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A STUDY OF THE EFFECTS OF A COMMERCIAL HYDRAULIC CLAM DREDGE ON BENTHIC COMMUNITIES IN ESTUARINE AREAS

Mark F. Godcharles

July 1971

Marine Research Laboratory
Florida Department of Natural Resources
Division of Marine Resources
St. Petersburg, Florida

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A STUDY OF THE EFFECTS OF A COMMERCIAL HYDRAULIC CLAM DREDGE ON BENTHIC COMMUNITIES IN ESTUARINE AREAS

Mark F. Godcharles

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ABSTRACT

A Maryland soft-shell escalator clam dredge, the R/V *Venus*, was used in a systematic sampling program to study its effects on representative bottom types (habitats) in Tampa Bay and to conduct clam exploration in Tampa and Boca Ciega Bays, the Cedar Keys area, and Tarpon Springs vicinity. Six experimental stations established in Tampa Bay were visually inspected and sampled with trynet before dredging and at various intervals after dredging. Benthic plug samples were taken at the final sampling. Sediment samples were also taken to assess textural changes by particle size analyses. Collected fauna were identified, counted, and in most instances, measured.

After more than a year no recolonization of sea grasses, *Thalassia testudinum* and *Syringodium filiforme*, occurred in any dredged area. Some regrowth of *Caulerpa prolifera* was observed 86 days after dredging. No increase of clam set was detected during the study. Analyses of trynet hauls showed no faunal variations between dredge and control plots at any time after dredging and benthic plug samples revealed marked faunal differences at only one station. Redredging with the R/V *Venus* revealed no faunal declines except for a marked decrease in quahogs, *Mercenaria campechiensis*, at one station.

Dredgehead water jets penetrated the substrate 18 inches and uprooted all vegetation. Dredge tracks remained visible from one to 86 days and some spots remained soft for over 500 days. Two stations showed a decrease of silt/clay particles immediately after dredging but only one showed a sustained decrease.

The greatest density of clams, *Mercenaria campechiensis*, was found in Tampa Bay and considerable numbers of surf clams, *Spisula raveneli*, were found on the Gulf side of Mullet Key. The greatest

*Contribution No. 172

This study was conducted in cooperation with the U. S. Department of Commerce, NOAA, National Marine Fisheries Service under PL 88-309 (Project No. 2-53-R).

production of clams (*M. campechiensis*) in the Cedar Key survey occurred at the Suwannee Reef and in the Tarpon Springs survey north of Honeymoon Island.

Two modifications to the harvester are recommended to increase efficiency and retard substrate damage. It is also recommended that these harvesters be permitted to operate in Florida on a permit basis and be prohibited in grassy areas.

INTRODUCTION

A vast expanse of estuarine and offshore bottom lands along Florida's coasts could provide suitable habitat for commercial clam populations. At one time the largest and most productive clam bed in the United States was in southwest Florida, off the Ten Thousand Islands (Schroeder, 1924; Tiller, Glude and Stringer, 1952; Carpenter, 1967). From the late 1800's until 1947 the abundant southern quahog, *Mercenaria campechiensis*, was harvested from these beds by mechanical dredges. Since the reported decline of this bed, harvesting of hard clams on the Florida west coast has been minimal (Table 1) and mechanical harvesting has ceased. East coast harvesting of the quahog has never equalled west coast production (Table 1). Presently the largest producing clam bed in Florida is off Port St. Joe, Florida, where commercial harvesting of the sunray venus clam, *Macrocallista nimbosa*, commenced in 1967 (Stokes, Joyce, and Ingle, 1968).

Present hand harvesting methods used in Florida cannot compete with the mechanized harvesters of Chesapeake Bay and Long Island Sound (Manning and Dunnington, 1955; Manning, 1957, 1959; Manning and Pfitzenmeyer, 1958; Medcof, 1961) and clam production is extremely limited. Many Floridians feel that the use of mechanical harvesters would damage the valuable shallow water grass flat "nursery" areas so important for the growth and survival of many sport and commercial species.

To help revive the Florida clam industry and to answer the inquiries of private industry and other interests about the use of mechanized harvesters, the Marine Research Laboratory initiated this study as a State-Federal matching fund project with the Bureau of Commercial Fisheries under the Commercial Fisheries Research and Development Act, PL 88-309. The primary objective was to evaluate the effects of a commercial hydraulic clam dredge on a variety of benthic communities in selected estuarine areas. Based on these results, we can determine whether this type of dredge should be allowed to work in Florida waters and what restrictions, if any, might be necessary.

METHODS AND MATERIALS

In January 1968, a commercial hydraulic (conveyor type) soft shell clam dredge (Figure 1) was purchased in Easton, Maryland from Mr. Fletcher Hanks, its designer and builder. The 68 ft. long, 12 ft. wide catamaran vessel was shipped to Florida and renamed the R/V *Venus*.

Suspended between the two 3 ft. x 3 ft pontoons is a 40 ft. 7 in. boom with attached dredgehead, housing an 18 in. wide conveyor belt (3.0 cm^2 mesh). The dredgehead is 3 ft. x 3 ft. at the mouth and tapers slightly to the conveyor belt located three feet from the cutting blade. A 3-53 GM diesel, which propels the vessel at 4 knots with a Murray and Tregurtha outdrive unit, drives a Gould (Model 3770, 4D) centrifugal pump and a hydraulic pump. When driven at 1500 rpm the centrifugal pump delivers 30 lb. (psi) to each of the eleven half-inch dredgehead nozzles for a total volume of 450 gallons per minute. Hydraulic motors (converters) drive the boom winch and rotate the conveyor belt.

High pressure water jets dislodge clams from the substrate and carry them to the conveyor belt. Clams are then conveyed to the pilot house where the catch is hand culled. The dredgehead is not forced through the substrate; rather, the water jets erode a trough while the outdrive unit provides steering and forward motion (Manning, 1957). Discarded material is returned to the trough through a hole in the deck.

ASSESSMENT OF DREDGING EFFECTS

Six experimental stations (Table 2, Figure 2) were established in lower Tampa and Boca Ciega Bays to study the effects of dredging on differing bottom communities. Stations with representative bottom types were selected following exploratory dredging by the R/V *Venus*. Sea grasses, *Thalassia testudinum* and *Syringodium filiforme*, represented the predominant bottom features at Stations 5 and 7; the alga *Caulerpa prolifera* predominated at Station 27. Algae and sea grasses did not cover the substrate at Stations 7, 12A, and 19.

Markers on the first established experimental station (#5) could not be found after Hurricane "Gladys" struck the Tampa Bay area in

TABLE 1. LANDINGS OF QUAHOG AND SUNRAY VENUS CLAMS (LABELED) IN POUNDS AND DOCKSIDE VALUE FOR FLORIDA EAST AND WEST COASTS, 1880-1969

Year	East Coast		West Coast		Total	
	Pounds	Value	Pounds	Value	Pounds	Value
1880	5,000	$ —	—	$ —	5,000	$ —
1908	57,000	—	182,000	—	239,000	—
1923	5.000	—	602,000	—	607,000	—
1930	49,840	—	661,736	—	711,576	—
1932	12,000	—	1,108,812	—	1,120,812	—
1940	6,700	—	701,100	—	707,800	—
1945	3,000	—	687,700	—	690,700	—
1950	875	263	4,375	1,313	5,250	1,576
1951	8,010	4,119	8,531	4,387	16,541	8,504
1952	4,648	2,324	10,073	5,036	14,721	7,360
1953	10,284	5,142	12,100	6,050	22,384	11,192
1954	4,953	2,477	26,413	13,206	31,366	15,683
1955	6,294	1,448	15,739	3,620	22,033	5,068
1956	500	175	18,149	6,352	18,649	6,527
1957	—	—	40,957	12,697	40,957	12,697
1958	1,374	426	18,673	5,789	20,047	6,215
1959	1,466	469	17,060	5,459	18,526	5,928
1960	2,134	683	23,893	7,646	26,027	8,329
1961	4,101	1,353	15,123	5,444	19,224	6,797
1962	2,746	879	225,973	50,392	228,719	51,271
1963	675	216	7,372	2,322	8,047	2,538
1964	1,121	359	71,697	23,882	72,818	24,241
1965	24,454	10,133	114,052	41,794	138,506	51,927
1966	2,401	840	3,475	1,216	5,876	2,056
1967	17,168	8,755	3,811	1,143	20,979	9,898
Sunray venus			350,170	35,017	350,017	35,017
1968	27,148	13,574	7,331	3,665	34,479	17,239
Sunray venus			410,099	41,906	410,099	41,906
1969	40,683	20,343	10,823	6,247	51,506	26,690
Sunray venus			635,684	64,522	635,684	64,522

Data from U.S. Fish and Wildlife Service Statistics Digests and from Florida Board of Conservation annual summaries of Florida marine landings.

