of commercial quantity and quality. Oysters grew up to 5 in. long by summer 1971.
October 1969 to October 1970	Green Point Flats plant, Franklin County: 1 mi south of Green Point in Apalachicola Bay. 4 to 6 ft deep.	87	548,184	Shucked shell was used to plant this reef on top of an extinct oyster bar. Strike was observed on the reef by 1970 and samples taken during summer 1971 revealed many 1 to 2 in. oysters. This reef is close to shucking houses at 2-Mile and will be available for commercial harvesting during the 1972-73 season.
¹⁵ November 1970 to March 1971	Cabbage Lump Flats No. 2 plant, Franklin County: 1 mi from the NE corner of St. Vincent Island. 6 ft deep.	20	130,704	This reef was constructed of shucked shell placed on top of an old reef covered by 6 to 8 inches of mud. Heavy strike was observed during summer 1971. This bed is expected to produce commercial oysters during the 1972-73 season.
November 1970 to March 1971	7-Mile plant, Franklin County: 300 yd offshore from the mainland at 7-Mile in St. Vincents Sound. 4 to 6 ft deep.	8	45,696	Shucked shell was used to construct this reef on top of an extinct reef under 4 to 6 inches of silt and mud. Samples taken in summer 1971 revealed a small strike. The site is adjacent to natural oyster reefs.
May 1967 to July 1971 TOTAL		308.5	1,904,688	

APPENDIX 3. GLOSSARY OF TERMS

- Coliform contamination:** water or other pollution caused by fecal bacteria.
- Commercial-sized oyster:** a legal-sized oyster, i.e., at least 3 inches long.
- Construction of oyster reefs:** the use of cultch to build or develop an oyster habitat similar to natural reefs upon an area where no natural oyster reef exists.
- Coon bar:** a bar or reef of coon oysters, generally in intertidal or higher salinity areas (30 o/oo).
- Coon oyster:** an undersized oyster, generally resulting from overcrowding or poor growing conditions.
- Cultch:** any solid material placed in the water to furnish points of attachment for oyster spat.
- Dockside value:** value of oysters to the tonger.
- Extinct oyster bar or reef:** a dead oyster bar, commonly found under sediments.
- Fossil (or mud) shell:** shell mixed or dredged from an extinct oyster, clam, or mussel bar or reef. This shell is commonly found buried under mud or sand.
- Fouling:** covering or clogging the surface of cultch by a variety of marine organisms, silt, or foreign matter, preventing or impeding oyster spat strike.
- Leased oyster reef:** submerged land leased for private oyster cultivation under the laws found in Chapter 370.16, Florida Statutes.
- Legal-sized oyster:** see commercial-sized oyster.
- Oolite limestone:** limestone, rock, or aggregate composed of minute cemented grains.
- Oyster:** the American eastern oyster, *Crassostrea virginica* (Gmelin).
- Oyster length:** the longest measurable length of an oyster. Technically, oyster "height."
- Oyster meats:** the flesh of oysters after removal from the shell.
- Oyster reef, bar, or bed:** an oyster habitat characteristically consisting of a raised area of bottom densely covered with oysters.
- Oyster tongs:** a tool for harvesting oysters (consisting of a pair of curved rakes on long handles connected for scissor-like use by an oysterman).
- Rehabilitation (of oyster reef):** restoration of an existing, but nonproducing, oyster reef.
- Shucked shell:** oyster shells (valves) remaining after the meats have been removed.
- Shucking house:** a building or place, usually commercial, where oysters are removed from their shells.
- Siltation:** accumulation of suspended nonliving materials on submerged surfaces, sometimes of sufficient thickness to smother oysters or prevent spat set.
- Spat:** a young, settled (postlarval) oyster.
- Strike or set (colloquial):** the act of oyster larvae attaching to oyster cultch; also the density of the resulting oyster spat.
- Submerged land, water bottoms:** land temporarily or permanently covered by water. Usually land below the mean high water mark.
- Tonger:** an oysterman who uses oyster tongs to gather oysters.

APPENDIX 4. CONVERSION TABLE OF UNITS USED

English units are used by Florida oystermen, hence their use in this paper. The following is a list of metric equivalents.

1 acre	=	4.047 x 10 ⁻¹ hectares	1 foot	=	3.048 x 10 ⁻¹ meters
1 acre	=	4.047 x 10 ³ square meters	1 horsepower	=	1.014 metric horsepower
1 bushel	=	1.2445 cubic feet	1 inch	=	2.540 x 10 ⁻² meters
1 bushel	=	3.524 x 10 ⁻² cubic meters	1 inch	=	2.540 centimeters
1 bushel	=	3.524 x 10 ¹ liters	1 pound	=	4.5 x 10 ⁻¹ kilograms
1 cubic foot	=	3.704 x 10 ⁻² cubic yards	1 ton (short)	=	9.0718 x 10 ² kilograms
1 cubic yard	=	7.646 x 10 ² liters	1 ton (short)	=	9.0718 x 10 ⁻¹ metric tons
1 cubic yard	=	7.646 x 10 ⁻¹ cubic meters			



Figure 1. Self-propelled barge loaded with shucked shell under way to a planting site in Apalachicola Bay.

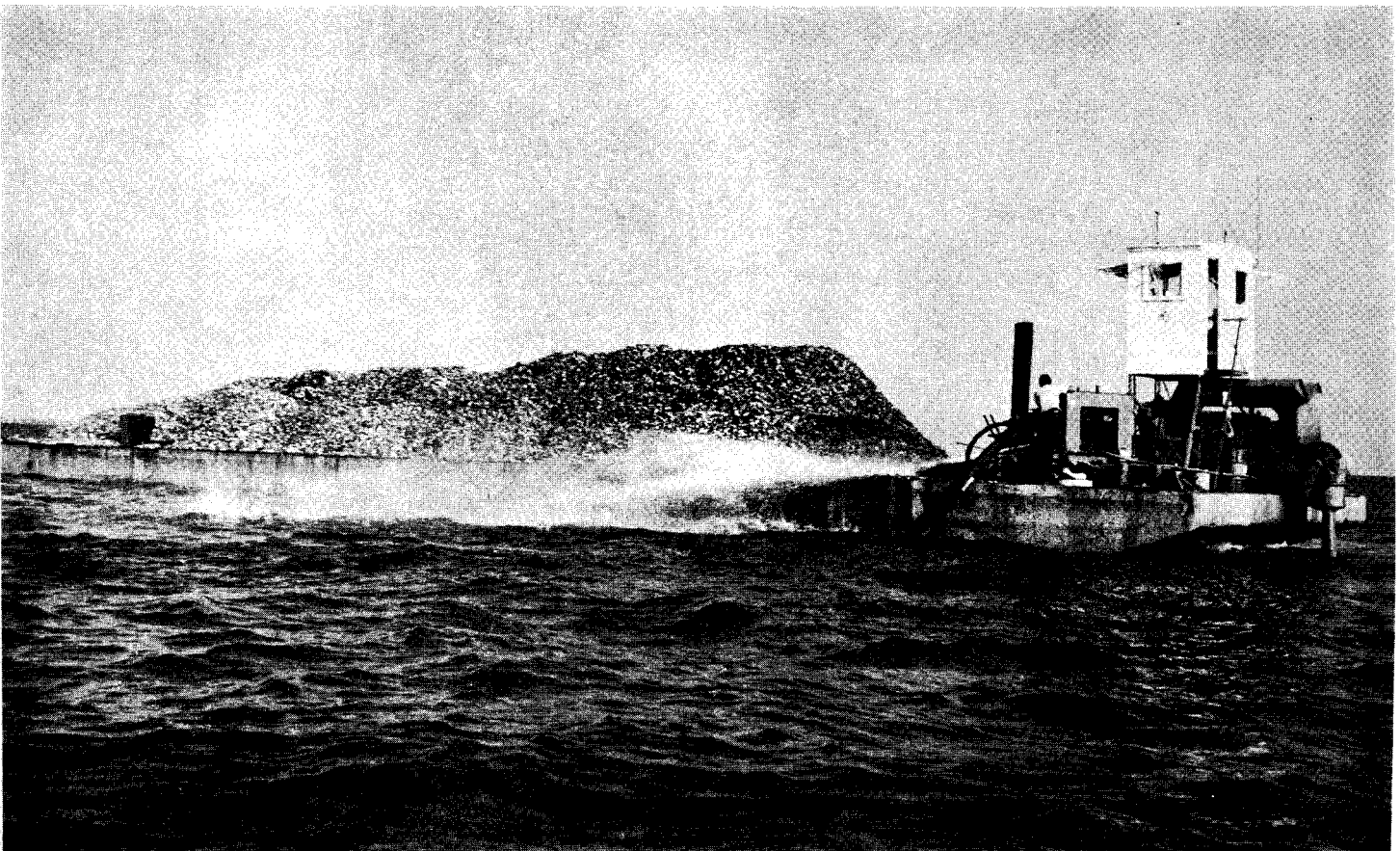


Figure 2. Shell being unloaded from barge anchored by spud using a high pressure water stream.

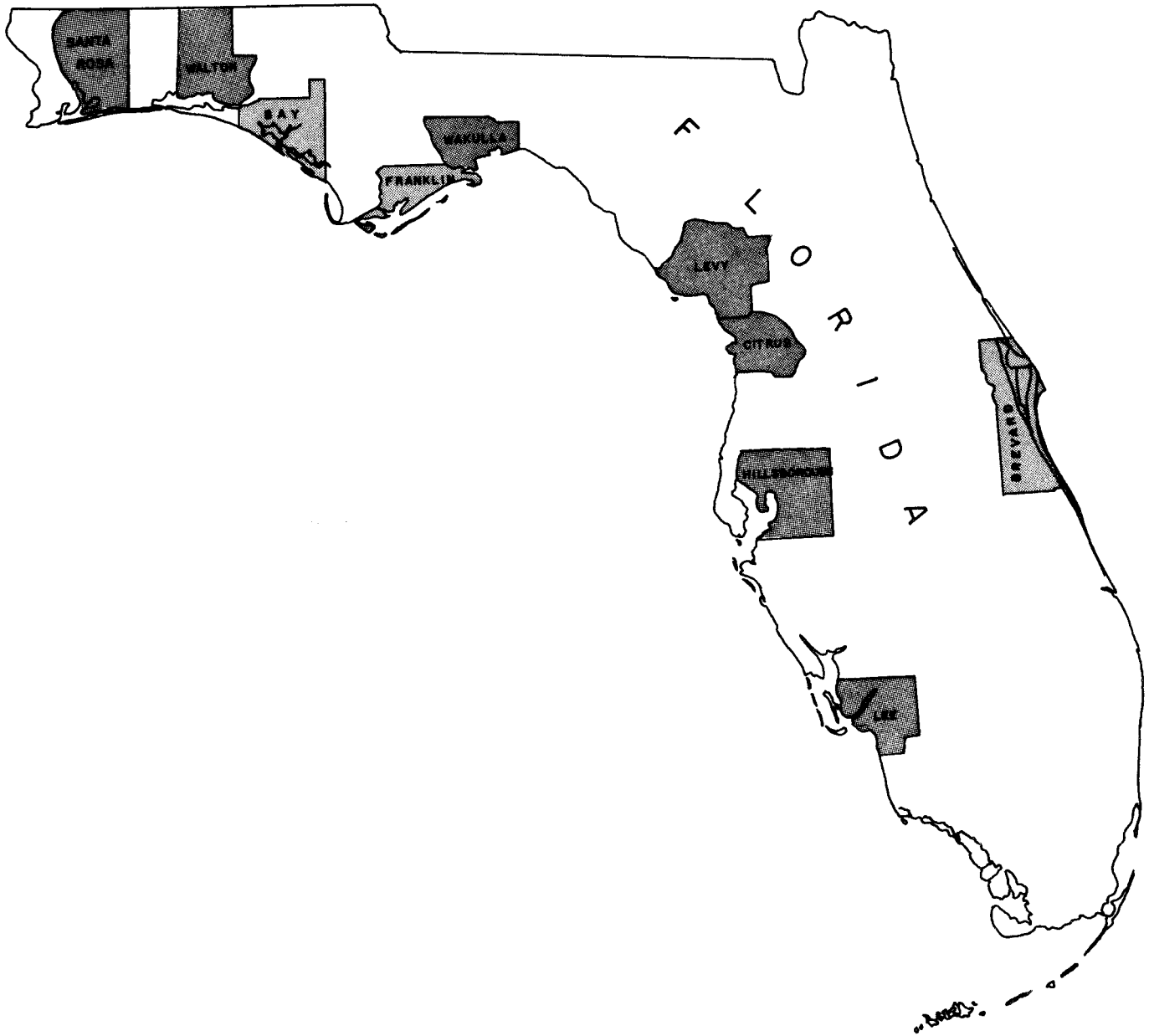


Figure 3. Counties in which oyster rehabilitation work has been conducted by the State.

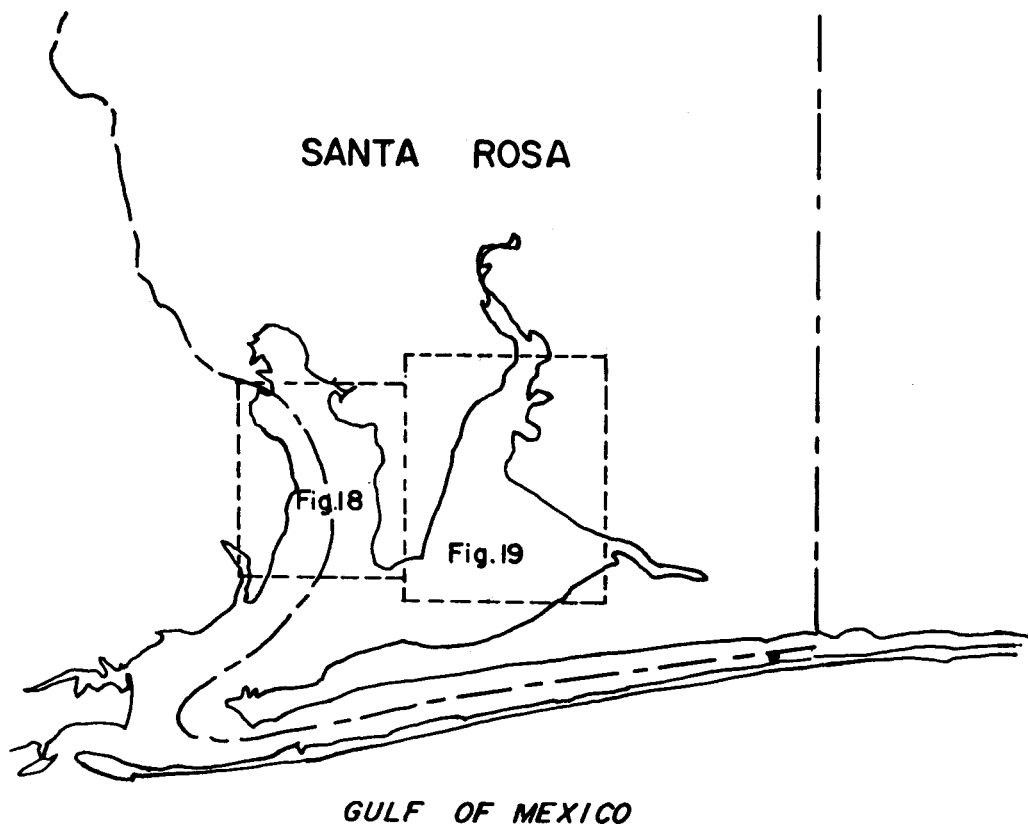


Figure 4. Oyster rehabilitation localities in Santa Rosa County.