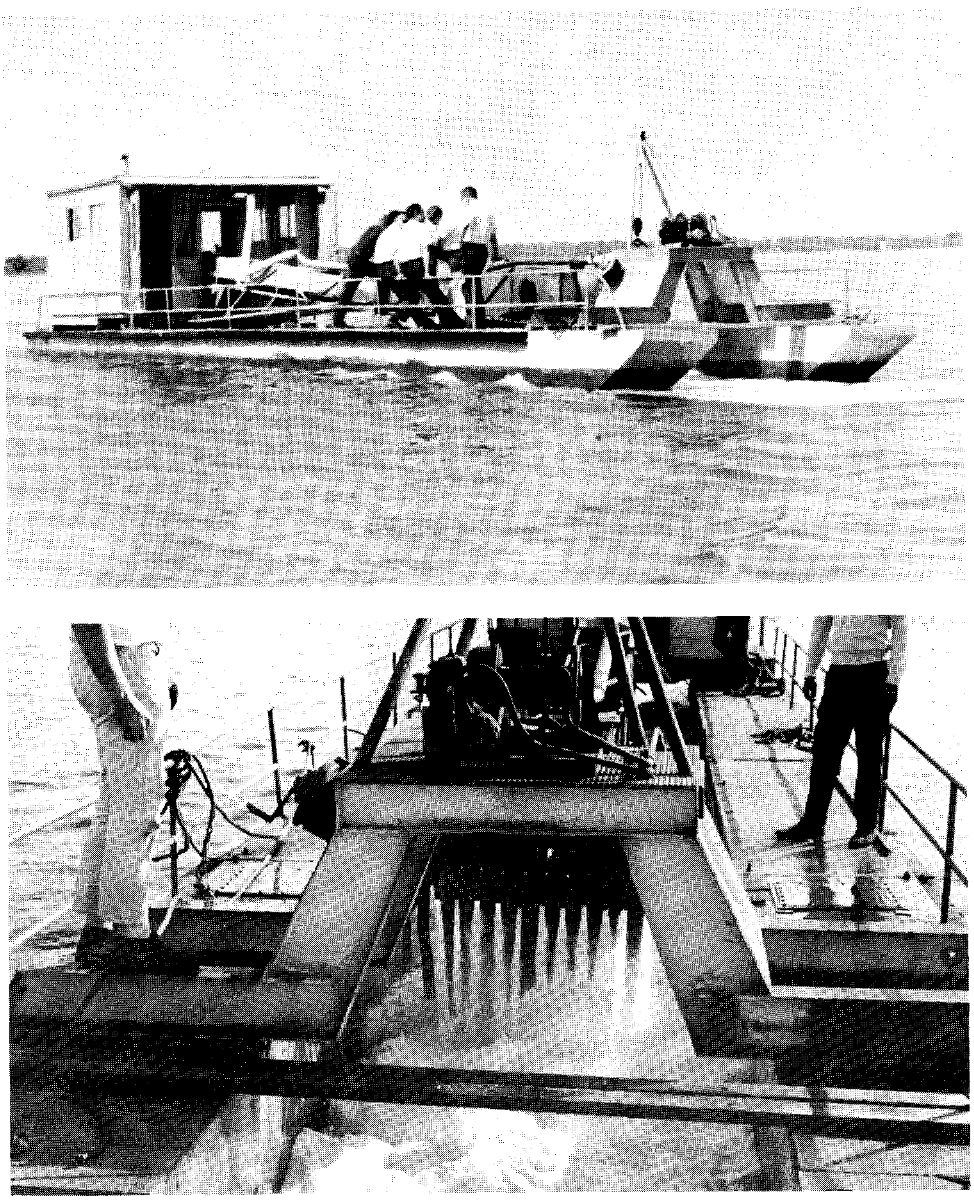

Figure 1. The R/V *Venus*.

October 1968. To prevent further loss of testing sites the following additional procedures were initiated: a bottom marker constructed of tires and cement-filled five gallon drum was positioned in the center of each station. The position of the station was pinpointed by measuring the angles between three charted landmarks and the marker with a sextant. If the float became detached from the bottom marker, the station was found by sextant and diving observations. This method was successful but very time-consuming, especially when underwater visibility was poor.

The design and sampling of the six experimental stations were similar. All sampling was conducted during daylight hours. An imaginary east-west line divided the control from the experimental (dredged) side, both of which were 22 m x 22 m (Figure 3). Scuba observations were made to ensure homogeneous bottom type for both sides for each station. Biological and sediment samples were taken from control and experimental sides before and at various intervals after dredging to monitor the extent of damage and recovery. The bottom was also observed during sampling.

Biological samples were taken with the R/V *Venus* and with trynet, box dredge, and benthic plug sampler. After initial sampling, the experimental side of each station was dredged with the R/V *Venus* and one strip was taken through the control to discern any faunal differences. The degree of dredging for each station is listed in Table 2. Samples were again taken with the R/V *Venus* at all stations except #19, in April 1970. Stations 5 and 7 were also redredged in March 1969. On these return samplings a single strip was dredged on each side.

A total of 76 15-minute hauls were taken with a 16 ft balloon trynet of 1 1/2 in. stretched mesh. Because the box dredge proved to be an inefficient sampler of infauna, particularly on grass beds, its use was discontinued and catch data is excluded from this report.

At the final sampling of all stations in April 1970, three samples were taken with a 0.125 m^2 x 0.23 m deep ($3.58 \times 10^{-3} m^3$) stainless steel benthic plug sampler as described by Taylor and Saloman (1969). These samples were taken in the same location as core samples (Figure 3). Samples were processed following the procedures outlined by Saloman and Taylor (1969) and Jones (1961). Fauna and debris separated from sediments on a 0.701 mm^2 mesh screen were preserved in 10% formalin and stained with rose bengal. Later the stained fauna were removed from the debris by hand.

TABLE 2. EXPERIMENTAL STATIONS IN TAMPA BAY

Station	Coordinates	Marine Plants	Degree of Dredging
5[1]	27° 40'34"N 82° 39'50"W	*Thalassia* — Dom. *Syringodium* — Sub.	Complete
5	27° 40'34"N 83° 39'07"W	*Thalassia* — Dom. *Syringodium* — Sub.	Complete
7	27° 40'34"N 82° 39'15"W	*Thalassia* — Dom. *Syringodium* — Sub.	Complete
27	27° 41'37"N 82° 31'34"W	*Caulerpa* — Dom. *Syringodium* — Sub. *Diplanthera* — Sub.	Stripped 50%
11	27° 38'55"N 82° 41'45"W	*Syringodium* — Dom. *Thalassia* — Sub.	Stripped 40%
12A	27° 36'08"N 82°46'32"W		Complete
19	27° 36'56"N 82° 44'43"W		Complete

[1] Following Hurricane "Gladys" (October 1968), station markers could not be located.

Dom. = dominant species; sub. = subdominant species

Thalassia = *Thalassia testudinum*; *Syringodium* = *Syringodium filiforme*; *Diplanthera* = *Diplanthera wrightii*

TABLE 3. PARTICLE SIZE CLASSES USED IN TEXTURAL ANALYSIS OF CORES FROM EXPERIMENTAL STATIONS IN TAMPA BAY

PHI	Screen Opening (mm)	Grain Size (mm)	Classification
-1	2	⟩2	Shell
0	1	⟨2, ⟩1	Very coarse sand, shell
1	0.500	⟨1, ⟩0.5	Coarse sand, shell
2	0.250	⟨0.5, ⟩0.25	Medium sand
3	0.125	⟨0.250, ⟩0.125	Fine sand
4	0.063	⟨0.125, ⟩0.063	Very fine sand
⟩4		⟨0.063	Silt/clay

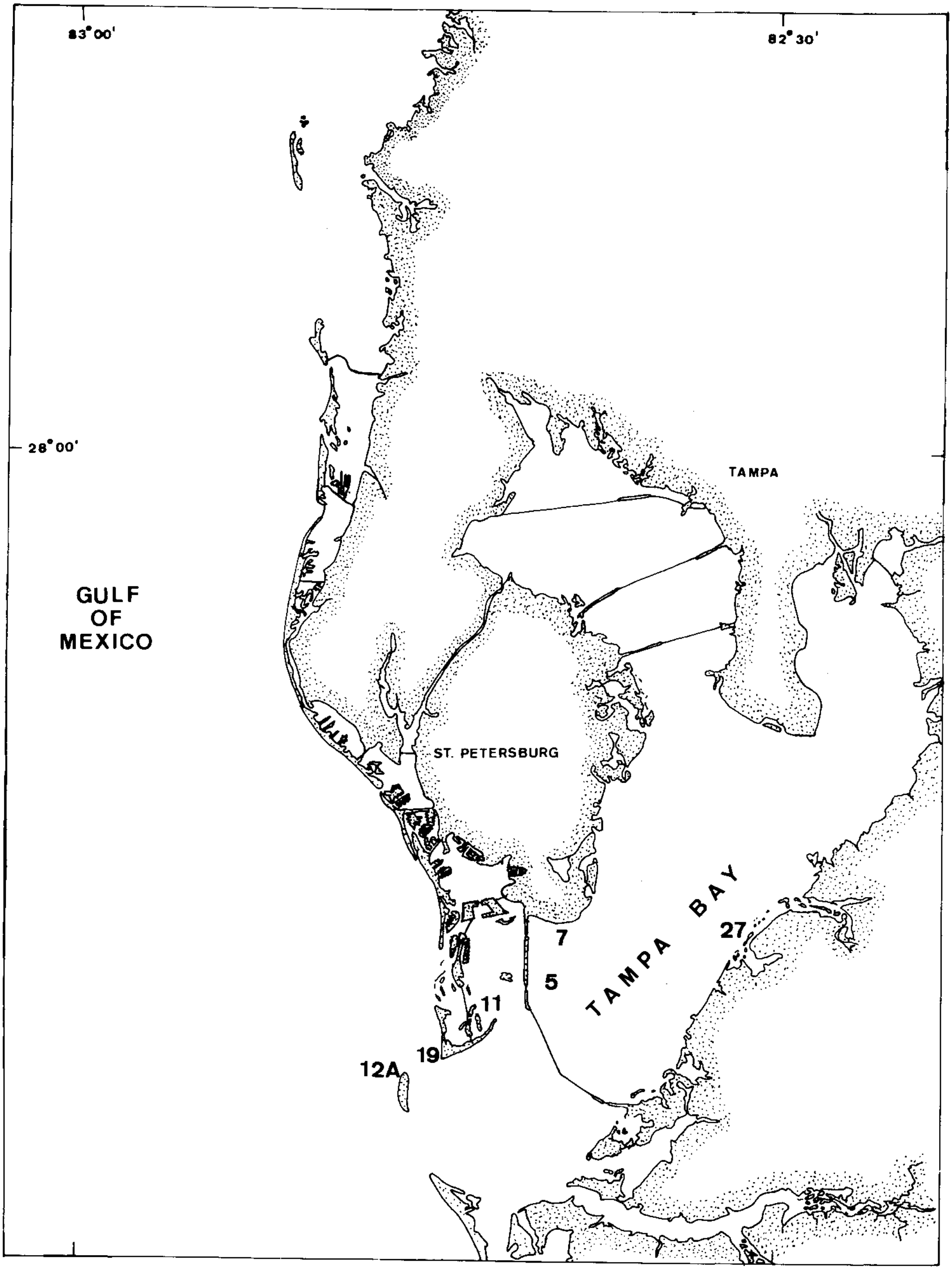

Figure 2. Experimental dredging stations in Tampa Bay.

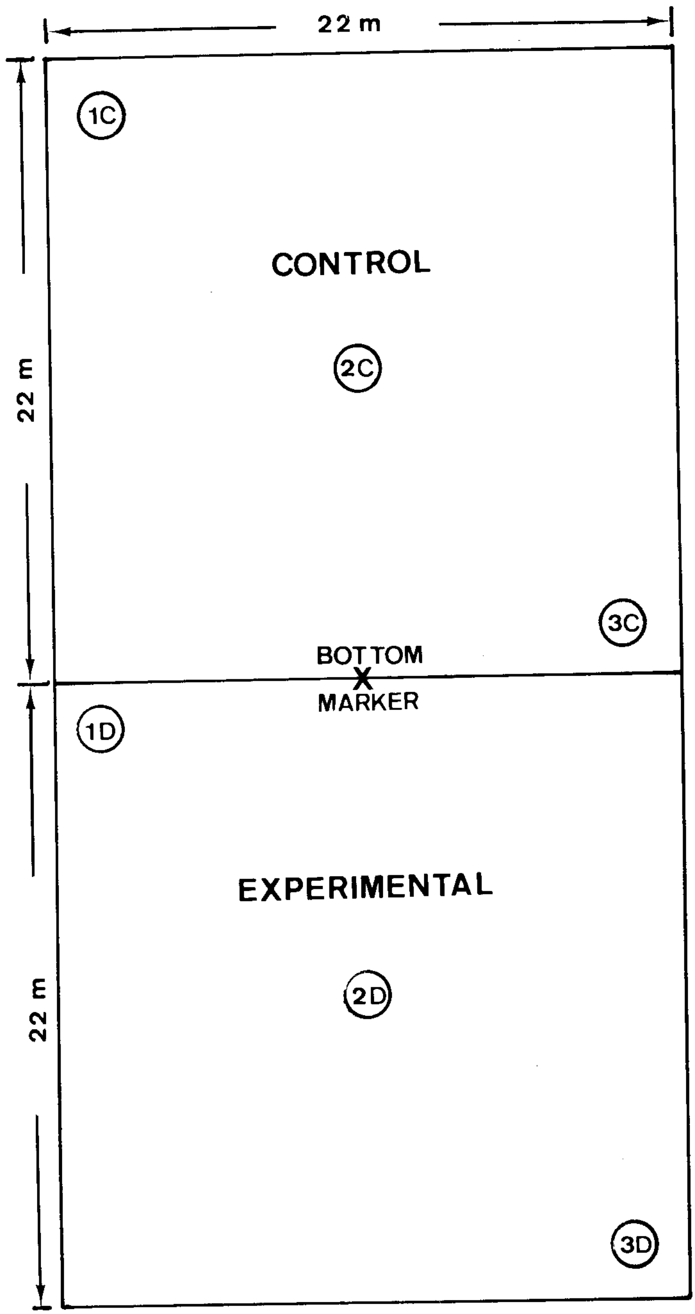

Figure 3. Design of experimental stations in Tampa Bay. Circled figures represent sites of core and benthic plug sampling.

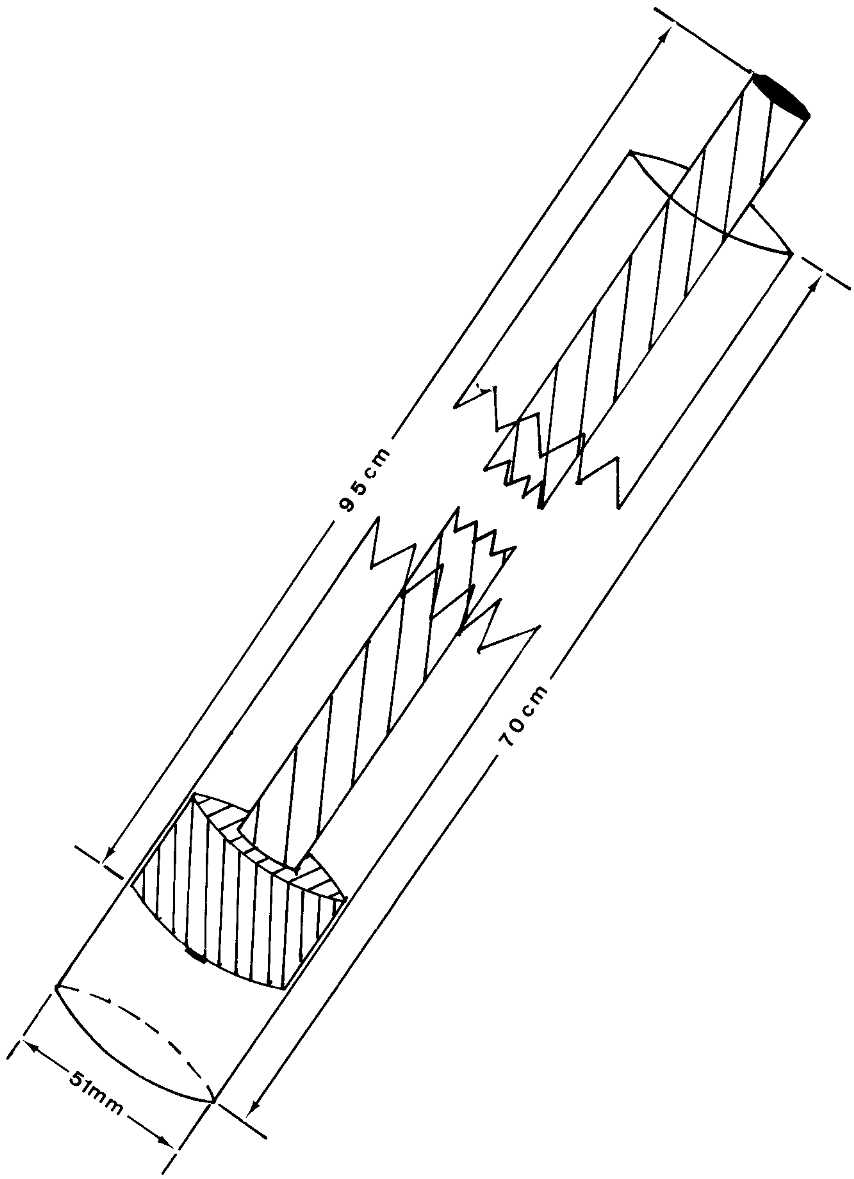

Figure 4. Core sampler.

All collected samples were returned to the laboratory for identification and measurement; rare and/or significant species were accessioned into our invertebrate and ichthyological reference collections.

Three five-inch deep sediment samples were taken from control and experimental plots (Figure 3) with a core sampler (Figure 4) designed by Thomas Savage of our Laboratory. Whenever possible, all core samples were taken from previously dredged troughs.

Core samples (228) from six stations were analyzed in the following manner. After removing salts from the sediment sample with distilled water, the silt/clay fraction was separated by wet sieving through a 63 micron mesh screen and its weight was determined by tares. Time did not permit the more precise pipetting (Soil Survey Staff, 1951; Krumbein and Pettijohn, 1938) and Coulter Counter techniques. The sediment remaining on the screen after wet sieving was dried and then fractioned by six stacked sieves using a Ro-Tap, a mechanical sifting device.

Weights were determined with a Mettler P1200N balance. Sediments were categorized into seven particle size classes (Table 3) based on the Wentworth Scale and interpreted into the logarithmic phi scale (after Krumbein, 1936). Percent weights for these particle size classes were tabulated from average weights obtained by analyzing the three cores. These control and experimental values were compared to detect any change in substrate composition.

Measurements were also made of bottom water temperature, pH, and salinity. Water clarity was measured with a Secchi disk.

EXPLORATORY FISHING WITH THE R/V *VENUS*

Since the commencement of exploratory dredging in January 1968, 111 stations have been sampled. In Tampa and Boca Ciega Bays, 59 stations were established through April 1970. Tampa Bay Stations were divided into four areas:

Area I (Figure 5)	Old Tampa Bay south to Smacks Bayou.
Area II (Figure 5)	West of main shipping channel from Smacks Bayou to east side of Sunshine Skyway Bridge.
Area III (Figure 5)	Southeast of main shipping channel from Camp Key Bay to Snead Point.

Area IV (Figure 5)	Southern Boca Ciega Bay and mouth of Tampa Bay.

A survey was also conducted in the Cedar Keys area from September through December 1969, in which 47 stations were sampled from Steinhatchee to Wacasassa Reef. These stations were divided into three areas:

Area V (Figure 6)	Rattlesnake Island to Wacasassa Reef, including Seahorse Reef.
Area VI (Figure 6)	Derrick Key to Red Bank Reef including Suwannee Reef.
Area VII (Figure 6)	Horseshoe Point to Steinhatchee.

On the return trip to St. Petersburg, seven stations were sampled in the Intracoastal Waterway from Anclote Key to Clearwater (Figure 5, Area VIII).

This study was initiated and concentrated in Tampa Bay because of its proximity to our facilities and because many aspects of its ecology have been documented, e.g., Springer and Woodburn (1960), Phillips (1960, 1962), Goodell and Gorsline (1961), Dragovich and Kelly (1964), and Sims and Stokes (1967).

The Cedar Key area was surveyed because its physiographic features, dotted with many freshwater outfalls, suggested that this estuarine system might provide suitable habitat for commercial clam populations. In addition, the vast expanse of shallow bottom lands under 12 ft deep was ideally suited for our escalator type clam dredge.

At exploratory stations an effort was made to collect, identify, count, and measure all specimens captured. Special attention was given to the southern quahog, *Mercenaria campechiensis*, sunray venus clam, *Macrocallista nimbosa*, and surf clam, *Spisula raveneli*, and other potentially commercial species. Rare or significant species were returned to the Laboratory for identification and accessioned into our collections. Salinity, temperature, Secchi disk readings, and substrate characters were recorded for each station (Tables 4, 5, and 6).