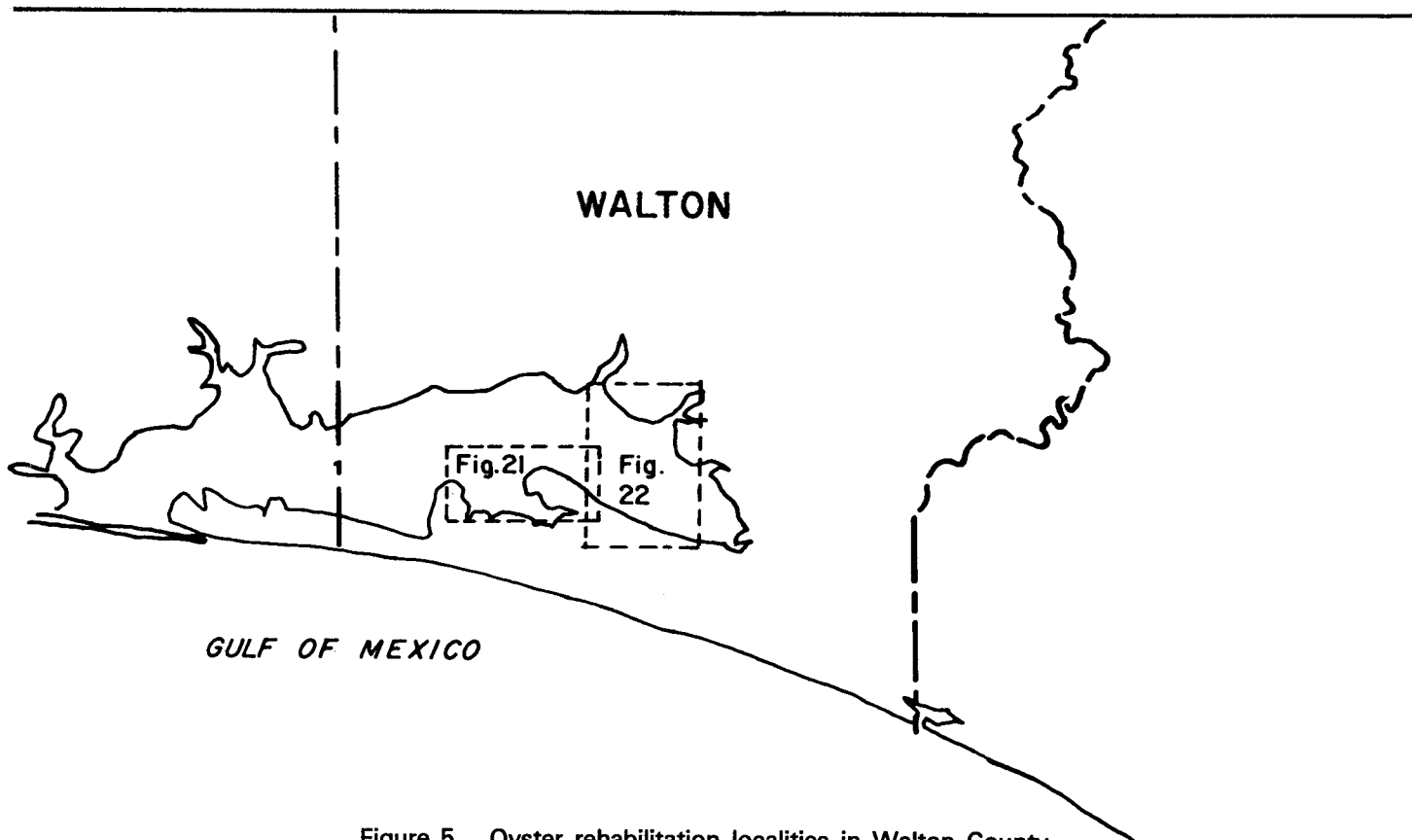


Figure 5. Oyster rehabilitation localities in Walton County.

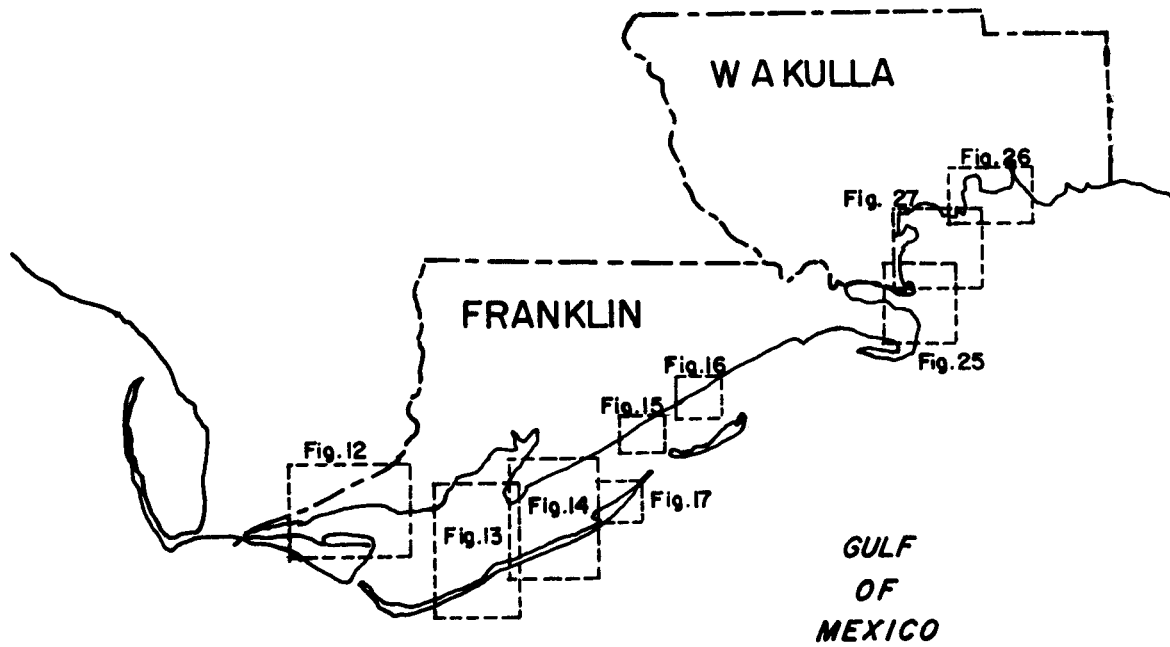


Figure 6. Oyster rehabilitation localities in Wakulla and Franklin Counties.

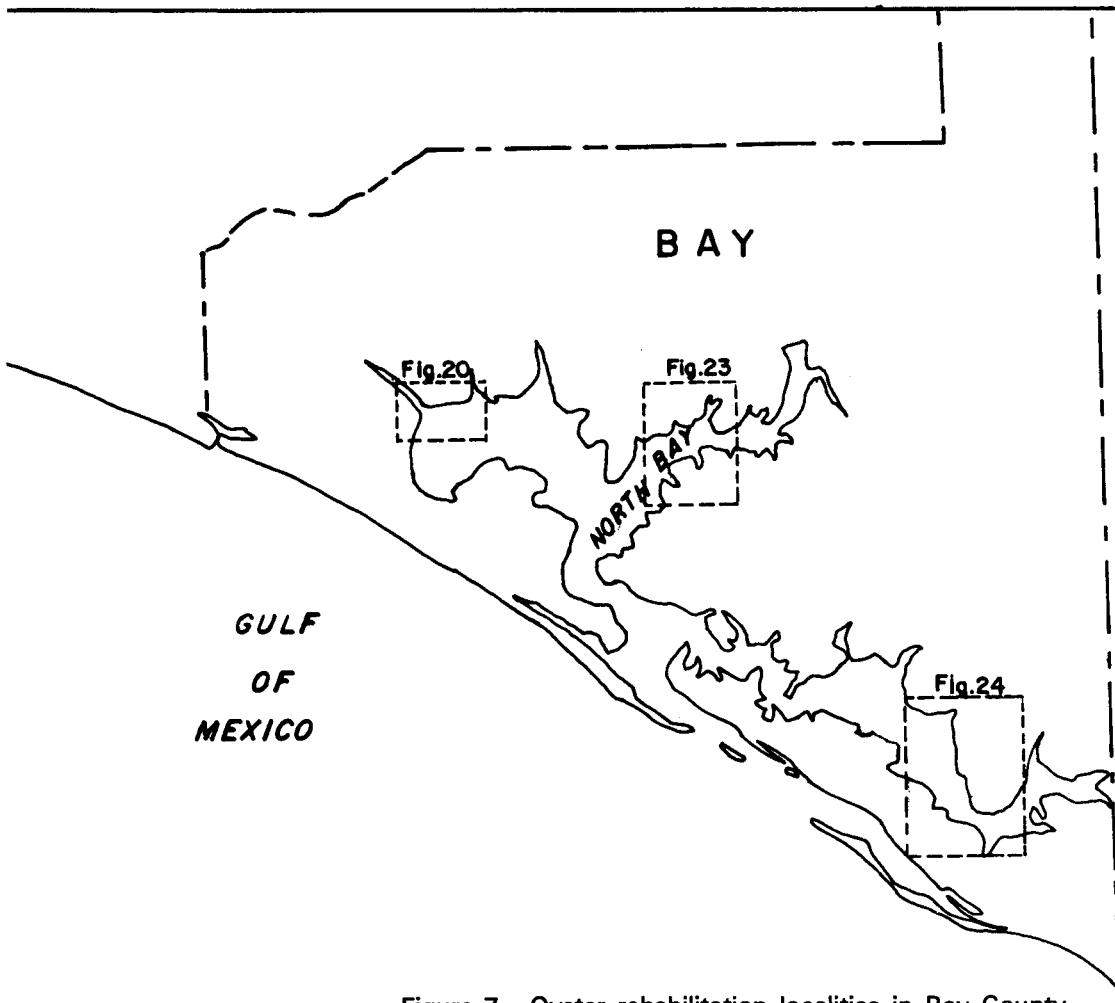


Figure 7. Oyster rehabilitation localities in Bay County.

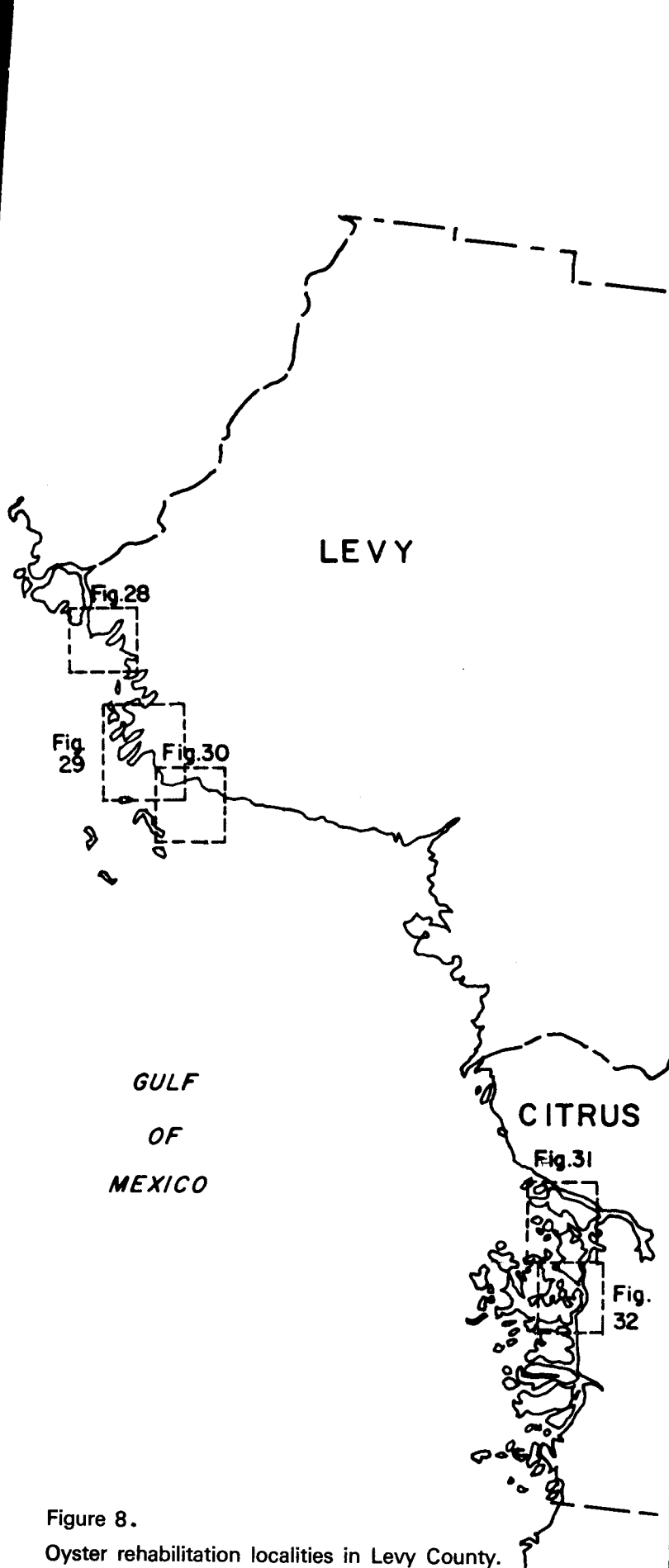


Figure 8.
Oyster rehabilitation localities in Levy County.

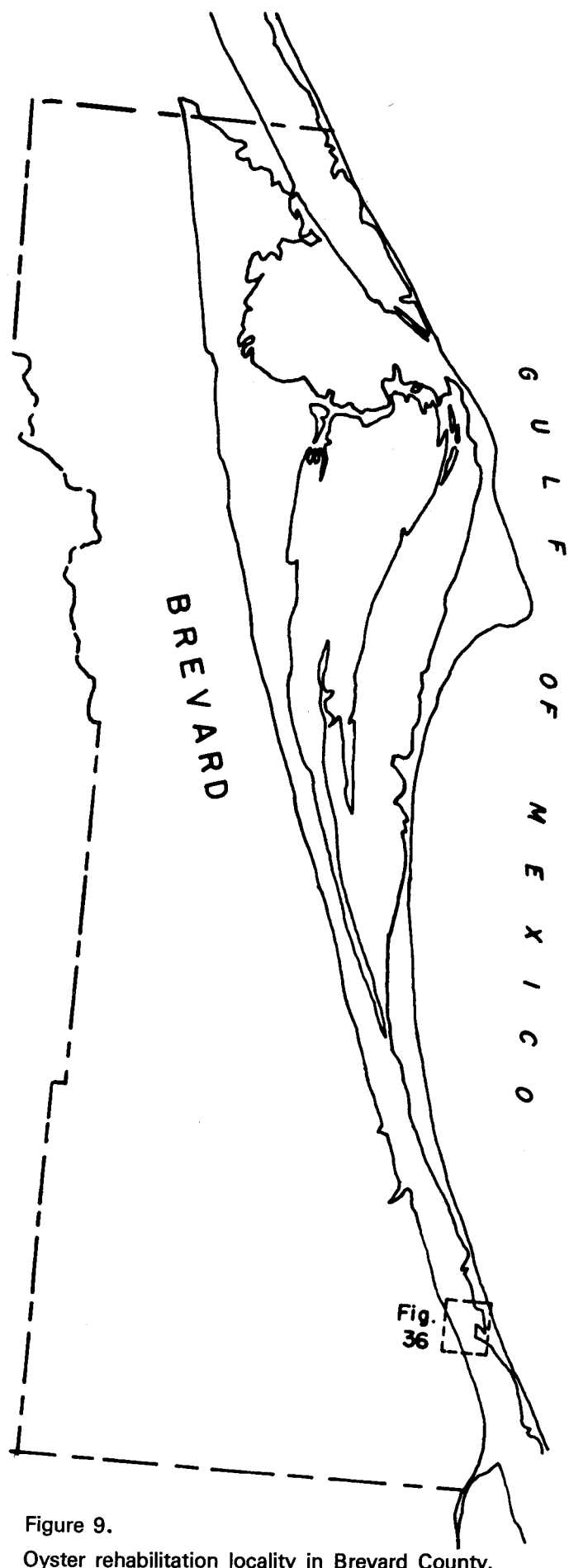


Figure 9.
Oyster rehabilitation locality in Brevard County.