The great volume of data prevents its publication in entirety but it has been accessioned into the Marine Research Laboratory Ar-

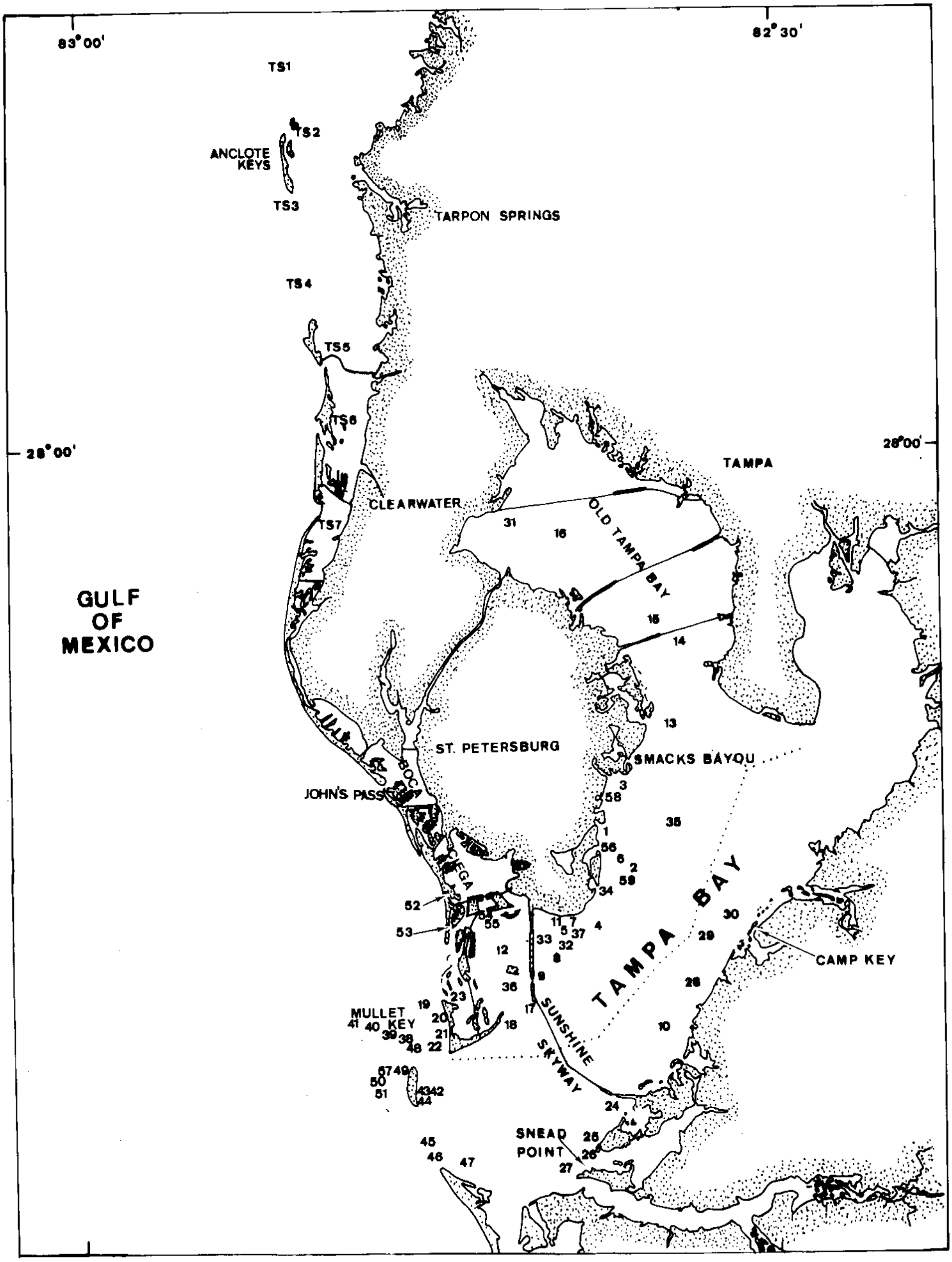

Figure 5. Exploratory fishing stations in Tampa and Boca Ciega Bays, and from Anclote Key to Clearwater.

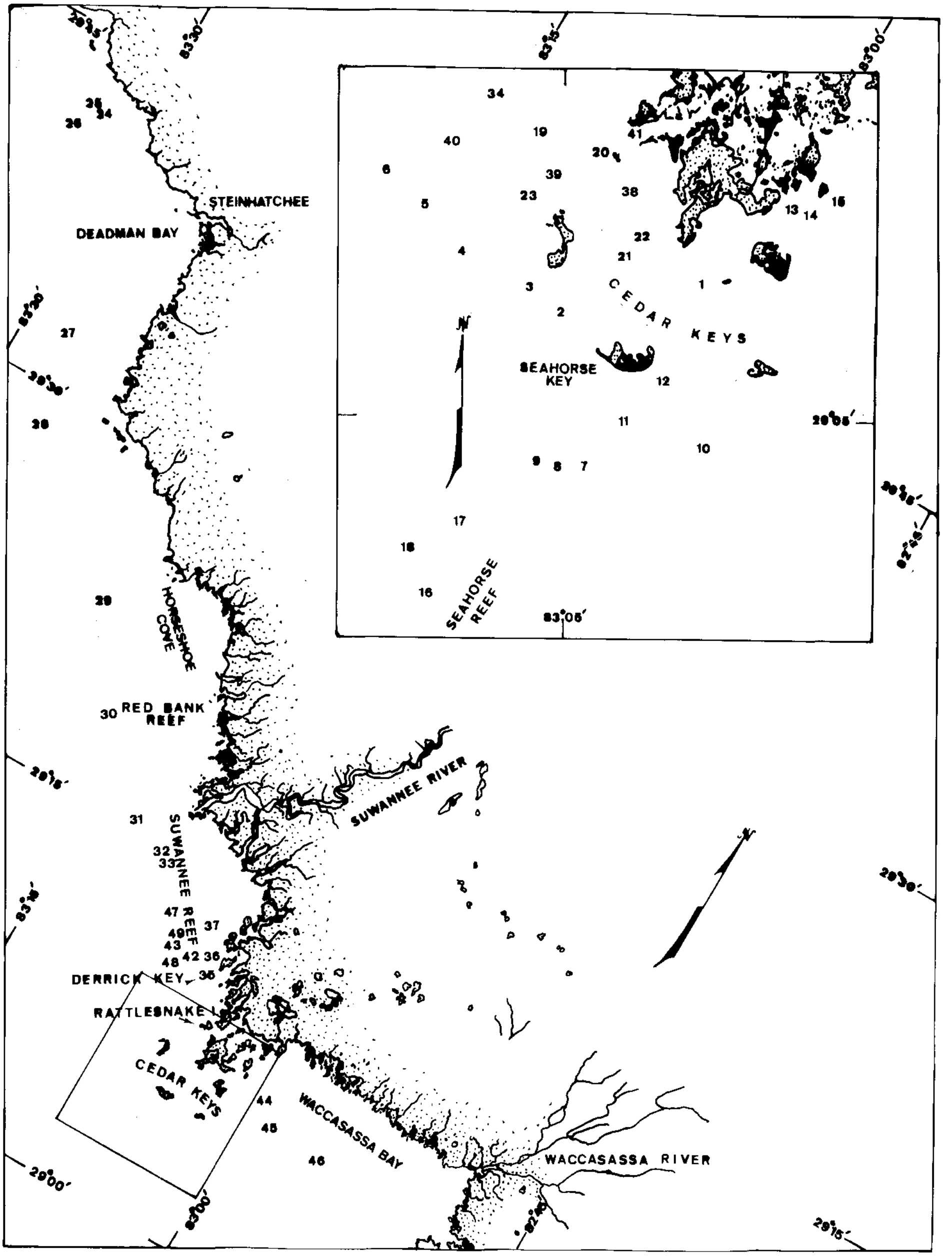

Figure 6. Exploratory fishing stations from Wacasassa Bay to Steinhatchee.

TABLE 4. PHYSICAL DATA FROM DREDGING STATIONS IN TAMPA AND BOCA CIEGA BAYS

Station	Date	Salinity (o/oo)	Temperature (°C)
1	2-18-70	22.62 S	17.5 S
4	2-18-70	23.69 S	17.5 S
6	2-18-70	21.54 S	18.0 S
8	11-14-68	27.50 S	18.2 S
8	11-15-68	26.00 S	19.0 S
8	3-28-69	22.08 B	18.0 B
8	4-21-70	27.46 B	25.0 B
10	3-20-68	32.00 S	19.0 S
11	12-20-68	28.45 S	16.0 S
11	1- 8-68	28.45 S	15.5 S
11	3- 7-69	30.70 B	16.0 B
11	4-21-70	27.46 B	27.5 B
12	3-26-68	33.00 S	17.5 S
13	3-28-68	28.00 S	19.0 S
14	3-28-68	27.50 S	18.5 S
16	3-28-68	26.50 S	20.5 S
16	5-15-68	30.00 S	28.0 S
18	3-29-68	30.50 S	23.0 S
21	4- 2-68	31.50 S	23.0 S
22	6-18-69	33.39 B	31.0 B
22	9- 5-69	31.23 B	29.5 B
27	4-10-68	30.00 S	26.0 S
28	5-14-68	33.00 S	27.0 S
29	5-14-68	33.00 S	27.0 S
30	5-14-68	32.50 S	27.0 S
30	6-14-68	32.00 S	30.5 S
30	4-15-69	28.54 B	19.6 B
30	4-17-69	28.54 B	26.5 B
30	5- 1-69	28.00 B	25.0 B
30	5- 7-69	28.00 B	26.2 B
30	4-23-70	25.31 B	27.3 B
31	5-15-68	30.00 S	28.0 S
32	5-22-68	33.00 S	27.0 S
32	5-31-68	32.00 S	28.0 S
32	9-11-68	26.00 S	29.5 S
33	5-28-68	32.50 S	28.0 S
35	5- 6-69	28.00 B	26.0 B
36	5-21-69	32.31 B	—
36	5-29-69	33.39 B	27.0 B
36	5-30-69	33.39 B	26.8 B
36	6- 3-69	35.00 B	29.0 B
36	6- 6-69	34.47 B	30.5 B
36	4-22-70	29.62 B	27.5 B
38	6-10-68	33.39 B	29.5 B

TABLE 4. (Continued)

Station	Date	Salinity (o/oo)	Temperature (°C)
39	6-10-69	33.39 B	29.5 B
40	6-10-69	33.39 B	29.5 B
41	6-10-69	33.39 B	29.5 B
42	6-13-69	35.00 B	30.0 B
43	6-13-69	35.00 B	30.0 B
44	6-13-69	35.00 B	30.0 B
45	6-13-69	35.00 B	30.0 B
46	6-13-69	35.00 B	30.0 B
47	6-13-69	35.00 B	30.0 B
48	6-18-69	33.39 B	31.0 B
49	6-18-69	33.39 B	31.0 B
50	6-18-69	33.39 B	31.0 B
51	6-18-69	33.39 B	31.0 B
56	2-18-70	21.54 S	18.0 S
57	8-22-69	32.31 B	31.0 B
57	8-23-69	32.31 B	31.0 B
57	8-26-69	32.31 B	31.0 B
57	4-22-70	32.31 B	25.3 B
58	2-18-70	21.54 S	17.5 S
59	2-18-70	23.69 S	17.5 S

B = bottom; S = surface

TABLE 5. PHYSICAL DATA FROM CEDAR KEY (CK) AND TARPON SPRINGS (TS) STATIONS

Station	Date	Bottom Salinity (o/oo)	Bottom Temperature (° C)
CK17	10-11-69	—	27.0
CK18	10-11-69	—	27.0
CK19	10-13-69	30.15	26.2
CK20	10-13-69	30.15	26.2
CK21	10-14-69	30.15	25.8
CK22	10-14-69	30.15	25.8
CK23	10-14-69	30.15	—
CK24	11- 6-69	33.39	16.5
CK25	11- 7-69	32.85	17.9
CK26	11-10-69	33.39	19.2
CK27	11-11-69	32.85	19.5
CK28	11-11-69	32.31	19.2
CK29	11-11-69	32.31	19.2
CK30	11-11-69	31.23	20.5
CK31	11-11-69	29.62	19.8
CK32	11-12-69	18.31	19.8
CK33	11-12-69	29.08	19.8

TABLE 5. (Continued)

Station	Date	Bottom Salinity (o/oo)	Bottom Temperature (° C)
CK33	12- 5-69	32.31	13.5
CK34	11-19-69	30.15	18.8
CK35	11-19-69	31.77	18.2
CK36	11-19-69	27.46	18.2
CK37	11-19-69	26.92	18.2
CK38	11-25-69	29.08	17.5
CK39	11-25-69	31.23	17.5
CK40	11-25-69	31.77	17.0
CK41	11-25-69	26.92	18.0
CK42	11-26-69	28.00	17.0
CK43	11-26-69	29.62	17.0
CK44	12- 4-69	23.16	13.5
CK45	12- 4-69	23.69	14.0
CK46	12- 4-69	27.46	14.1
CK47	12- 5-69	31.23	13.5
CK48	12- 6-69	30.15	13.8
CK49	12- 6-69	31.23	14.0
TS1	12-18-69	26.92	15.0
TS2	12-18-69	26.92	15.0
TS3	12-18-69	25.85	16.0
TS4	12-18-69	27.46	16.5
TS5	12-18-69	26.92	16.5

TABLE 6. PHYSICAL DATA FROM EXPERIMENTAL STATIONS IN TAMPA BAY

Station	Date	Salinity (o/oo)	pH	Temperature (°C)	Secchi (ft)
5	11- 7-68	29.00 S	—	24.2 S	—
	11-21-68	26.30 S	—	15.5 S	—
	12-19-68	29.62 S	7.7 S	14.5 S	—
	1-24-69	30.69 S	7.7 S	18.0 S	8
	2-24-69	30.15 B	7.7 B	16.7 B	6
	3-20-69	30.69 B	8.0 B	18.5 B	7
	7-30-69	31.23 B	7.9 B	30.5 B	6
	4- 9-70	24.77 B	—	23.5 B	—
7	12-19-68	29.62 S	7.1 S	14.5 S	—
		28.54 S	7.9 S	15.5 S	—
		29.08 S	8.0 S	19.0 S	5
	2-21-69	31.77 B	7.9 B	14.8 B	5
	3-19-69	29.62 B	—	17.5 B	—
	4-28-69	29.08 B	8.1 B	24.0 B	5
	8-13-69	27.46 B	7.0 B	28.7 B	—
	4-14-70	26.38 B	—	20.5 B	4
	5-21-69	32.31 B	8.3 B	28.0 B	4
	5-29-69	33.39 B	7.9 B	27.0 B	3
	6- 9-69	30.15 B	7.2 B	33.3 B	3
	6-17-69	32.31 B	7.8 B	31.0 B	4
	7-31-69	32.31 B	7.7 B	29.8 B	3
	8-29-69	—	—	29.5 B	3
	4- 7-69	29.08 B	—	23.5 B	3
	4- 8-69	29.08 B	—	22.5 B	3
12A	8-21-69	—	—	31.0 B	8
	8-22-69	32.31 B	7.3 B	30.5 B	8
	8-27-69	32.31 B	7.8 B	30.0 B	7
	9-11-69	32.85 B	7.1 B	29.8 B	6
	4-16-70	29.08 B	—	24.0 B	8
19	9- 4-69	31.23 B	7.3 B	29.3 B	6
	9- 8-69	26.92 B	—	29.0 B	8
	4-16-70	29.08 S	—	23.5 S	7
27	4-11-69	27.46 B	8.0 B	26.0 B	4
	5- 8-69	29.08 B	7.2 B	26.0 B	3
	5-16-69	28.00 B	7.5 B	27.5 B	4
	5-27-69	30.15 B	7.3 B	29.0 B	5
	6- 6-69	29.62 B	8.0 B	29.5 B	3
	8- 1-69	28.00 B	7.7 B	30.0 B	2
	9- 8-69	26.92 B	7.0 B	30.5 B	3
	4-16-70	22.08 B	—	20.5 B	3

B = bottom; S = surface

chives and can be made available to bona fide researchers for use on our premises:

I. Sampling gear and locations of use
   A. R/V *Venus* — Tampa Bay, Boca Ciega Bay, Wacasassa Reef, Cedar Keys and vicinity, Suwannee Reef, Horseshoe Point, Steinhatchee

   (Note: The following gear were used only in Tampa Bay and lower Boca Ciega Bay)

   B. Trynet
   C. Box dredge
   D. Benthic plug

II. Biological data taken at each sampling
   A. Identification of specimens taken
   B. Number of each species captured
   C. Length measurements of fish (SL), mollusks, and crustaceans

RESULTS AND DISCUSSION

SUBSTRATE ALTERATION AND RECOVERY

Results demonstrate that the dredgehead water jets are capable of penetrating the substrate to a depth of 18 inches and that virtually all attached vegetation in its path is uprooted. Similar effects were noted by Manning (1957) in Chesapeake Bay. The degree of troughing and the time necessary for substrate recovery depend upon substrate type, presence of algae and sea grass, and current and wave action.

The immediate and lasting effects of dredging on the substrate and overlying vegetation at each of the six experimental stations in Tampa Bay are as follows.

Station 5

This station was completely dredged and most of the sea grasses, *Thalassia testudinum* and *Syringodinium filiforme*, were removed from the dredged plot, leaving a bare sand bottom with a few sea grass blades. Two days after dredging (18 November 1968) trenches eroded by the dredgehead were 1 ft deep, and sand deposits were observed on the control side. These troughs became progressively less pronounced, and by one month after dredging the substrate was level. Immediately after dredging sediments were loosely packed; this condition persisted in spots throughout the sampling period.

Scuba observations were made immediately after redredging one strip through the control and experimental plots on 3 March 1969, 113 days after dredging. A trench 3 ft wide by 1 ft deep was observed on the experimental plot. The dredge had uncovered a deep stratum of dead shell which had not been exposed at the initial dredging. Most of this dead shell was collected by the dredge and redeposited in and alongside the dredged trench below. This exposure of a deeper stratum may have resulted from loss of overlying sand, although lowering of the substrate was not observed during diving observations.

Throughout the 509 monitoring days no regrowth of any sea grass was observed. Even the single swath through the control plot remained plainly visible throughout the sampling period because grass had failed to re-cover the 3 ft sandy strip running some 72 ft through dense *Thalassia testudinum* growth.

Station 27

The most marked substrate changes, both immediate and long lasting, occurred at this shallow water station. One day after completion of dredging, trenches ranged from 6 to 18 in. deep. Trenches were deep at this station because the plot was only partially dredged (to simulate a commercial operation) and because the vessel's propeller wash scoured the trenches and prevented redeposition of suspended sediments into the trench. Moreover, trenches were slow to fill because they were flanked by undisturbed substrate with *Caulerpa prolifera* cover which remained compact and kept trench walls subangular. These trenches gradually filled. After 20 days (27 May 1969) they were 6 in. deep, after 86 days (1 August 1969) they were 1-2 in. deep, and by the following April the substrate was level. During this recovery period the loose sandy bottom became more compact.

This was the only station exhibiting any regrowth of vegetation. After 86 days of recovery some previously dredged areas were flecked with new blades of *Caulerpa prolifera*. At the final inspection of this station (13 April 1970) the control swath could not be located because the old dredge track was covered with new *Caulerpa* growth. However, at this final inspection *Caulerpa* had declined markedly in the northwest corner of the experimental plot. New growth was observed in this area in August 1969. A possible explanation is that north and northwest winds of winter storms generate waves that churn the bottom at this shallow water station, thus producing conditions unsuitable for sea grass or algae attachment. Damage was more severe to this station because the bottom had only partially recovered and was more vulnerable to sediment shifting and erosion. This is supported by the fact that the five-gallon cement-filled bottom marker and attached tires had become completely buried in the substrate.

Station 11

Dredging at this shallow sea grass-covered station was partial (50%), with effects similar to those found at Station 27. After 55 days (31 July 1969) troughs remained 18 in. deep but had decreased to 7 in. by 84 days. Between 29 August 1969 and 7 April 1970 troughs filled completely and became level with the surrounding substrate. Dead *Chione cancellata* shells dredged from the substrate littered the bottom till 55 days after dredging and were not visible at the final sampling.

At the final sampling, scars from old dredge tracks could be seen from the water surface. The sea grasses predominating at this station, *Thalassia testudinum* and *Syringodinium filiforme*, had not regrown in the denuded strips.

Lack of sea grass growth in dredged areas agrees with observations of Phillips (1960) that once the apex of the elongating *Thalassia* rhizome has been severed it does not continue to grow. Although this observation is specifically directed to *Thalassia*, it may also apply to *Syringodium* which failed to regenerate during this study. Phillips (1960) conducted plant recolonization studies at Cats Point and Bird Key Middle Ground (Tampa Bay) in 1958. At both locations he uprooted a small plot of *Thalassia*. *Diplanthera wrightii* invaded the Bird Key Middle Ground plot and covered half of it in five months (May to October 1958), maintaining this coverage through the last observation, 10 February 1959. At the Cats Point station no regrowth was observed from May through September 1958.

Since sexual reproduction is limited for *Thalassia, Syringodium,* and *Diplanthera* (Phillips, 1960), regrowth of sea grasses by this method is unlikely. Continued observation on sea grass stations could provide useful information concerning the time required for regrowth, the succession of sea grasses in regrowth areas, and the means of colonization.

Station 7

After dredging (9 January 1969), 8 to 12 in. trenches were observed and these persisted for at least a week. Two months after dredging (24 February 1969) a slight rolling effect was evident and after three months (26 March 1969) the bottom had become level. Like other stations, the substrate was loose after dredging but recovered its original firmness within three months.

Although this station was not covered with sea grasses, it had a dense layer of onuphid polychaetes, *Onuphis nebulosa,* forming a stable bottom. The cement-filled five-gallon bottom marker was still atop the substrate after 453 days.

Stations 12A and 19

Stations 12A and 19 showed little evidence of dredging even immediately after harvesting, except for the bottom being littered with sand dollars, *Mellita quinquiesperforata,* and dead shell, mostly *Spisula raveneli.* These were eventually reburied.