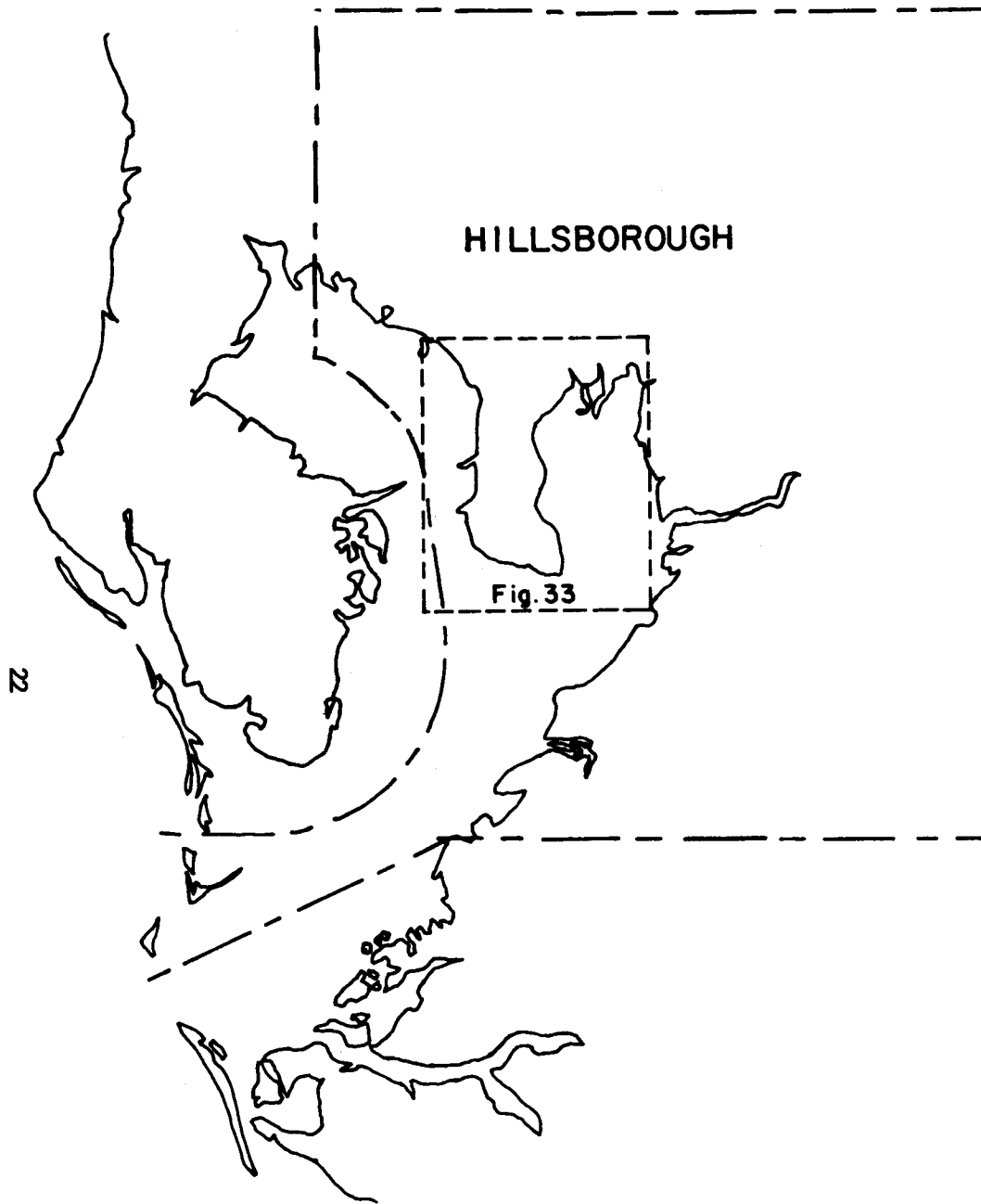


Figure 10. Oyster rehabilitation locality in Hillsborough County.

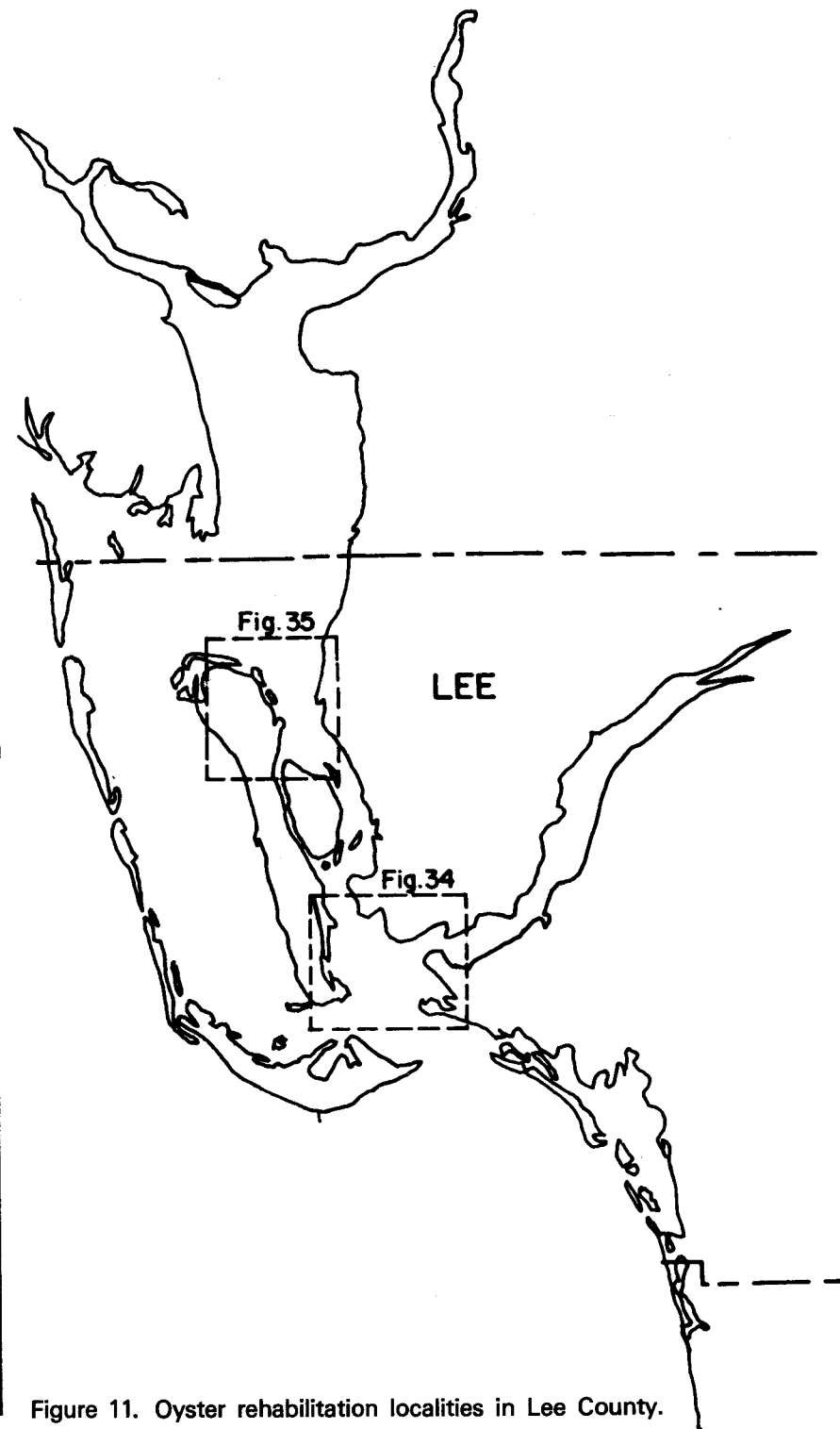


Figure 11. Oyster rehabilitation localities in Lee County.

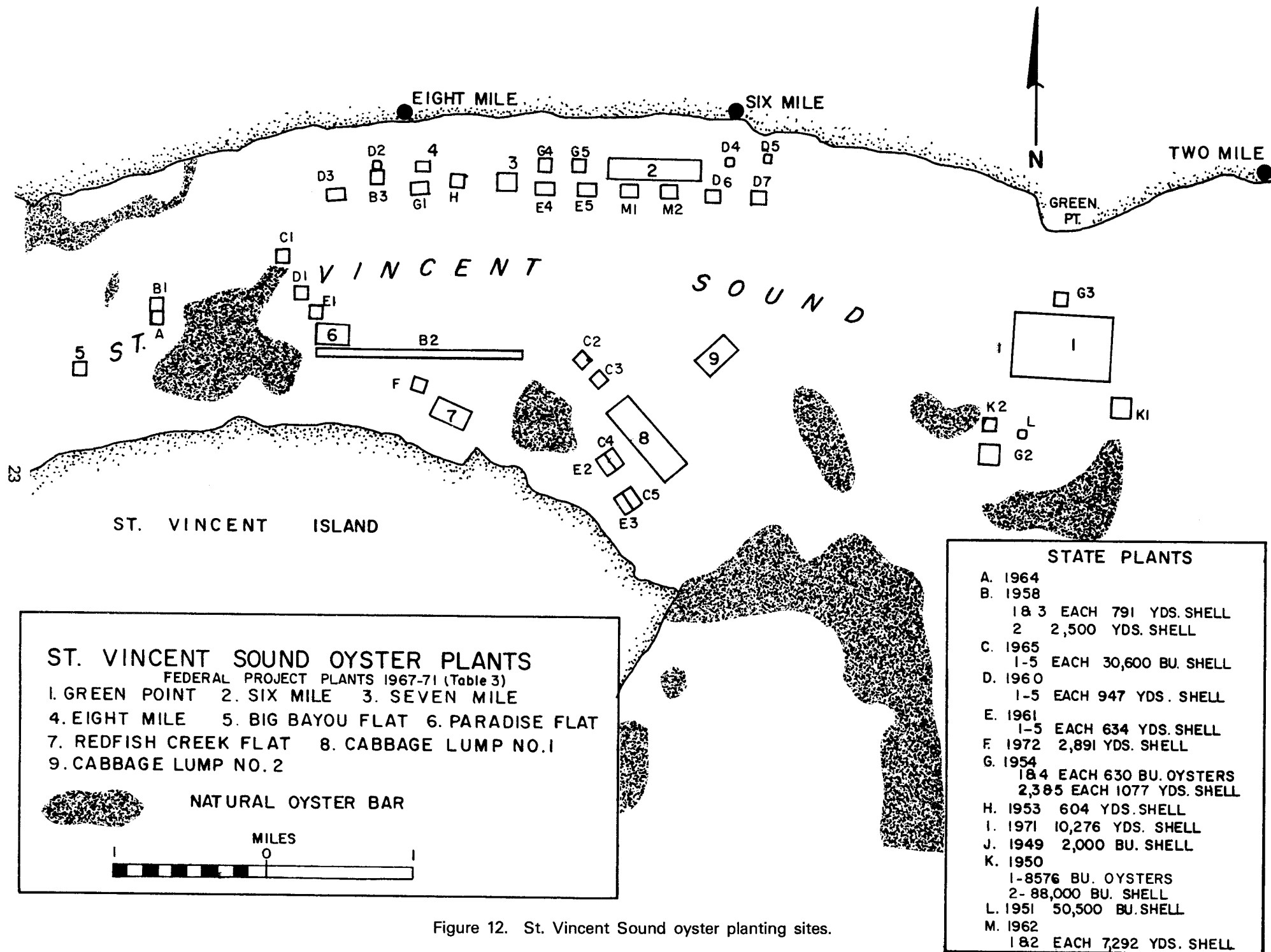
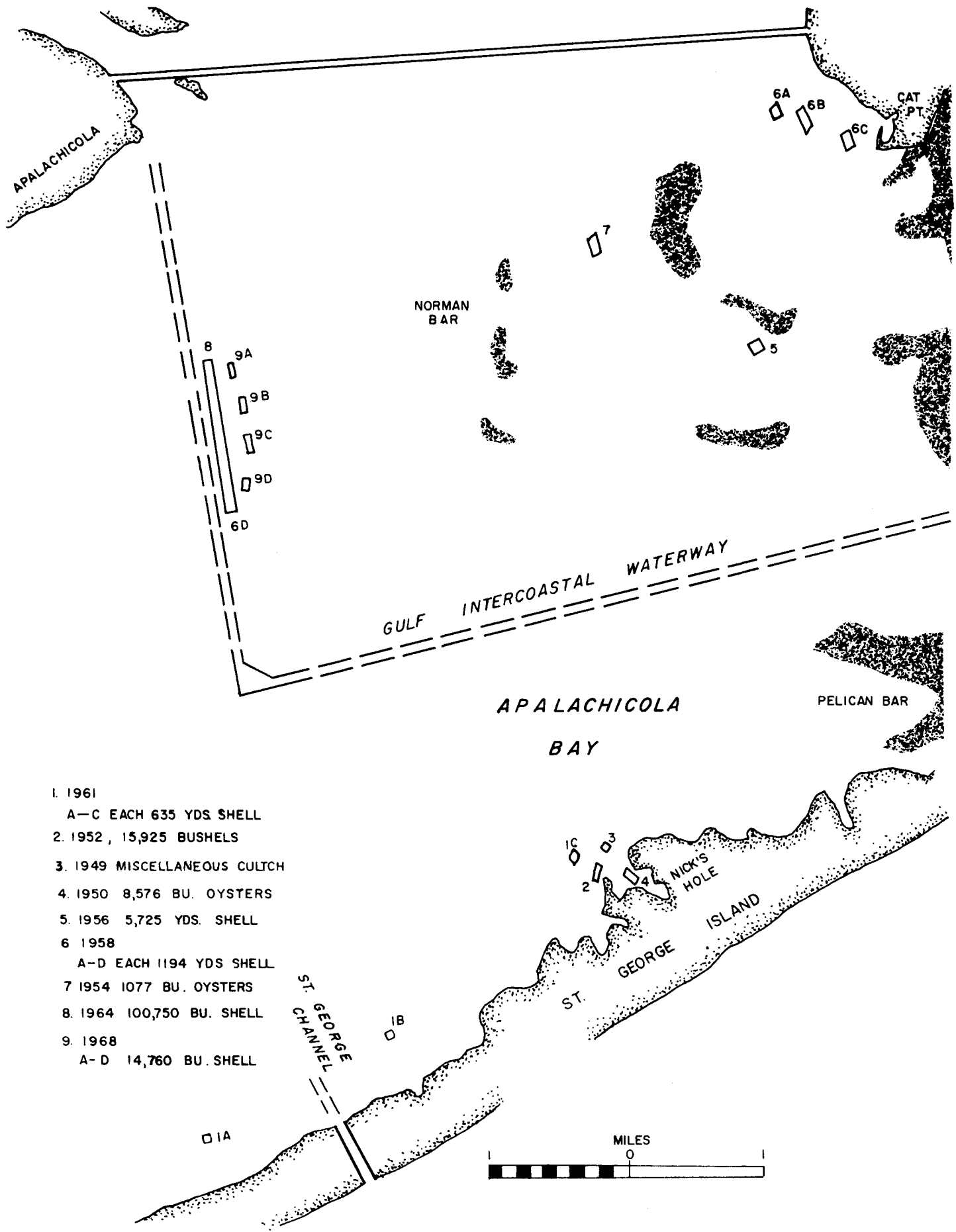


Figure 12. St. Vincent Sound oyster planting sites.



- 1. 1961
A-C EACH 635 YDS SHELL
- 2. 1952, 15,925 BUSHELS
- 3. 1949 MISCELLANEOUS CULTCH
- 4. 1950 8,576 BU. OYSTERS
- 5. 1956 5,725 YDS. SHELL
- 6. 1958
A-D EACH 1194 YDS SHELL
- 7. 1954 1077 BU. OYSTERS
- 8. 1964 100,750 BU. SHELL
- 9. 1968
A-D 14,760 BU. SHELL

Figure 13. Central Apalachicola Bay oyster planting sites.