These stations are located inshore along the Gulf of Mexico and surf and currents expedited their recovery. During the Cedar Key survey the dredge was observed in operation on Sea Horse Reef which has the same sandy shell bottom as Stations 12A and 19. The trench eroded by the dredgehead filled rapidly, mostly with surrounding substrate, almost immediately after dredging. The sediment placed in suspension by the dredge formed a cloud around the dredgehead and soon settled to the bottom. Only a two-inch ridge on each side of the three-foot track distinguished where the dredge had operated. The track was filled with loosely packed soupy sand to a depth of 18 inches.

Attempts were made to photograph substrates affected by the dredge immediately after dredging and during the monitoring period but poor water visibility precluded all efforts.

RESULTS OF TEXTURAL ANALYSES

Graphs of fraction percent were plotted against time for each of the seven particle size classes (Table 3) for control and experimental sediment data. These were prepared for each station to assess textural changes in substrate after dredging and at various intervals thereafter. Although values fluctuated within each category, control and experimental values were generally similar for each sampling. The variation of these mean values within each class reflects the range of values obtained for each set of three sediment samples. Apparently the inherent differences of substrate composition within a given area and seasonal changes caused by waves, currents, and other physical conditions obscured any effects which may have been caused by dredging.

The larger sand particles are redeposited near the working dredge while silt/clay particles remain longer in suspension and may be carried away by local currents. Analyses of core samples taken immediately after dredging indicate that there were measurable losses of silt/clay particles at Station 27 (5% to 2%) and Station 11 (7% to 4%). At Station 27 the decrease was sustained throughout the one year monitoring period. At Station 11 silt/clay values for experimental and control plots approached equivalent predredging values. Studies in Virginia also showed a decrease in silt/clay particles immediately after hydraulic dredging (Haven, 1970).

ASSESSMENT OF DREDGING EFFECTS ON FAUNA

Trynet Data

Fauna identified from trynet hauls made at Tampa Bay experimental stations are listed in Table 7. A faunal list was also prepared for control and experimental hauls made at each station and the occurrence and abundance of all listed species were compared. These lists indicate no apparent differences between fauna collected from hauls on control and experimental plots. Rather, faunal variations were of a seasonal nature and substantiate the well-documented fact that estuaries, especially grass flat areas, play an important part in the life histories of most commercial and sports species. Effects of the trynet on the substrate were negligible.

TABLE 7. FAUNA COLLECTED WITH R/V *VENUS* AT EXPLORATORY STATIONS IN TAMPA BAY (TB), CEDAR KEY (CK), AND TARPON SPRINGS (TS)

NEMERTINA — *TB* 11

BRACHIOPODA

Glottidia pyramidata — *TB*, 9, 30; *CK* 32

MOLLUSCA

Gastropoda

Turbo castanea — *CK* 25, 27
Turritella acropora — *TB* 8
Cochliolepis parasitica — *TB* 11
Cochliolepis striata — *TB* 11
Balcis intermedia — *TB* 4
Crepidula plana — *TB* 8, 11, 30, 58: *CK* 25
Crepidula fornicata — *TB* 11, 30, 35, 42, 58: *CK* 25, 42
Strombus alatus — *TB* 11, 42, 43, 46, 47, 54: *CK* 16, 17, 24, 29, 31
Polinices duplicatus — *TB* 6, 8, 11, 22, 30, 35, 36, 37, 38, 39, 40, 46, 47, 49, 51, 57: *CK* 1, 6, 8, 10, 16, 17, 18, 21, 22, 23, 24, 29, 30, 33, 34, 42, 43, 46, 47, 48: *TS* 5
Sinum perspectivum — *TB* 8, 11, 30, 35, 38, 39, 40, 41, 49, 51, 56, 57: *CK* 6, 7, 10, 16, 17, 18, 19, 23, 29, 30, 34, 42, 43, 46, 48
Ficus communis — *CK* 16, 30
Murex dilectus — *CK* 25, 29
Urosalpinx perrugata — *TB* 8, 11, 30
Melongena corona — *TB* 8, 30: *CK* 20, 43
Busycon contrarium — *TB* 8, 11, 22, 40, 49: *CK* 16, 17, 20, 21, 23, 25, 34, 43, 48: *TS* 3
Busycon spiratum — *TB* 11, 30, 35, 36, 41, 56: *CK* 13, 18, 20, 25, 27, 30, 32, 33, 34, 42, 43, 48, 49
Nassarius vibex — *TB* 8, 30
Pleuroploca gigantea — *TB* 8: *CK* 23
Fasciolaria tulipa — *TB* 8, 10, 30, 36: *CK* 25
Fasciolaria hunteria — *TB* 8, 10, 30, 58: *CK* 2, 20, 24, 25, 34, 43, 48, 49
Oliva sayana — *TB* 1, 4, 6, 8, 11, 22, 30, 35, 38, 40, 41, 42, 44, 45, 46, 50, 53, 56, 57, 58, 59: *CK* 3, 4, 7, 10, 16, 17, 24, 25, 26, 28, 29, 30, 33, 43
Cancellaria reticulata — *CK* 16, 17, 18
Prunum apicinum — *TB* 11
Conus floridanus — *TB* 4
Terebra dislocata — *TB* 38, 39, 47
Kurtziella cerinella — *TB* 1

TABLE 7 (Continued)

Scaphopoda
Dentalium texasianum — *TB* 5

Bivalvia
Noetia ponderosa — *TB* 8, 11, 22, 42, 43: *CK* 3, 7, 17, 30, 33, 43, 46, 47
Atrina rigida — *TB* 3, 5, 7, 8, 10, 11, 17, 24, 30, 32, 35, 36, 57, 58: *CK* 24, 25, 28, 31, 33, 34, 43, 48, 49
Atrina serrata — *TB* 11, 43, 57: *CK* 33
Argopecten irradians concentricus — *TB* 9, 22, 36, 47: *CK* 2, 16, 20, 25, 27
Crassostrea virginica — *CK* 31
Cardita floridana — *TB* 30, 36: *CK* 25, 31, 48, 49
Phacoides pectinata — *TB* 4
Lucina pennsylvanica — *TB* 4: *CK* 16, 17, 18, 24, 25, 26, 27, 28, 30, 43
Lucina floridana — *TB* 30, 36: *CK* 30
Trachycardium egmontianum — *TB* 8: *CK* 2, 25, 26, 27, 30, 43, 46, 49
Dinocardium robustum vanhyningi — *TB* 4, 5, 7, 8, 11, 13, 20, 21, 22, 24, 27, 32, 37, 38, 39, 43, 45, 46, 47, 48, 49, 50, 51, 57: *CK* 4, 8, 10, 13, 16, 17, 19, 21, 23, 29, 30, 33, 34, 42, 43, 44, 46, 47, 48, 49: *TS* 1, 2
Mercenaria campechiensis — *TB* 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 23, 24, 26, 28, 29, 30, 32, 33, 34, 35, 36, 37, 38, 43, 52, 54, 56, 58: *CK* 7, 10, 28, 30, 31, 33, 34, 36, 42, 43, 48, 49: *TS* 1, 2, 4
Chione cancellata — *CK* 20, 24, 25, 27, 28, 29, 42, 46, 48, 49
Macrocallista nimbosa — *TB* 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24, 26, 27, 28, 29, 32, 33, 35, 36, 37, 38, 39, 44, 45, 46, 47, 49, 50, 51, 56, 57, 59: *CK* 5, 7, 8, 9, 10, 12, 13, 14, 16, 17, 18, 23, 25, 28, 29, 30, 33, 34, 43, 47, 48, 49; TS 1,2
Dosinia discus — *TB* 1, 5, 6, 8, 11, 16, 28, 29, 30, 31, 43, 52, 55, 56, 57: *CK* 7, 8, 19, 20, 23, 33, 35, 36, 47, 49: *TS* 1
Dosinia elegans — *TB* 4
Tellina magna — *CK* 16
Tellina alternata — *TB* 6, 8, 11: *CK* 2, 33
Tellina sp. — *CK* 20
Ensis minor — *TB* 30, 36
Spisula raveneli — *TB* 15, 22, 30, 38, 39, 40, 41, 49, 50, 51: *CK* 16, 18, 19, 33, 48, 49
Mactra fragilis — *TB* 8, 30
Anatina plicatella — 4, 12, 13, 56: *CK* 13, 20, 21, 23, 33, 42, 47: *TS* 5
Anatina anatina — *TB* 4
Corbula contracta — *TB* 8
Cyrtopleura costata — *TB* 11, 15, 32, 33, 36

TABLE 7 (Continued)

SIPUNCULOIDEA — *TB* 8, 9, 11, 12, 23, 24, 32, 36, 44, 48, 50, 53, 57: *CK* 4, 5, 7, 10, 13, 16, 18, 20, 21, 22, 23, 24, 28, 29, 30, 33, 34, 42, 43, 47, 48: *TS* 1

ANNELIDA
- Ploynoidae — *TB* 7, 8, 11, 32, 33
  - *Phylohartmania taylori* — *TB* 1
  - *Lepidonotus sublevis* — *TB* 37
- Polyodontidae — *TB* 7, 8, 11, 32, 33
- Mereidae — *TB* 11
- Nephtyidae — *TB* 11
- Glyceridae-Goniadidae — *TB* 11
- Onuphidae — *TB* 1, 8, 11, 30, 36: *CK* 34
- Eunicidae — *TB* 11
- Arabellidae — *TB* 11
- Orbiniidae — *TB* 11
- Paraonidae — *TB* 11
- Chaetopteridae — *TB* 11, 30: *CK* 6, 31, 33, 34, 37, 42, 47, 48, 49: *TS* 5
- Cirratulidae — *TB* 11
- Arenicolidae — *TB* 6, 11: *CK* 17, 18
- Maldanidae — *TB* 8, 11
  - *Branchioascychis cristata* — *TB* 12
  - *Maldane saise* — *TB* 4
- Oweniidae — *TB* 4
  - *Owenia fusiformis* — *TB* 4
- Terebellidae — *TB* 11

ARTHROPODA
- Merostomata
  - *Xiphosura polyphemus* — *TB* 8, 11, 30, 32, 36
- Crustacea
  - Stomatopoda
    - *Squilla neglecta* — *TB* 4
    - *Squilla empusa* — *TB* 8
  - Decapoda
    - *Penaeus duorarum* — *TB* 8, 30, 36: *CK* 1, 17, 20, 25, 26, 33, 42, 46, 49
    - *Trachypeneus similis* — *TB* 11

TABLE 7 (Continued)

Pontonia domestica — *TB* 4
Latreutes parvulus — *TB* 8
[2] *Callianassa trilobata* — *TB* 4, 8, 11, 12, 16, 30, 33, 35: *CK* 21
Pagurus longicarpus — *TB* 4, 8, 11, 30, 35: *CK* 3, 6
Pagurus pollicaris — *TB* 8, 11, 30, 36: *CK* 21, 23, 30, 31, 33, 42
Pagurus annulipes — *TB* 8
Albunea sp. — *TB* 39, 41: *CK* 17, 18, 29, 33
Emerita sp. — *TB* 39, 50, 57
Persephona punctata aquilonaris — *TB* 8, 11, 35, 39, 40, 46, 49: *CK* 17, 18, 30, 33, 45, 47, 49: *TS* 1, 3, 4
Hepatus epheleticus — *TB* 8, 11, 35, 39, 40, 46, 49: *CK* 17, 18, 30, 33, 45, 47, 49: *TS* 1, 3, 4
Ovalipes guadulpensis — *TB* 58: *CK* 16, 17, 47
Portunus gibbesii — *TB* 1, 8, 11, 30, 32, 35, 36, 39: *CK* 17, 21, 29, 30, 31, 32, 33, 34, 42, 43, 45, 46, 47, 48, 49: *TS* 4
Portunus sp. — *CK* 20, 25
Callinectes sapidus — *TB* 30, 36: *CK* 35, 36
Menippe mercenaria — *TB* 8, 11, 17, 23, 30, 32, 37, 53, 58: *CK* 1, 20, 24, 29, 31, 42, 47
Neopanope texana texana — *TB* 8, 11, 30, 36, 58: *CK* 49
Panopeus herbstii — *TB* 30
Pinnotheres maculatus — *TB* 8, 11, 30
Pinnotheres ostreum — *TB* 8
Pinnixa cristata — *TB* 4
Pitho anisodon — *TB* 8, 30, 36
Libinia emarginata — *TB* 11: *CK* 24
Libinia dubia — *TB* 8, 11, 16, 30, 36, 43, 57: *CK* 5, 12, 17, 21, 22, 23, 33, 34, 36, 43, 45, 46, 48, 49
Libinia sp. — *CK* 29, 30, 33, 42, 43

ECHINODERMATA
Holothuroidea
Thyone briareus — *TB* 8, 11, 30, 36: *CK* 21, 24, 48
Thyonella gemata — *TB* 8, 11: *CK* 25
Penacta pygameus — *TB* 8, 11, 30, 36: *CK* 7, 10, 20, 25, 29, 42, 43, 45, 48: *TS* 4
Echinoidea
Moira atropos — *TB* 5, 8, 11, 12, 20, 21, 32, 43: *CK* 8, 9, 13, 17, 19, 22, 23, 24, 29, 30, 31, 32, 33, 47: *TS* 1, 3
Lytechinus variegatus — *TB* 18, 25, 27, 36, 42, 43: *CK* 2, 10, 12, 20, 21, 23, 24, 25, 26, 27, 29, 30: *TS* 4

TABLE 7 (Continued)

Mellita quinquiesperforata — *TB* 1, 5, 6, 8, 11, 22, 32, 35, 38, 39, 40, 41, 42, 44, 45, 46, 47, 48, 49, 56, 57, 58: *CK* 1, 3, 4, 5, 7, 8, 9, 10, 13, 14, 15, 16, 17, 18, 19, 21, 22, 23, 24, 25, 28, 29, 30, 31, 32, 33, 34, 35, 36, 42, 43, 47, 48, 49: *TS* 1

Asteroidea

Astropecten sp. — *TB* 1, 8, 11, 30, 32, 35, 41, 42, 44, 56: *CK* 17, 27
Luidia sp. — *TB* 1, 8, 11, 20, 21, 28, 30, 35, 38, 39, 40, 41, 45: *CK* 13, 16, 19, 30, 45, 48: *TS* 3
Echiniaster spinulosus — *TB* 30, 38: *CK* 8, 17, 45, 46: *TS* 1

Ophiuroidea

Ophiophragmus wurdemani — *TB* 4, 11, 30, 38, 39, 40, 41, 42, 49, 50, 57
Ophioghgarmus sp. — *CK* 9, 13, 18, 27, 29, 33, 36, 42, 43, 44, 45, 46, 47; *TS* 1
Ophioderma brevispinum — *TB* 30
Ophiolepsis elegans — *TB* 11

CHORDATA

Enteropneusta

Enteropneusta balanoglossus — *TB* 8

Osteichthyes

Hippocampus erectus — *TB* 35: *CK* 46
Syngnathus sp. — *TB* 8
Lagodon rhomboides — *TB* 8, 36
Achirus lineatus — *TB* 8
Trinectes maculatus — *TB* 8, 11
Symphurus plagiusa — *TB* 11, 30
Sphoeroides nephelus — *TB* 8
Chilomycterus schoepfi — *TB* 8

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[1] Living specimens of *Cochliolepis* collected by the R/V *Venus* were sent to Dr. D. R. Moore of the Institute of Marine Sciences, Miami, Florida. Based on this material, Dr. Moore delivered a paper concerning the anatomy of this species to the 1970 Annual Meeting of the American Malacological Union (Moore, 1970).

[2] Most of the type material for this new species was collected by the R/V *Venus* in Tampa Bay during the course of this study (Biffar, 1970).

Benthic Plug Data

Fauna identified from benthic plug collections are listed in Table 8. This data was also summarized in Table 9 for three phyla: Mollusca, Annelida (Polychaeta), and Crustacea.

Marked differences in abundance between control and experimental fauna were encountered only at Station 27. In the three plugs taken on the dredged side, mollusks and crustaceans were not present. A similar effort on the control side yielded 48 mollusks and 96 crustaceans. The control produced more than 45 polychaetes, whereas the experimental produced about 10. Only one of the 12 identified polychaete families occurred on both plots.

The other sea grass stations, 5 and 11, did not exhibit such marked faunal differences. At Station 5, bivalves from control samples were three times as prevalent as those from experimental samples, representing twice as many species and over twice as many families. Fifty percent of the bivalve species and 40% of the families were coincident. The control yielded more polychaetes (49 vs. 21) and only three of the 11 families represented were coincident.

No gastropods were collected at Station 11. Nine bivalves, eight of which were tellins, were collected from experimental plugs, but no bivalves were taken from the control. The dredged side also produced more polychaetes (36 vs. 20) and of the 15 families identified only three occurred on both plots. A considerable number of crustaceans (127) were collected from the control and amphipods represented 118 of these. Plugs from the experimental side yielded only two amphipods.

Station 7 exhibited more faunal homogeneity than any of the other stations (Table 9). The other nonvegetated stations (12A and 19) provided only sketchy data for benthic plug analysis but no significant differences are apparent between control and experimental populations.

Of 36 benthic plug samples, only one *Macrocallista nimbosa* (6 mm) was collected and no *Mercenaria campechiensis*.

TABLE 8. FAUNA COLLECTED WITH R/V *VENUS*, TRYNET, AND BENTHIC PLUG SAMPLER AT EXPERIMENTAL DREDGING STATIONS IN TAMPA BAY

V = R/V *Venus*, T = Trynet, B = Benthic Plug Sampler

	Experimental Stations 5	7	27	11	12A	19
PLATYHELMINTHES		T				
NEMERTINA		VT				
BRACHIOPODA						
Glottidia pyramidata	V		V			
MOLLUSCA						
Gastropoda						
Turritella acropora	V					
Bittium varium		T	T	T		
Crepidula plana	VT	VT	V			
Crepidula fornicata	T	VT	VT	T		
Strombus alatus		V				
Polinices duplicatus	V	V	V	V	V	VT
Natica pusilla	B					B
Sinum perspectivum	V	VT	V		VT	T
Urosalpinx perrugata	V	VT	VT			
Eupleura sulcidentata		T				
Anachis semiplicata	T	T	TB	T		
Anachis ostreicola	T					
Mitrella lunata	T	T	TB	T		
Melongena corona	V		VT			
Busycon contrarium	V	VT		T		VT
Busycon spiratum		VT	V	V		
Nassarius vibex	VT	T	VTB	T		
Pleuroploca gigantea	V					
Fasciolaria tulipa	V		V	V		
Fasciolaria hunteria	V	T	V			
Olivella sp.					B	
Oliva sayana	V	VT	V		VTB	V
Marginella eburneola				T		
Prunum apicinum	B	VTB	T	T		
Terebra dislocata					V	V
Bursatella leachi plei			T			
Scaphopoda						
Dentalium texasianum	V					
Bivalvia						
Nucula proxima	B	B				
Nuculana acuta		B				
Anadara transversa	T	T	TB			

TABLE 8 (Continued)

	5	7	27	11	12A	19
Noetia ponderosa	V	V				V
Brachidontes exustus	B		B			
Musculus lateralis	T	TB	T	T		
Atrina serrata		V			V	
Atrina rigida	V	VT	VT	V	V	
Argopecten irradians concentricus	T		T	VT		V
Cardita floridana			V	VT		
Lucina floridana			V	V		
Trachycardium egmontianum	V					
Dinocardium robustum vanhyningi	V	VT			V	V
Mercenaria campechiensis	V	V	V	V		V
Macrocallista nimbosa	V	VB		V	V	V
Gouldia cerina		B		B		
Dosinia discus	V	V	V			
Tellina alternata	V	V				
Tellina rom.	B	B	T	B		
Ensis minor	B		VB	V		
Mulina lateralis	B	B				
Spisula raveneli					VT	VT
Mactra fragilis	VB	B	VB			
Mactra sp.		T				
Corbula contracta	V					
Cyrtopleura costata		V		V		
Cephalopoda						
Lolliguncula brevis	T	T				
SIPUNCULOIDEA	V	VB		V	V	V
ANNELIDA						
Polychaeta						
Polynoidae		T		B		
Polyondontidae	V	V				
Sigalionidae		V	B			
Phyllodocidae		B	B	B	B	
Hesionidae		B				
[1] Pilargidae		B				
Syllidae		B				
Nereidae	BT	VT	B	TB		
Nephtyidae		V				B
Glyceridae-Goniadidae	B	VB	B	B		
Onuphidae	VB	VB	VB	VB		
Eunicidae		VB	B	B		
Arabellidae		VB	B			
Dorvilleidae		V				
Orbiniidae	B	VB				B
Paraonidae	B	VB		B		
Spionidae	B	B		B		
Magelonidae			B		B	
Chaetopteridae			V			

TABLE 8 (Continued)