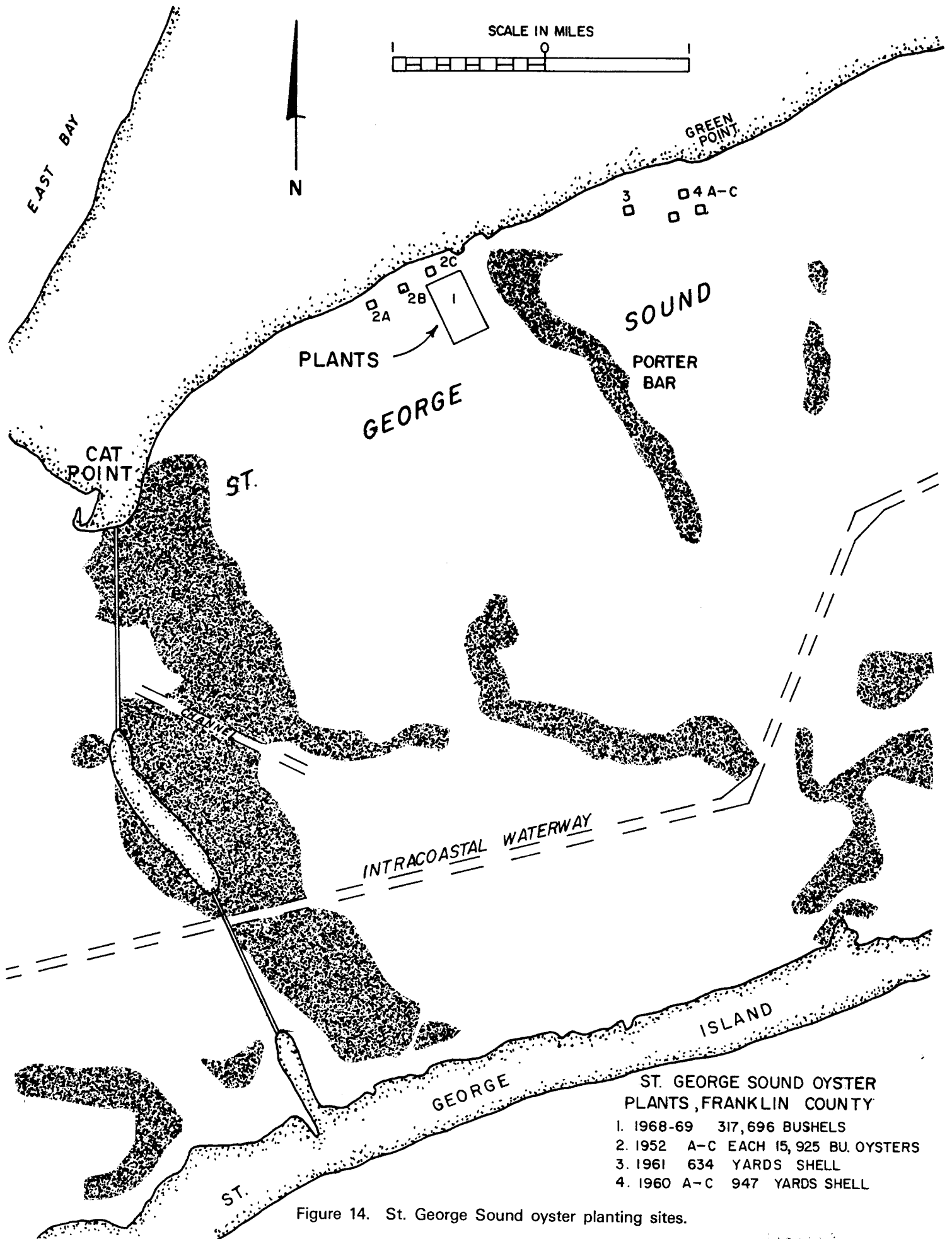
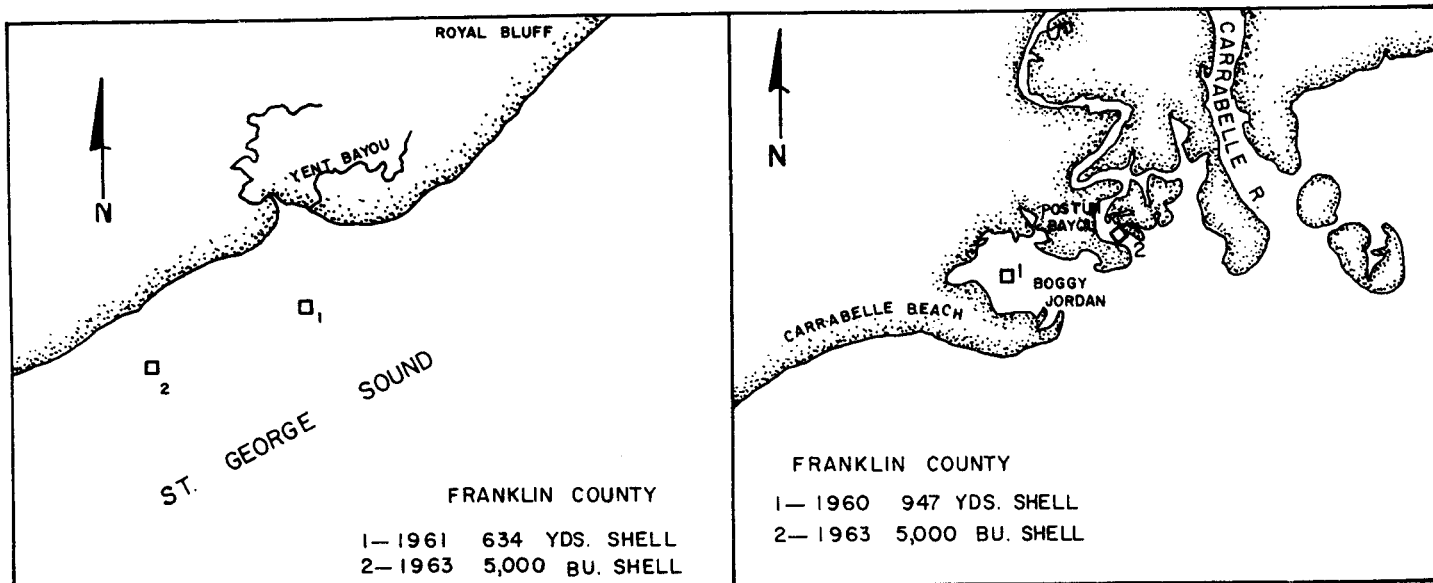
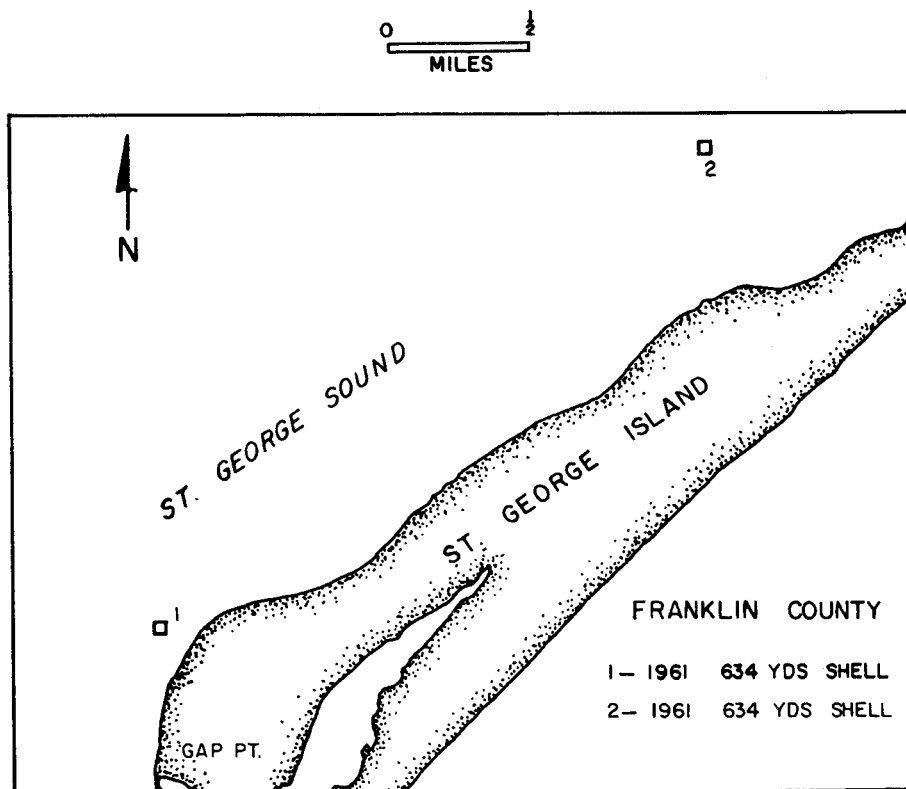


Figure 14. St. George Sound oyster planting sites.



Figures 15 (above, left), 16 (above, right), and 17 (below).
Oyster plants in eastern St. George Sound (all to same scale).



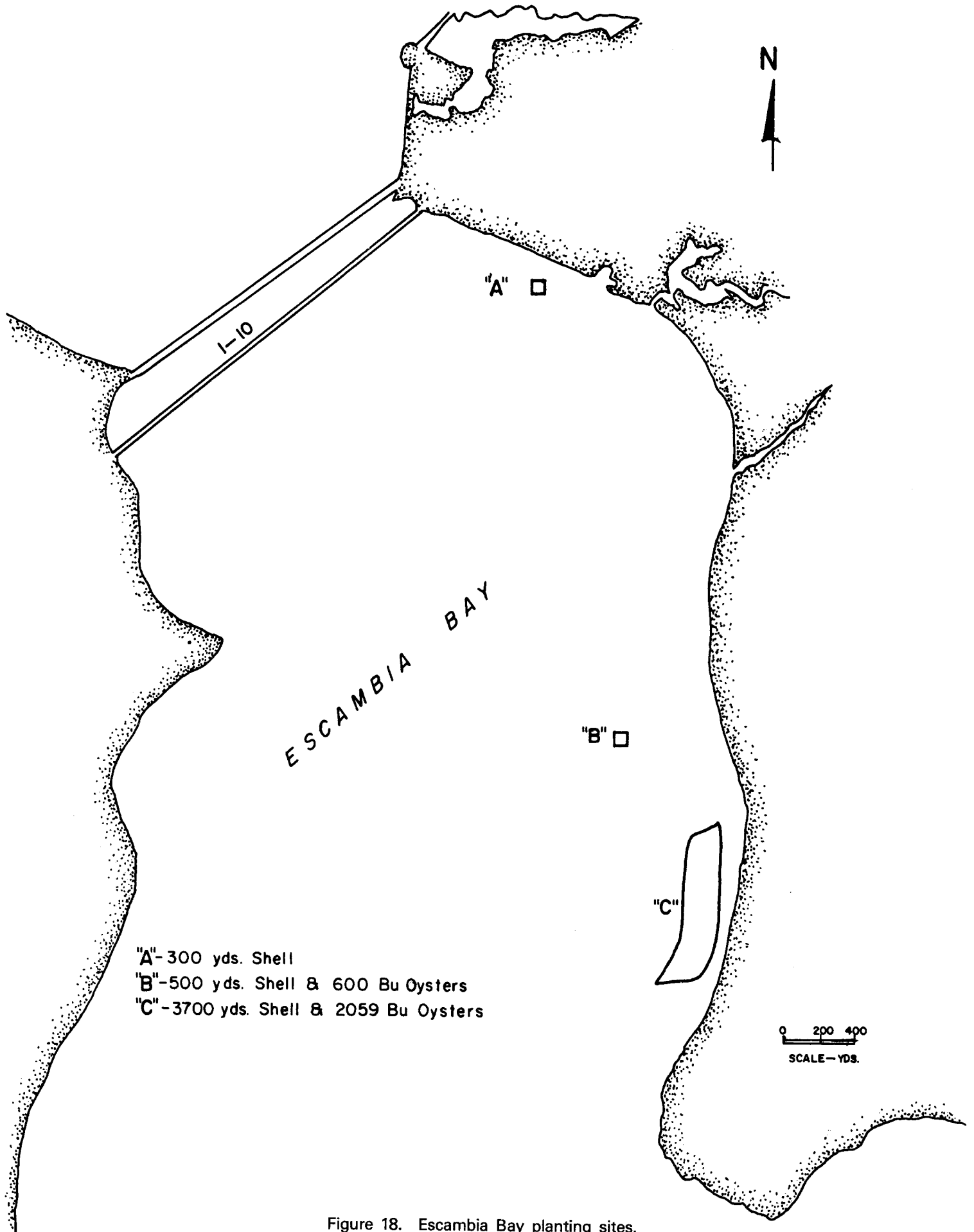


Figure 18. Escambia Bay planting sites.

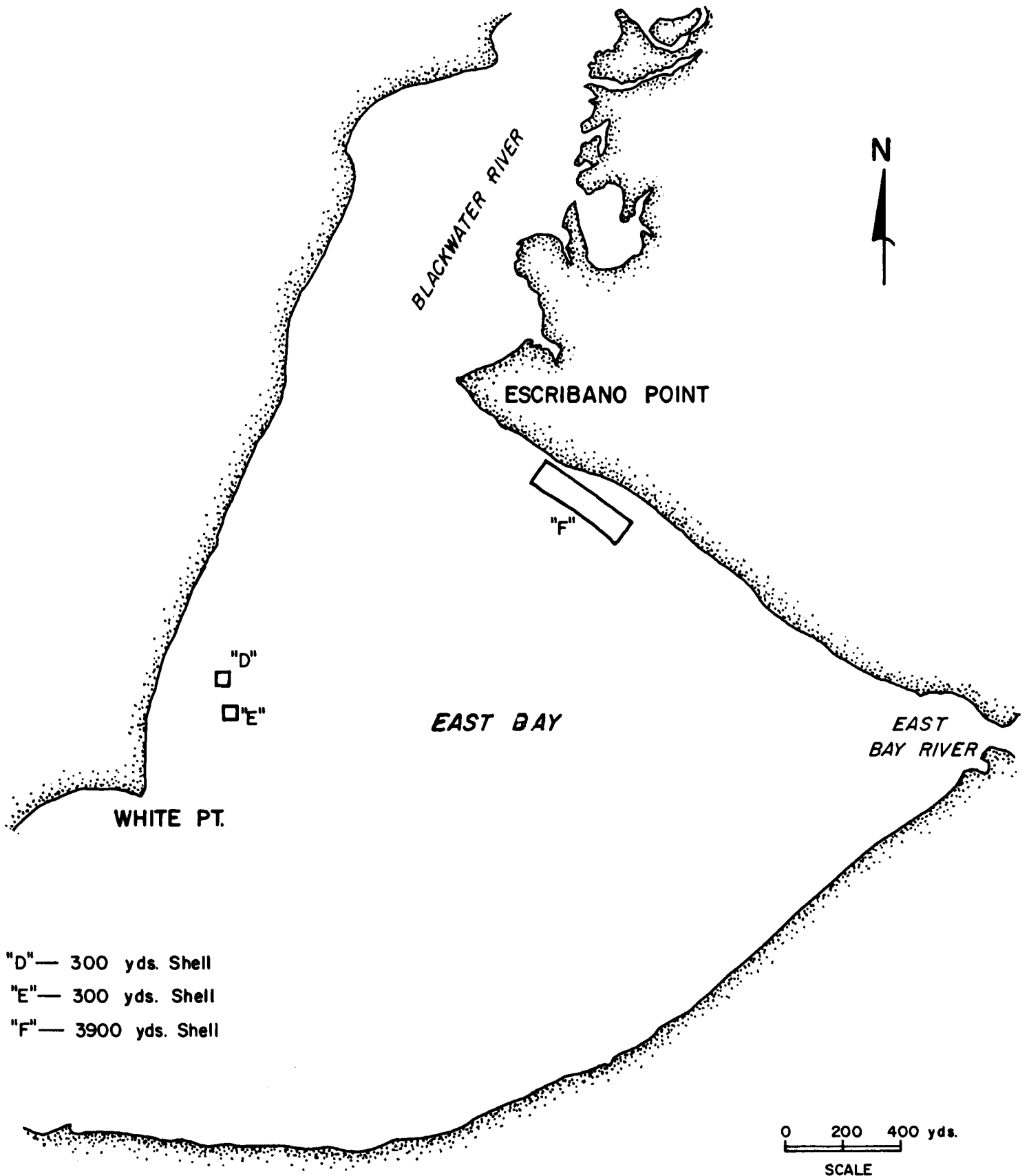


Figure 19. East Bay planting sites.

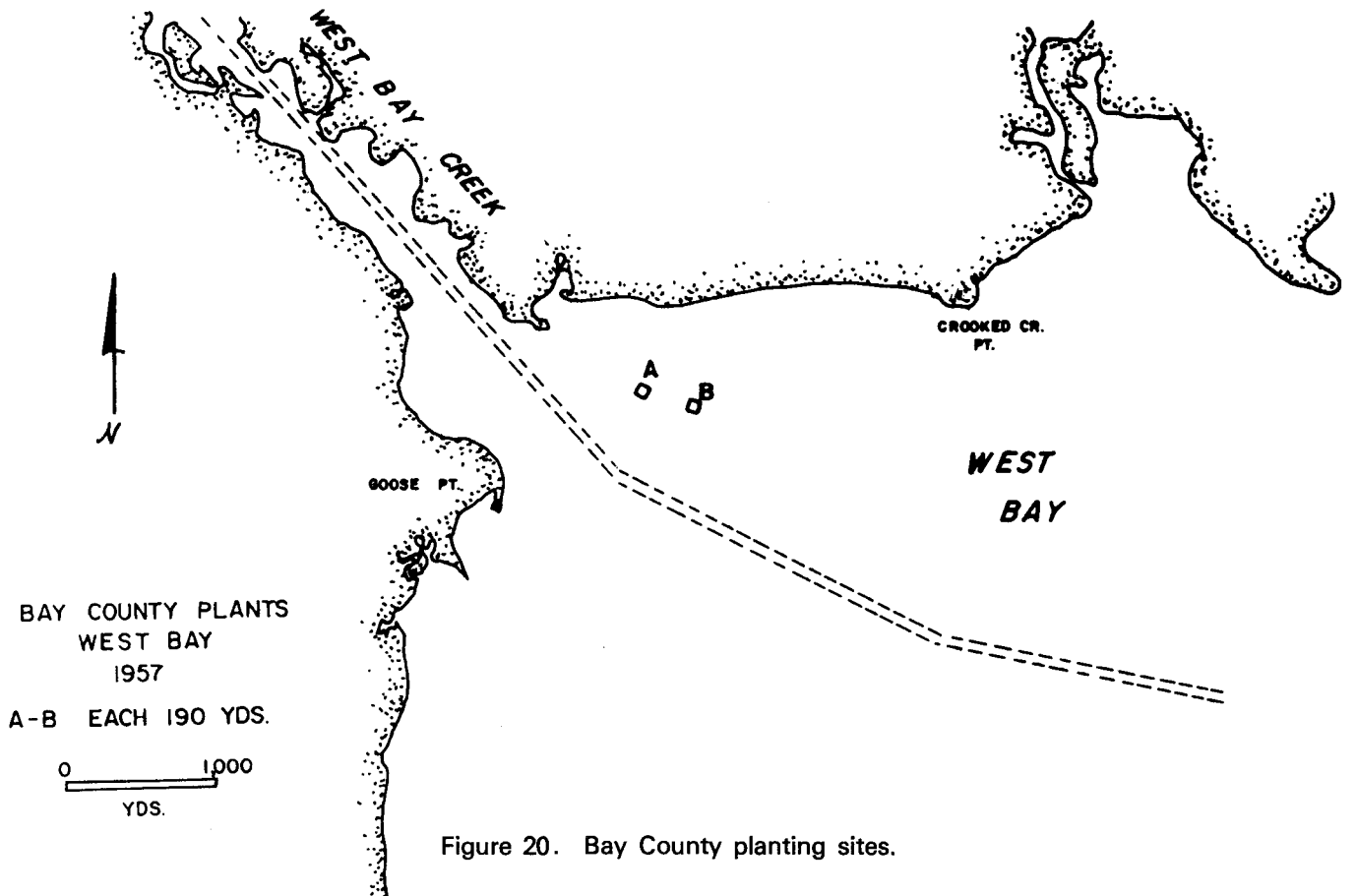


Figure 20. Bay County planting sites.

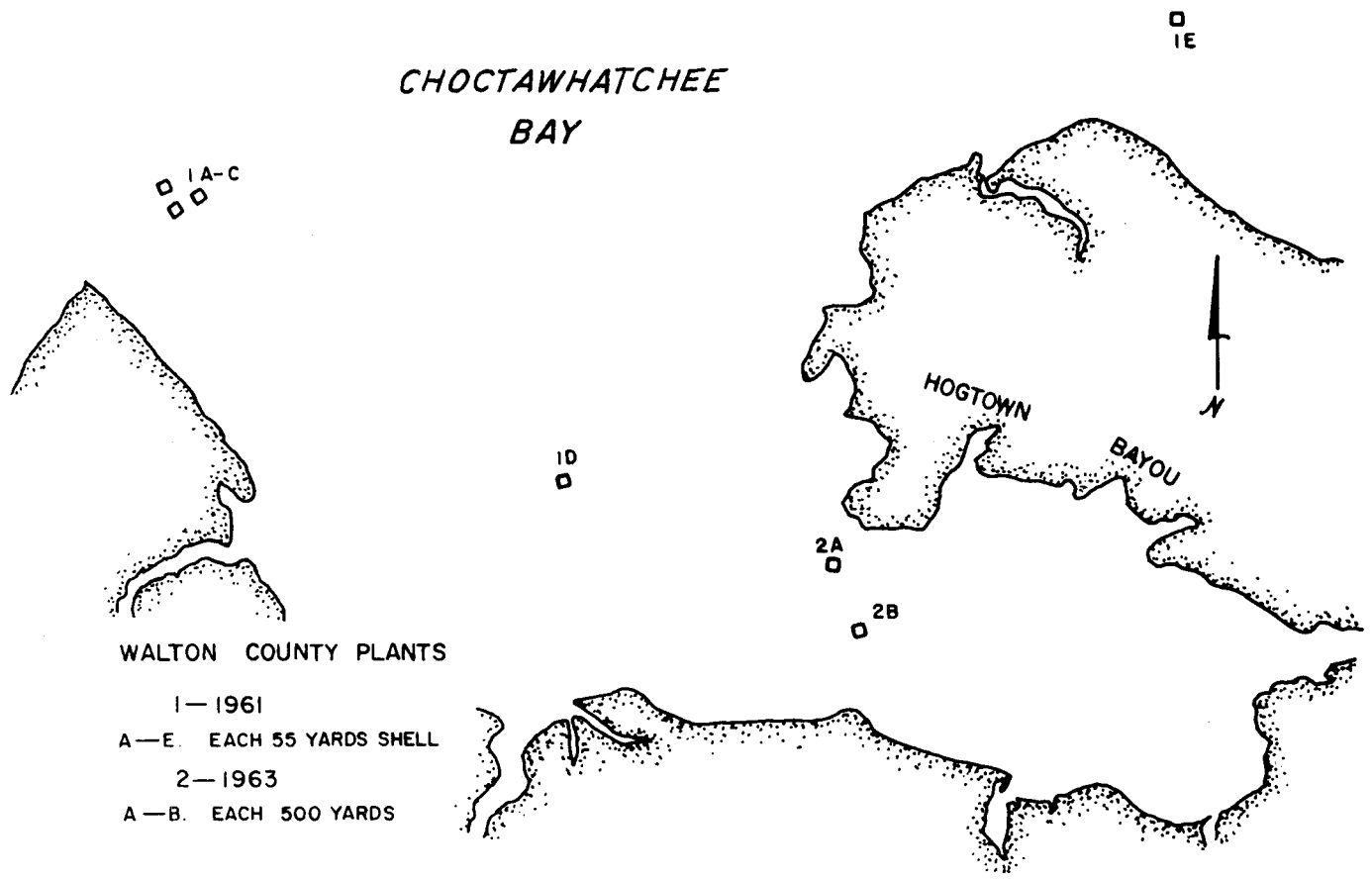


Figure 21. Walton County planting sites.

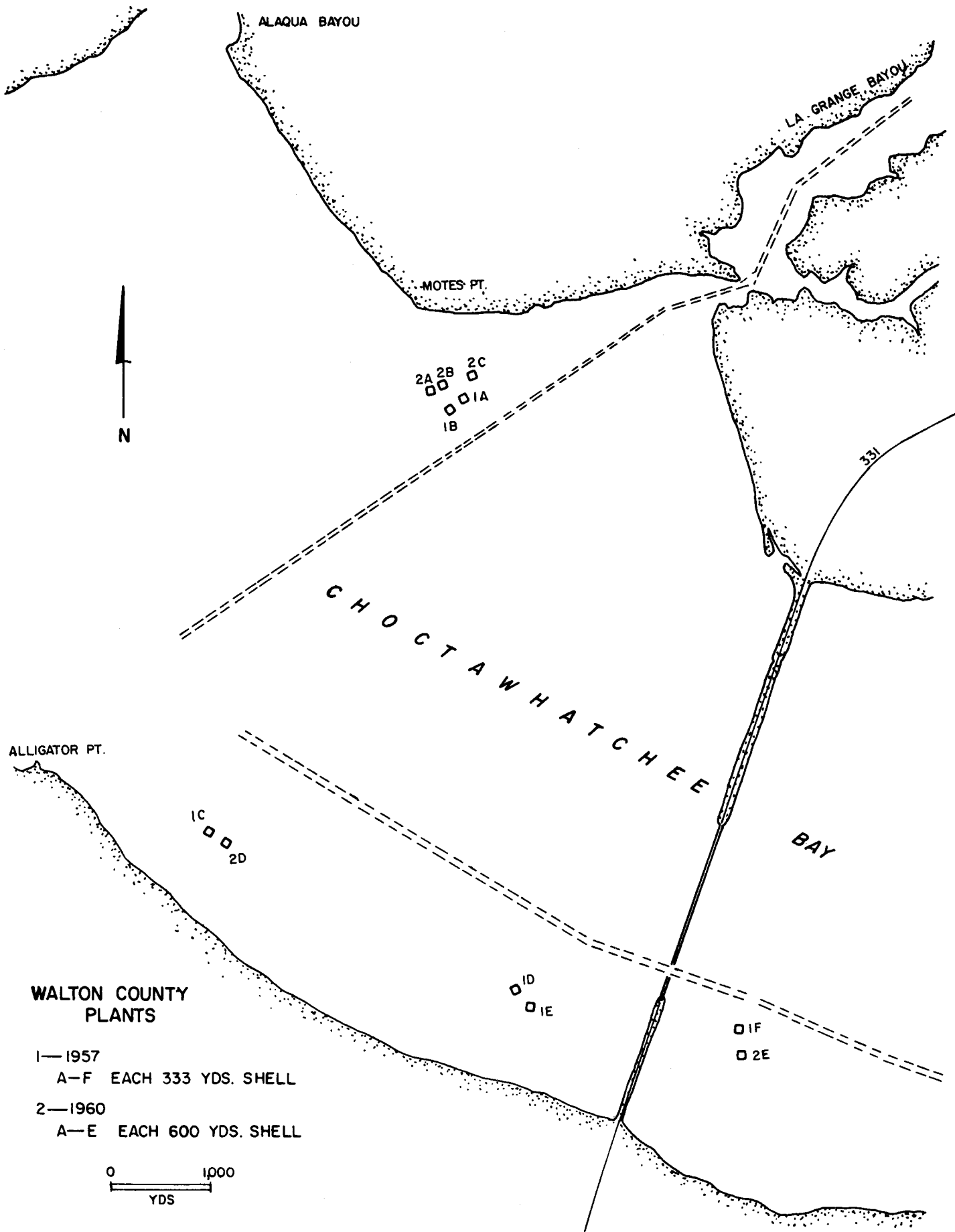
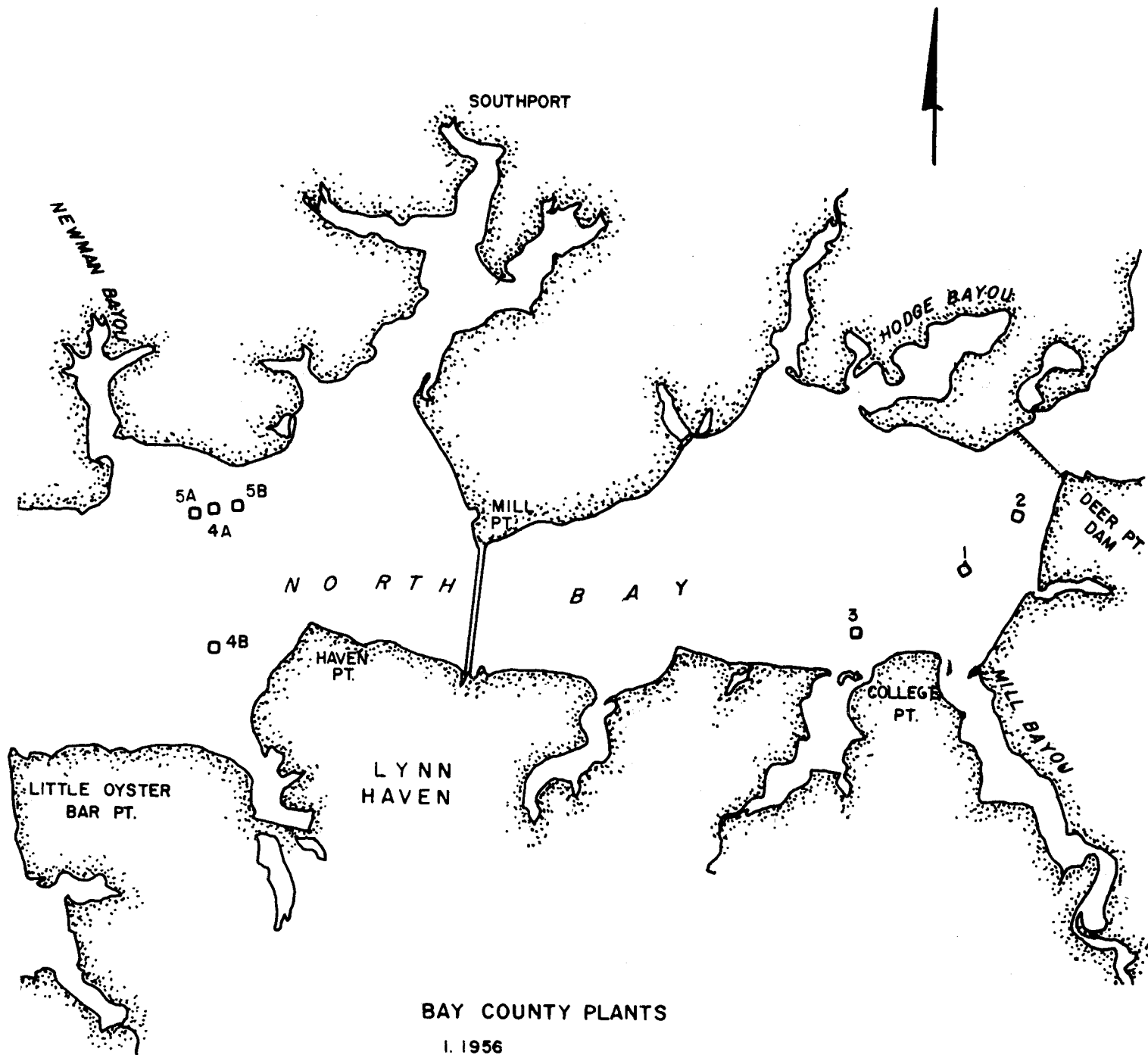


Figure 22. Walton County planting sites.



BAY COUNTY PLANTS

- 1. 1956
- 2. 1957 — 190 YDS. SHELL
- 3. 1960
- 4. 1964
- A, B EACH 11,000 BU. SHELL
- 5. 1969

0 ————— 1,000
YDS.

Figure 23. Bay County planting sites.

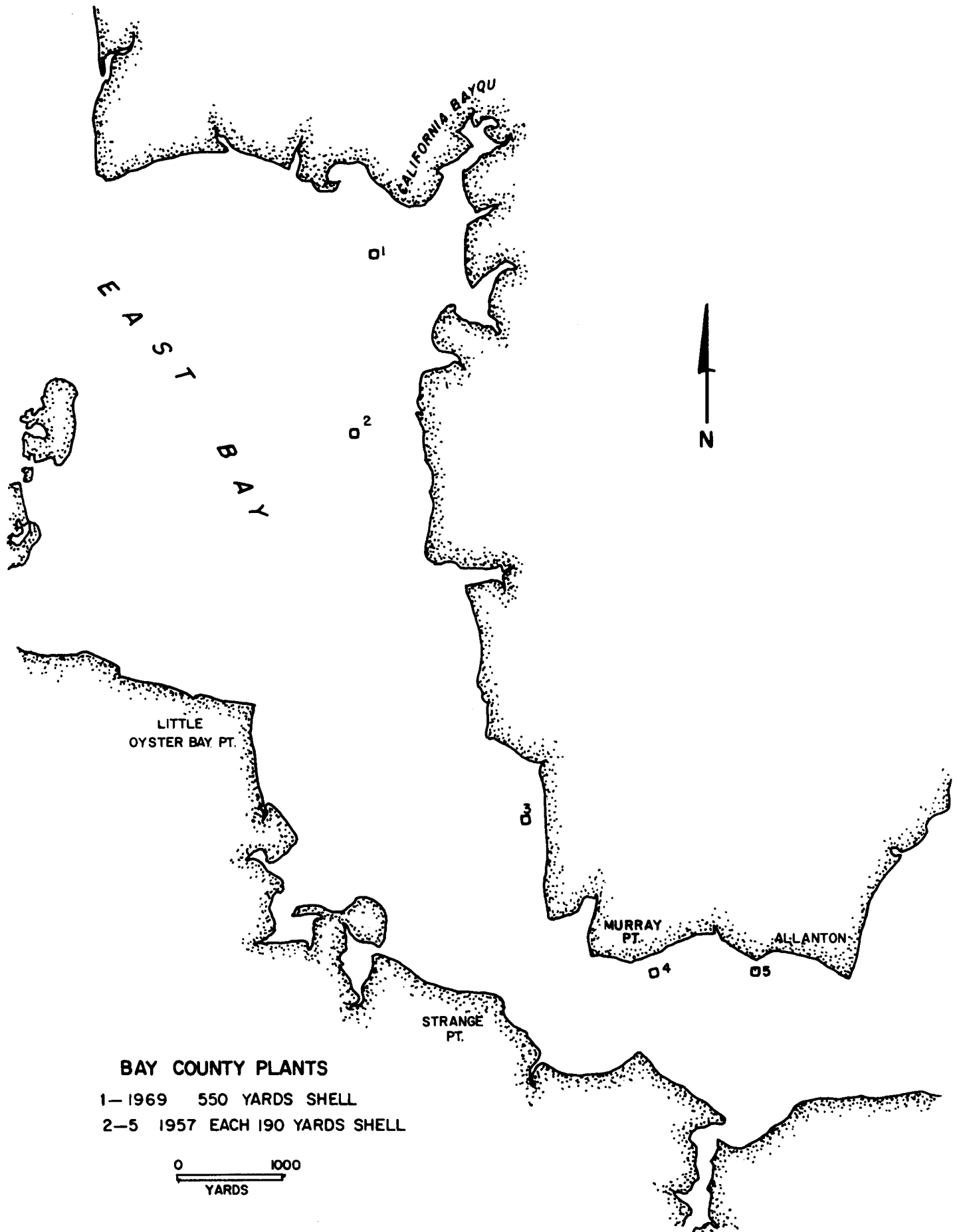
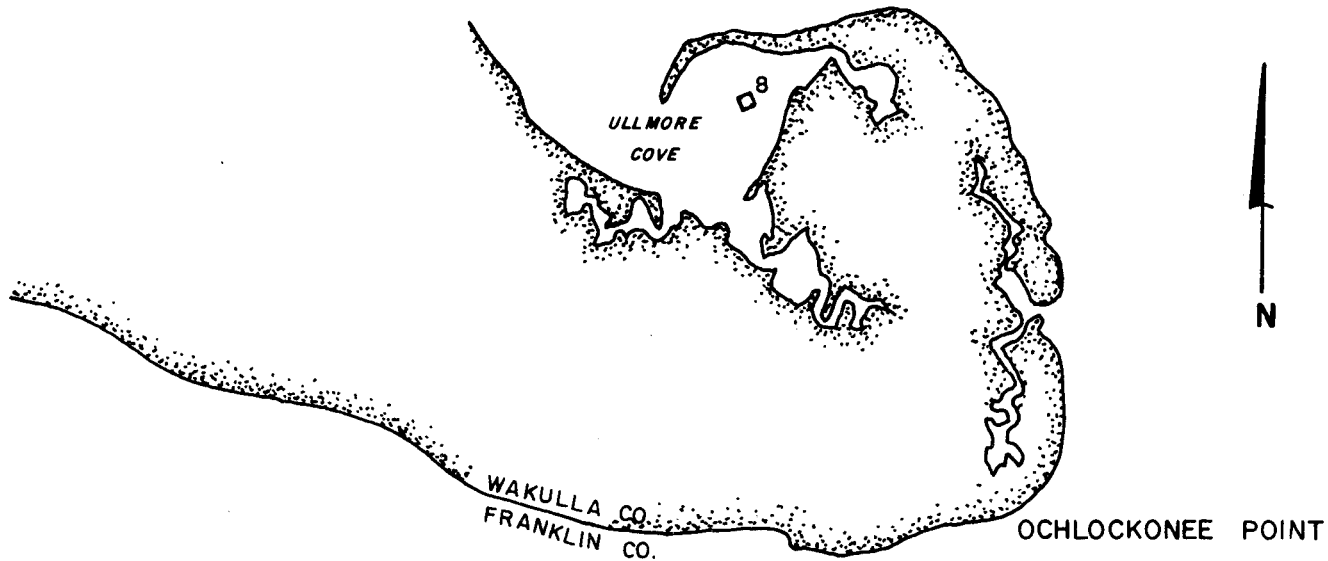


Figure 24. Bay County planting sites.



OCHLOCKONEE
BAY

ULLMORE COVE &
CHAIRES CREEK PLANTS
WAKULLA—FRANKLIN COUNTY
1957

- 1- 160 BUSHELS
- 2- 80 "
- 3- 160 "
- 4- 320 "
- 5- 356 "
- 6- 160 "
- 7- 160 "
- 8- 60 "

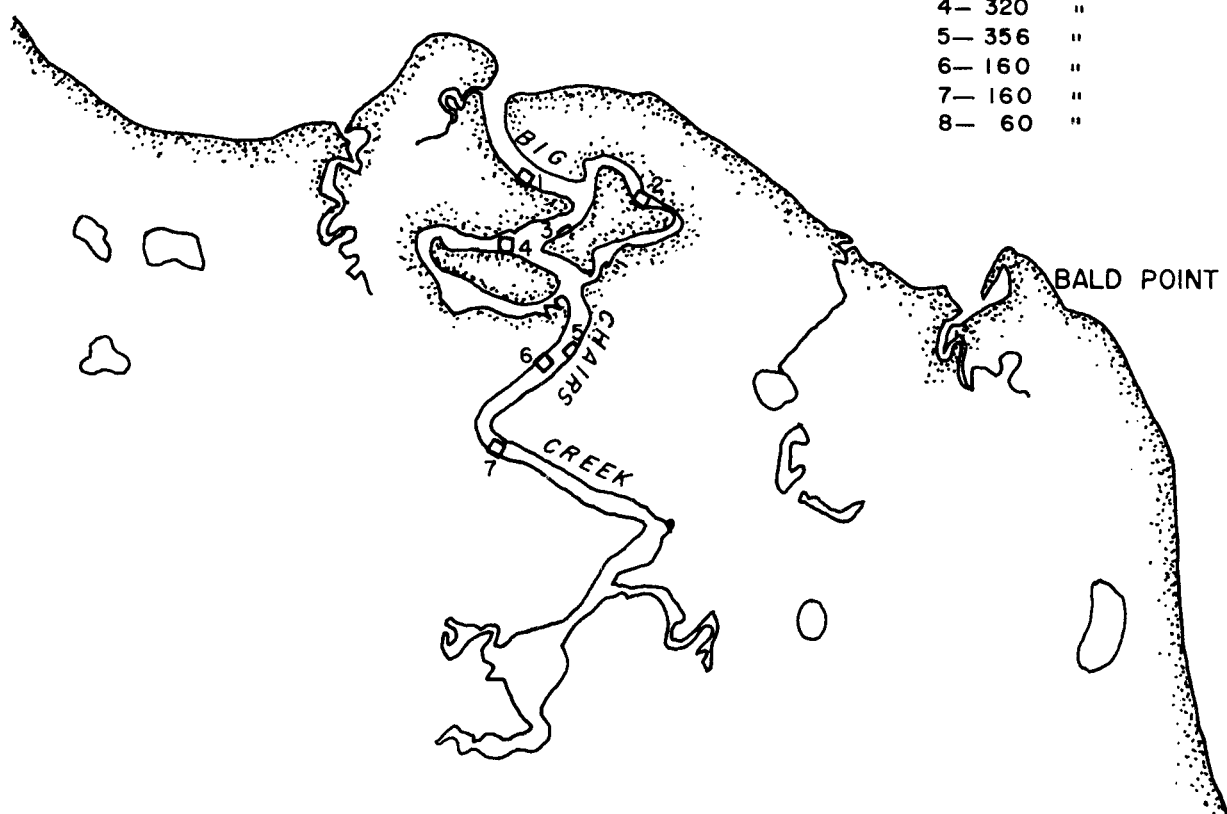
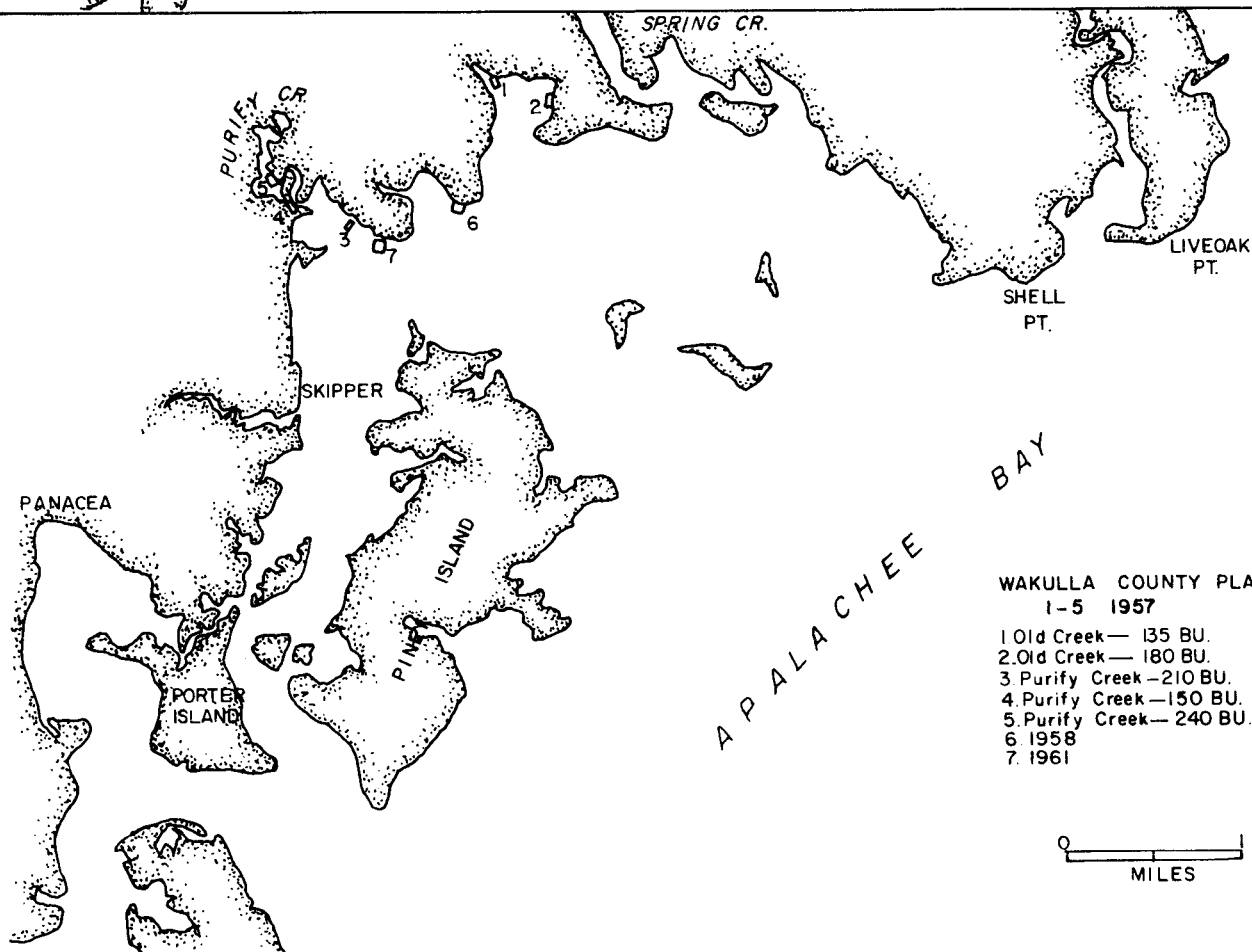
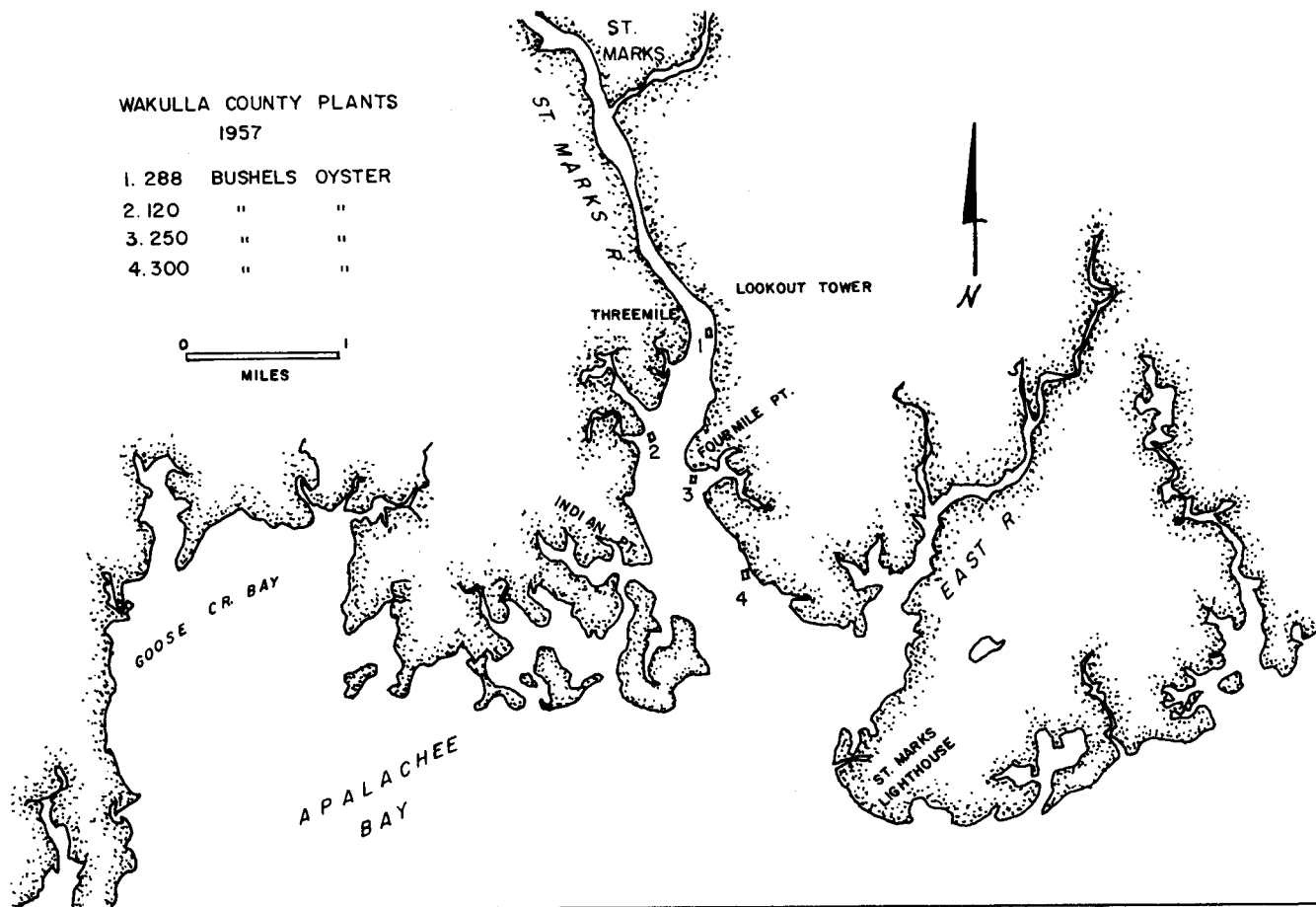


Figure 25. Wakulla-Franklin Counties planting sites.

WAKULLA COUNTY PLANTS
1957

1.	288	BUSHELS	OYSTER
2.	120	"	"
3.	250	"	"
4.	300	"	"

0 1
MILES

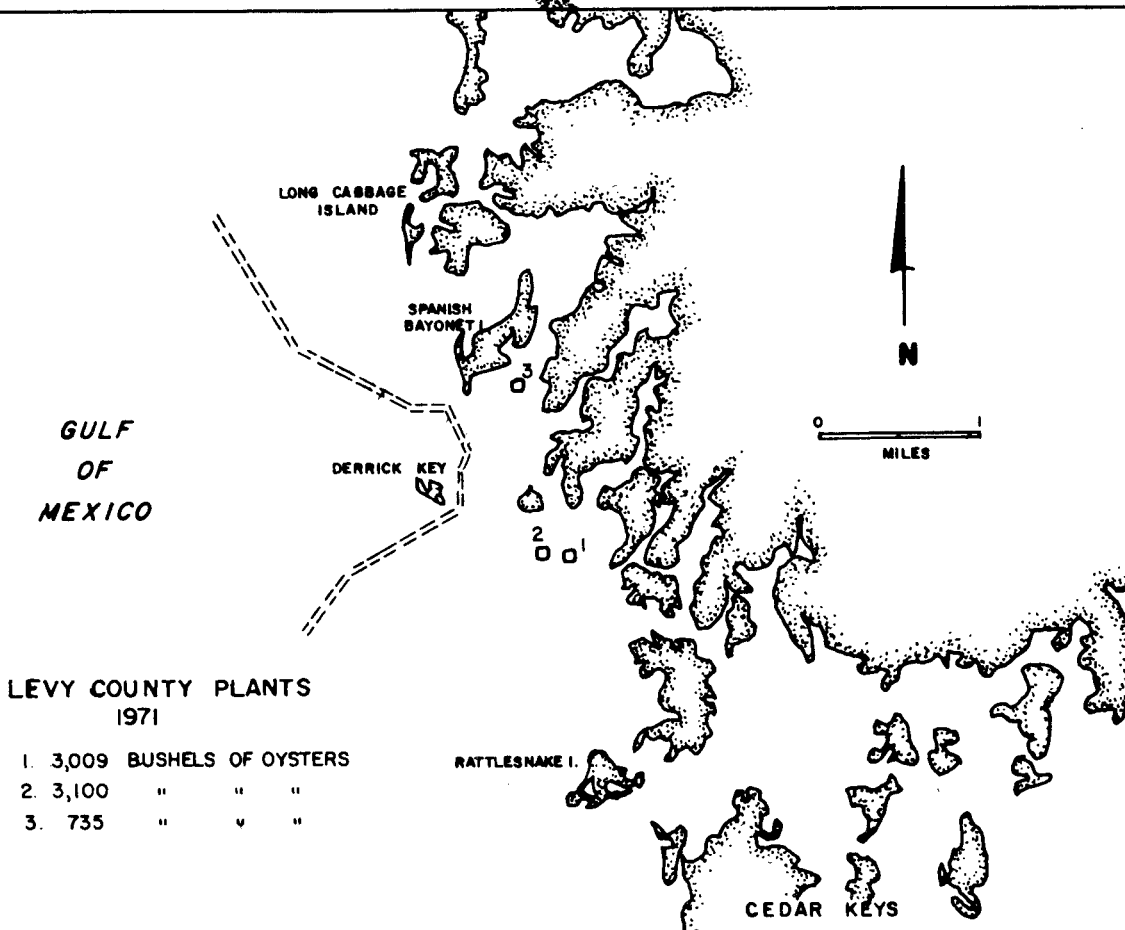
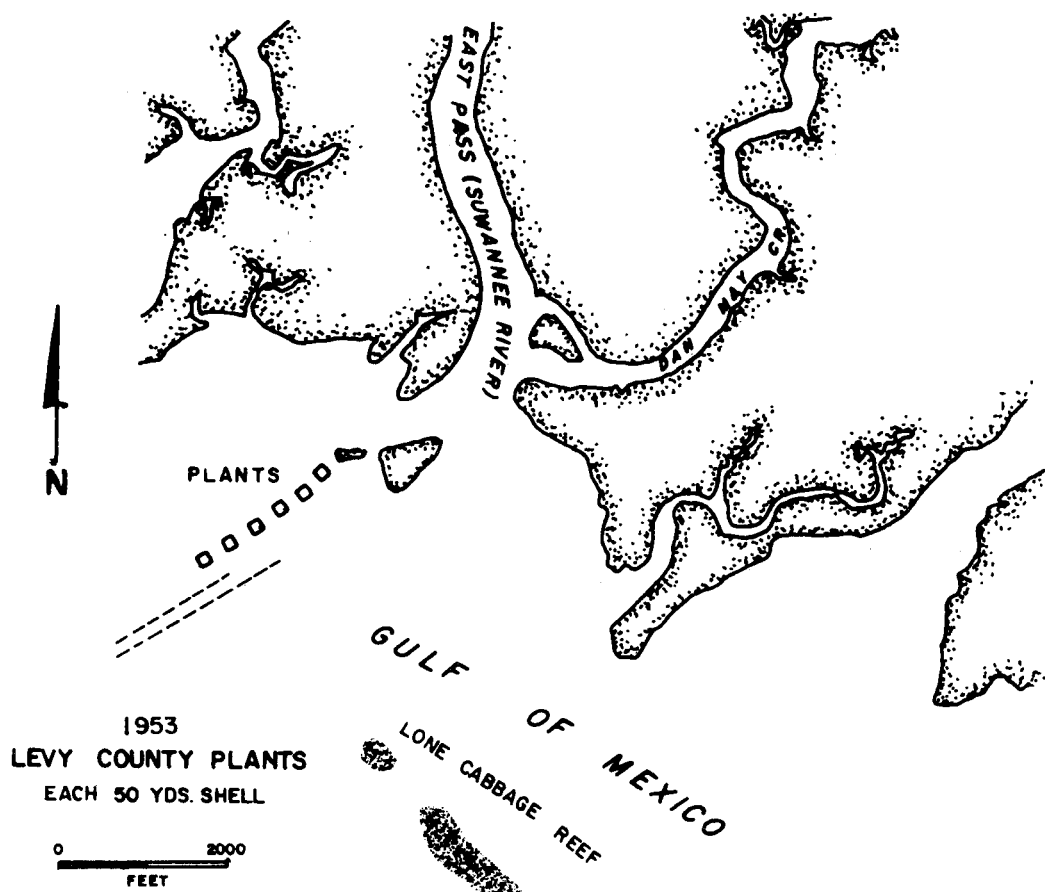


WAKULLA COUNTY PLANTS
1-5 1957

1.	Old Creek	135	BU.
2.	Old Creek	180	BU.
3.	Purify Creek	210	BU.
4.	Purify Creek	150	BU.
5.	Purify Creek	240	BU.
6.	1958		
7.	1961		

0 1
MILES

Figures 26 (above) and 27 (below). Wakulla County planting sites.



Figures 28 (above) and 29 (below). Levy County planting sites.

Figure 30. Levy County planting sites on Corrigan Reef.

1955

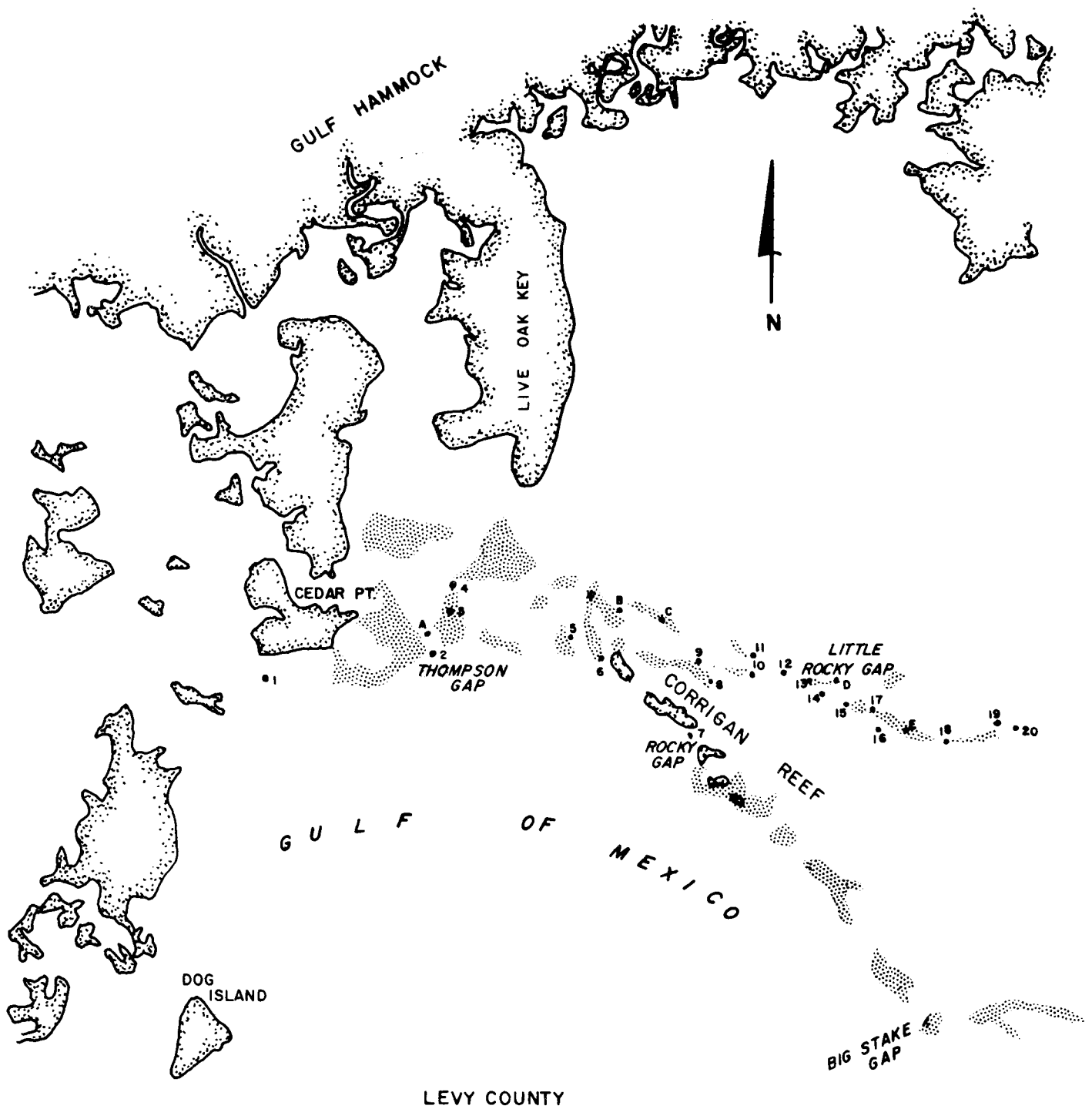
A, 2, 7, 13. Each 25 yards.

1966

2, 4, A, 10, 13, 15, 17. Each 14 yards.

B, C, D, E. Dredged out and planted each 12 yards.

AREA	1971	1972	NAME OF GAP
1	0	8,795 Bushels	
2	743 Bushels	2,810 Bushels	Thompson Gap
3	1,660 Bushels	1,693 Bushels	
4	847 Bushels	3,978 Bushels	
5	338 Bushels	2,054 Bushels	Crooked Gap
6	607 Bushels	2,163 Bushels	Cowpen Gap
7	6,683 Bushels	1,652 Bushels	Rocky Gap
8	1,223 Bushels	599 Bushels	
10	0	878 Bushels	
11	0	2,653 Bushels	
12	565 Bushels	561 Bushels	
13	3,044 Bushels	2,556 Bushels	Little Rocky Gap
14	1,117 Bushels	1,151 Bushels	
15	692 Bushels	1,296 Bushels	
16	1,219 Bushels	2,234 Bushels	
18	5,037 Bushels	2,468 Bushels	Round Bar
19	1,192 Bushels	566 Bushels	
20	5,295 Bushels	4,168 Bushels	Long Bar



LEVY COUNTY



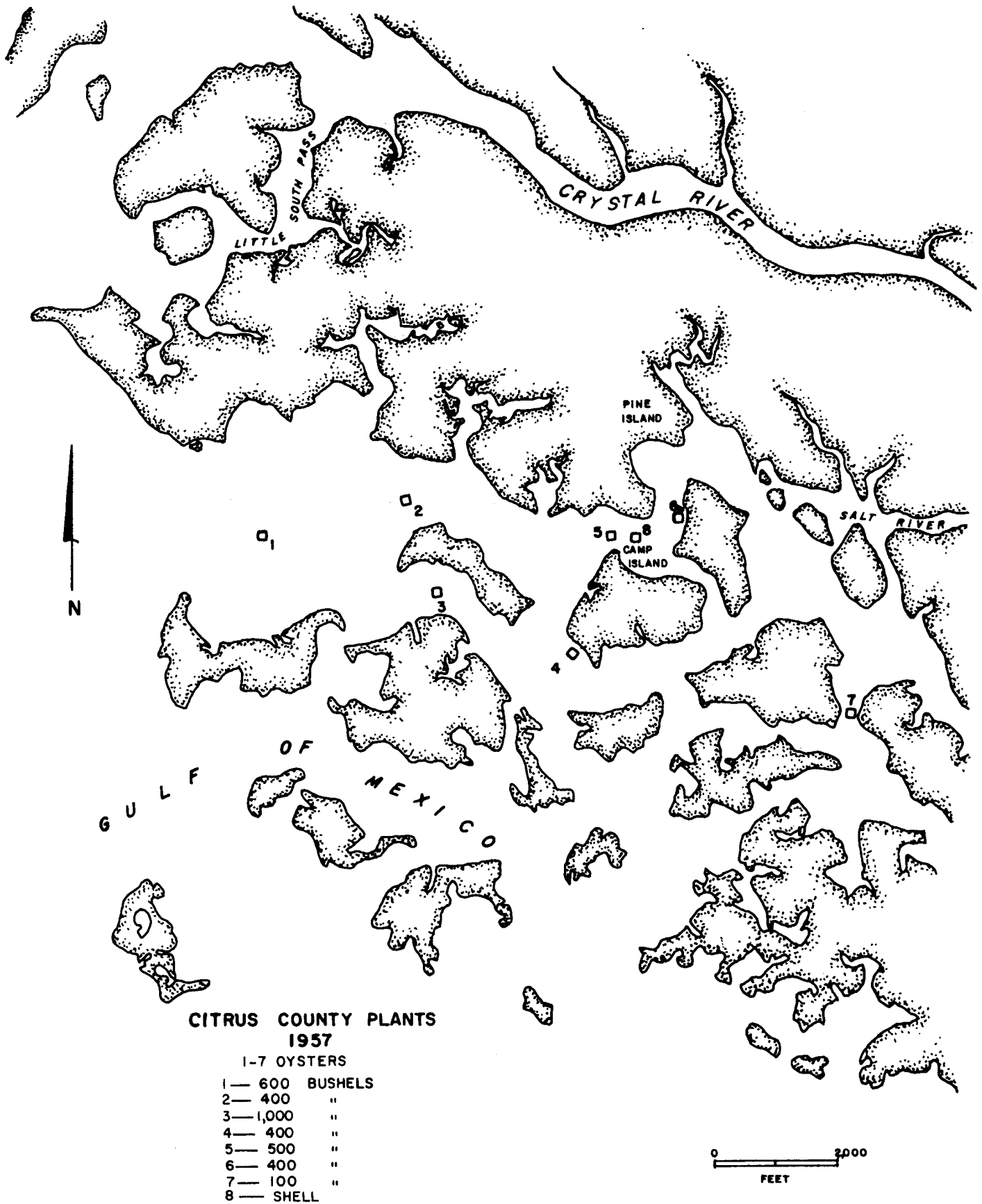


Figure 31. Citrus County planting sites.

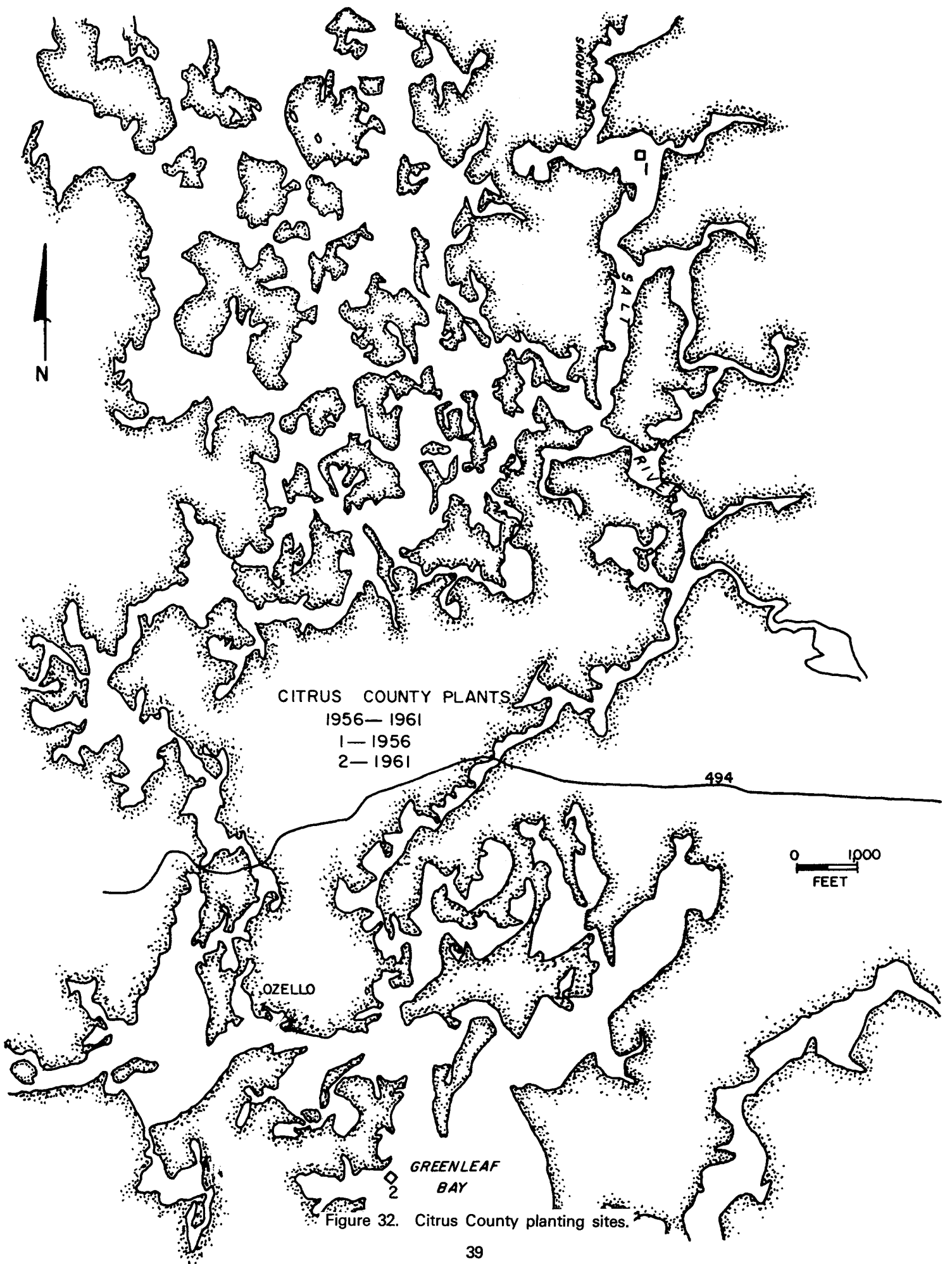
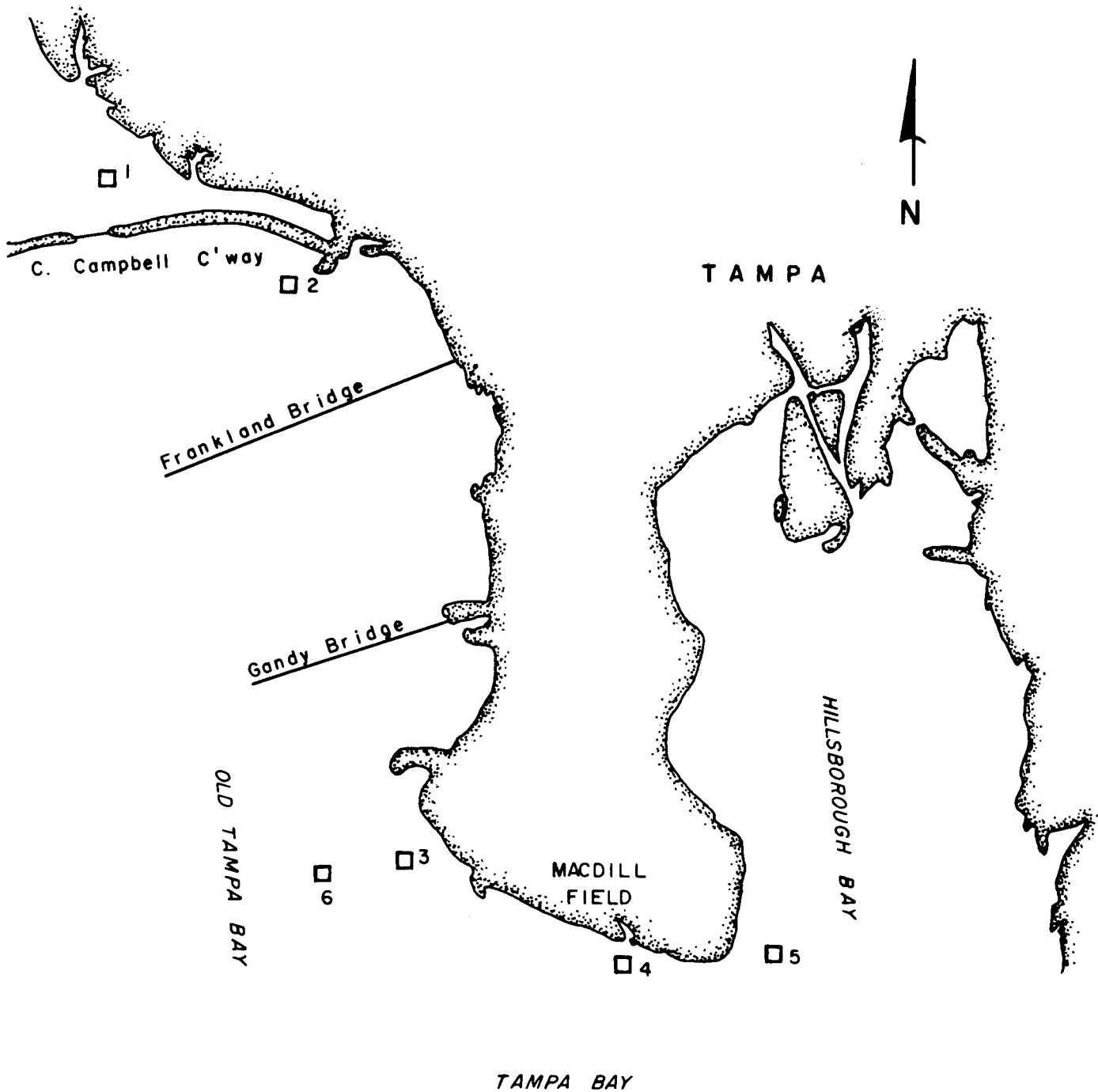


Figure 32. Citrus County planting sites.



**SHELL PLANTING SITES
HILLSBOROUGH COUNTY**

1-5	1961		
1	-	600	CUBIC YARDS
2	-	1200	" "
3	-	"	" "
4	-	"	" "
5	-	"	" "
6	-	1965	" "

Figure 33. Hillsborough County planting sites.

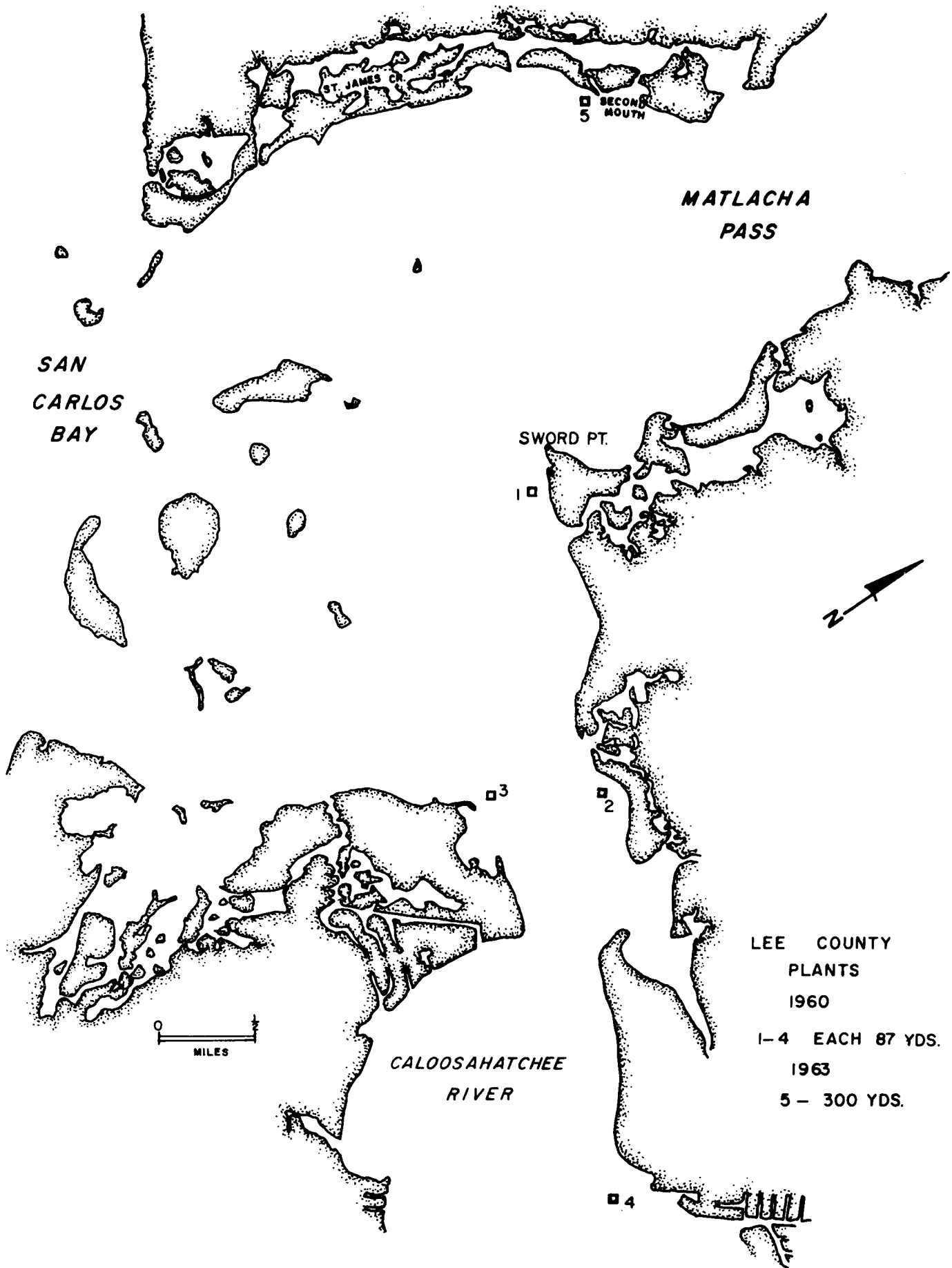


Figure 34. Lee County planting sites.

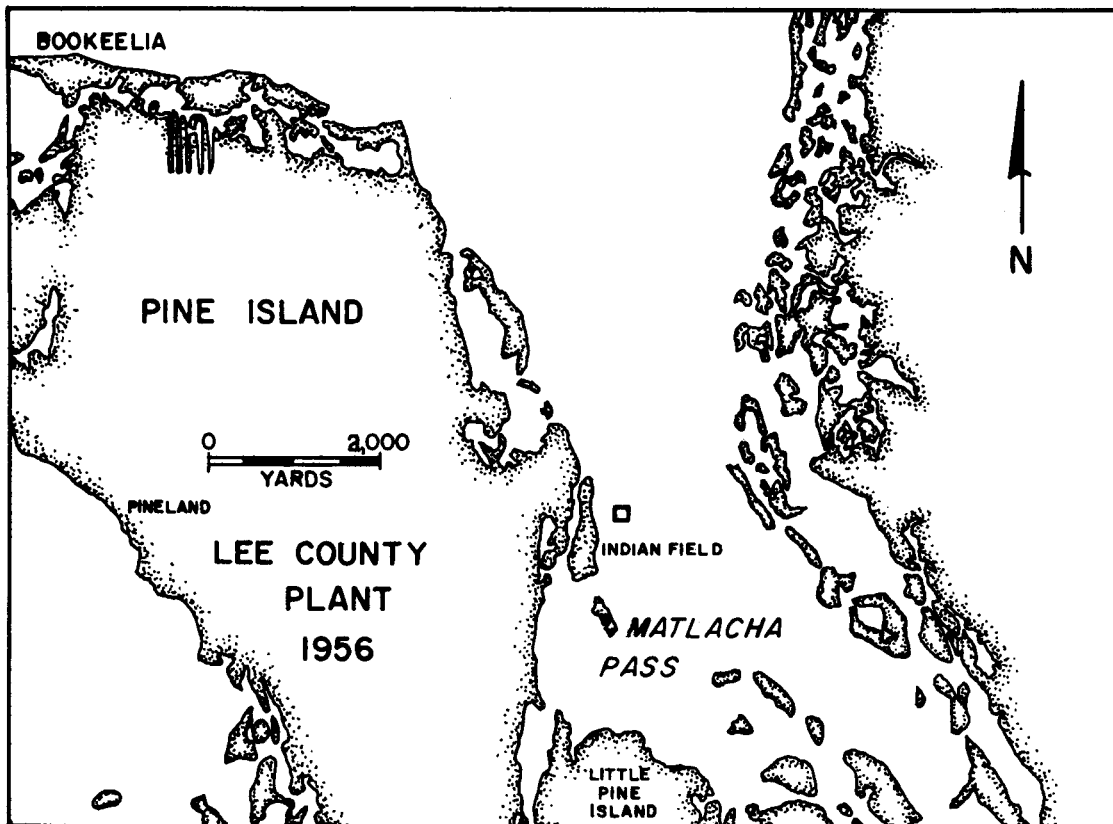


Figure 35. Lee County planting site.

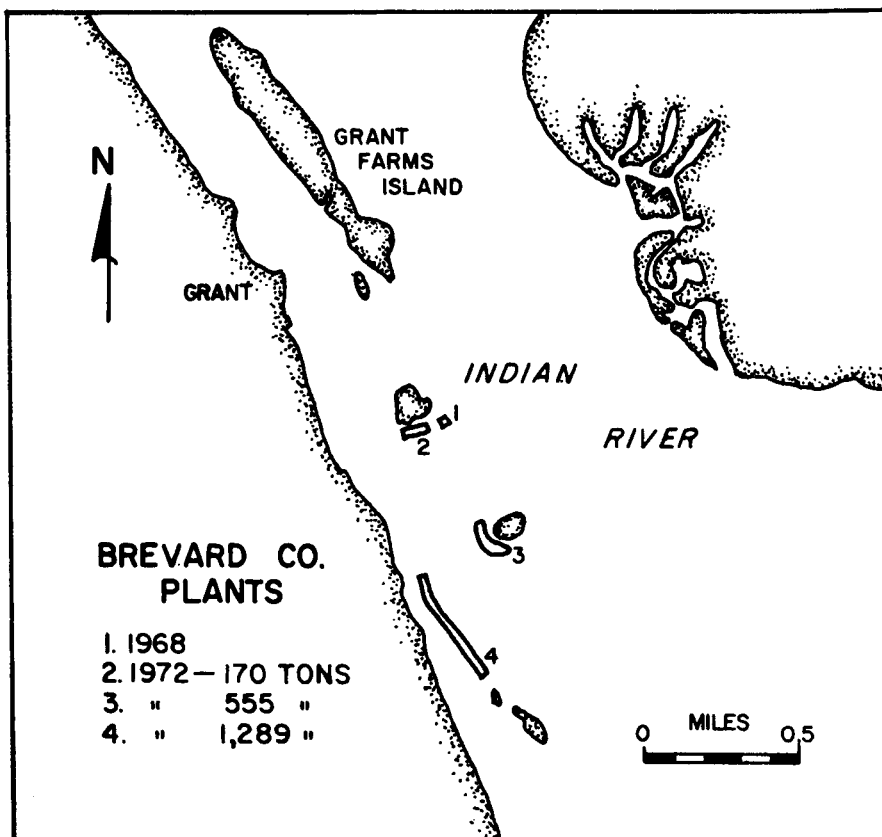


Figure 36. Brevard County planting sites.