	5	7	27	11	12A	19
Cirratulidae		VB	B	B		
Opheliidae	B			B	B	
Capitellidae		B	B	B		
Arenicolidae		V				
Maldanidae	VB	VB	B	B		
Oweniidae	B	B				
Pectinariidae	B	B	B	B		
Ampharetidae				B		
Terebellidae		V				
ARTHROPODA						
Merostomata						
Xiphosura polyphemus	V	T	V	V		
Crustacea						
Cumacea	B					
Isopoda	B	B	B	B	B	
Amphipoda	B	B	B	B	B	
Stomatopoda						
Squilla empusa	V					
Decapoda						
Penaeus duorarum	VT	T	VT	VT		
Trachypeneus similis	T	V				
Sicyonia typica	T					
Periclimenes longicaudatus	T		T	T		
Palaemon floridanus		T	T	T		
Palaemonetes intermedius			T	T		
Alpheus herterochaelis		T		T		
Synalpheus sp.	T	T				
Latreutes fucorus				B		
Latreutes parvulus	T					
Hippolyte pleuracantha			T	T		
Tozeuma carolinese	T	B	T	TB		
Callianassa trilobata	V	V	V			
Petrolisthes armatus		T				
Pagurus longicarpus	VT	VTB	VT	TB		T
Pagurus pollicaris	VT	VT	VT	V		
Pagurus impressus		T				
Pagurus annulipes	VTB	T	TB	TB		
Albunea gibbesii					V	
Emerita talpoida					V	
Persephona punctata aquilonaris	V	VT				
Hepatus epheliticus	V	V				
Ovalipes guadulpensis					V	
Portunus gibbesii	VT	VT	VT	V		T
Callinectes sapidus	T	T	VT	VT		

TABLE 8 (Continued)

	5	7	27	11	12A	
Pilumnus sp.		T				
Menippe mercenaria	VT	VT	V	T		
Hexapanopeus angustifrons		T				
Neopanope texana texana	VT	VT	VTB	VT		
Neopanope packardii		T				
Panopeus herbstii			V			
Panopeus occidentalis		T				
Pinnotheres maculatus		V				
Pinnotheres ostreum	V		V			
Pinnixa sayana		B				
Metoporhaphis calcarata	T					
Pitho anisodon	V		V	VT		
Libinia emarginata		V				
Libinia dubia	VT	VT	VT	VT	V	
ECHINODERMATA						
Holothuroidea						
Thyone briareus	V	VB	VB	V		
Thyonella gemmata	V	V				
Pentacta pygmaeus	VT	V	V	VT		
Echinoidea						
Moira atropos	V	V			T	T
Lytechinus variegatus		T		VT		
Mellita quinquiesperforata	VTB	VT		T	VTB	VTB
Asteroidea						
Astropecten rom	VT	VT				
Luidia sp.	VT	T			T	T
Echinaster spinulosus			VT	T		
Ophiuroidea						
Ophiophragmus filograneus	B					
Ophiophragmus wurdemani		V			VB	
Ophioderma brevispinum			VB			
Ophiolepis elegans		V				
CHORDATA						
Enteropneusta						
Entereopneusta blanaglossus	V					
Cephalocordata						
Branchiostoma floridae	B			B	B	
Chondrichthyes						
Sphyrna tiburo		T				
Rhinobatos lentiginosus		T				
Dasyatis sayi	T	T	T			
Gymnura micrura		T				
Osteichthyes						
Anchoa mitchilli		T	T	T		
Synodus foetens	T	T		T		

TABLE 8 (Continued)

	5	7	27	11	12A	19
Bagre marinum		T				
Arius felis		T	T			
Opsanus beta		T	VT	T		
Ogcephalus corniger		T				
Urophycis floridanus		T				
Hippocampus erectus	T	T	T			
Hippocampus zosterae				T		
Syngnathus sp.	V		T	T		
Centropristis striata melana	T			T		
Diplectrum formosum	T	T				
Mycteroperca microlepis				T		
Lutjanus synagris	T			T		
Eucinostomus argenteus		T				
Eucinostomus gula	T	T	T	T		
Orthopristis chrysoptera	T	T	T	T		
Archosargus probatocephalus			T	T		
Calamus arctifrons	T					
Diplodus holbrooki	T		T	T		
Lagodon rhomboides	VT	T	T	VT		
Bairdiella chrysura	T		T	T		
Cynoscion nebulosus				T		
Leiostomus xanthurus	T	T		T		
Chaetodipterus faber		T	T	T	T	
Blenniidae		T				
Gobiidae		T				
Gobiosoma bosci			T	T		
Prionotus scitulus latifrons	T	T		T	T	T
Prionotus tribulus crassiceps		T				
Ancylopsetta quadrocellata		T		T		
Etropus crossotus		T				
Paralichthys albigutta	T	T	T	T	T	T
Syacium papillosum		T				
Achirus lineatus	V					
Trinectes maculatus	T	VT		T		
Symphurus plagiusa		VT	VT			
Aluterus schoepfi	T					
Monocanthus ciliatus	T					
Monocanthus hispidis	T	T				
Lactophrys quadricornis	T	T	T	T		
Sphoeroides nephelus	VT	T	T	T		
Chilomycterus schoepfi	VT	T	T	T		

[1] The family Pilargidae is represented by one species, *Ancistrosyllis jonesi* Pettibone, 1966, in our collections. This constitutes the first record for the species outside the Chesapeake Bay area.

TABLE 9. SUMMARY OF BENTHIC PLUG ANALYSES FOR MOLLUSCA, POLYCHAETA, AND CRUSTACEA: TAMPA BAY EXPERIMENTAL STATIONS

	Station 5		Station 7		Station 27		Station 11		Station 12A		Station 19	
	Control	Dredge	Control	Dredge	Control	Dredge	Control	Dredge	Control	Dredge	Control	Dredge
MOLLUSCA												
Gastropoda												
Individuals	2	1	1	1	17	0	0	0	8	9	0	1
Species	2	1	1	1	3	2	0	0	1	2	0	1
Families	2	1	1	1	2	0	0	0	1	2	0	1
Concurring species	1		1		0		0		1		0	
Concurring families	1		1		0		0		1		0	
Bivalvia												
Individuals	15	5	31	29	31	0	0	9	0	3	4	3
Species	6	3	6	6	4	0	0	2	0	1	1	1
Families	5	2	5	5	4	0	0	2	0	1	1	1
Concurring species	3		4		0		0		0		1	
Concurring families	2		4		0		0		0		1	
POLYCHAETA												
Errantia												
Individuals	4	4	32+	27+	41+	7+	14+	20+	1	0	1	1
Families	3	2	8	8	5	3	5	4	1	0	1	1
Concurring families	1		6		1		2		0		1	
Sedentaria												
Individuals	45	17	29+	35+	4	3	6	24+	5	0	0	0
Families	4	5	7	8	3	2	2	8	2	0	0	0
Concurring families	2		7		0		1		0		0	
CRUSTACEA												
Individuals	39	56	0	6	96	0	127	7	12	2	0	0
Species	4+	5+	0	4+	5+	0	5+	4	3+	1+	0	0
Families	3+	5+	0	4+	4+	0	4+	3	3+	1+	0	0
Orders	4	3	0	3	3	0	3	2	2	1	0	0
Concurring species	1+		0		0		2		1+		0	
Concurring families	1+		0		0		2		1+		0	
Concurring orders	3		0		0		2		1		0	

+ = fragments

REDREDGING WITH THE R/V *VENUS*

Redredging at Station 5 was conducted on 28 March 1969 and 21 April 1970, 132 and 512 days after final dredging. At the first resampling, 25 minutes of dredging on the control plot yielded 123 southern quahogs and 19 sunray venus clams, while a similar effort on the experimental side yielded 32 sunrays and only 2 quahogs. At the second resampling, five minutes of dredging on the control yielded 13 quahogs and 5 sunrays, while a five minute run on the experimental side yielded 4 sunrays and 1 quahog. Sizes of these clams indicate that no set had taken place during the monitoring period.

Collections from redredging at Station 7, taken 68 and 468 days after initial dredging, show a similar decline of clam abundance on the experimental side. Station 7 was also resampled twice with the R/V *Venus* and length (mm) measurements of clams collected are listed for each sampling date in Table 10.

In contrast to clams collected at Station 5, the small size of those from Station 7, collected during April 1970, indicates that recruitment occurred during the previous year for both quahogs and sunrays.

Since Stations 27 and 11 were only partially dredged, it was impossible to redredge in original strips. For this reason, comparisons cannot be made between control and experimental catches. Length measurements of quahogs taken at Station 27 indicate a successful set for 1969-70, whereas at Station 11 (Boca Ciega Bay) they do not. Taylor and Saloman (1969) also observed a poor set in Boca Ciega Bay for 1967-68. Annual recruitment of the southern quahog has been shown by Taylor and Saloman (1968) to vary greatly from year to year.

Faunal collections made with the R/V *Venus* at Station 12A 240 days after initial dredging suggest that this area had completely recovered.

Redredging samplings do not reveal any mass mortalities from suffocation or burial by suspended sediments.

TAMPA BAY CLAM SURVEY

Area I

Stations in Area I (Table 11) were sampled during the beginning

TABLE 10. LENGTH (MM) OF *MACROCALLISTA NIMBOSA* AND *MERCENARIA CAMPECHIENSIS* COLLECTED AT STATION 7 WITH THE R/V VENUS

	3-17-69		4-21-70	
	Control	Dredge	Control	Dredge
Mercenaria campechiensis	29, 34	30, 31	27, 68	28
Macrocallista nimbosa	52, 53, 61 62, 75, 78	45, 59	42, 44, 49 51, 52, 53, 62, 63	51, 80

TABLE 11. NUMBER AND MEAN SIZE (MM) OF *MACROCALLISTA NIMBOSA, MERCENARIA CAMPECHIENSIS*, AND *SPISULA RAVENELI* COLLECTED AT TAMPA AND BOCA CIEGA BAYS (AREAS I-IV)

Effort Values Are Based on Total Clam Production Per 15 Minute Dredging

		M. nimbosa		*M. campechiensis*		*S. raveneli*		
Station	Date	No. Caught	Mean Size	No. Caught	Mean Size	No. Caught	Mean Size	Effort Clams/15 Min
AREA I								
13	3-28-68	66*		50*				88
14	3-28-68	32*		1				33
15	3-28-68	+		+				
16	3-28-68	+						
	5-15-68	+		+				
AREA II								
1	2-28-69	8	65	2	97			15
	2-28-70	9	75	8	79			26
2	1-17-68	+		+				
3	1-17-68	+		+				
4	9-16-69	83	121	142	88			28
	2-18-70	14	76	1	114			15
5	1-18-68	+		+				
	10- 3-68			+				
6	2-28-69	86	74	22	30			15
	2-18-70	39	83	14	101			31
	3-23-70	77	98	19	77			41

TABLE 11 (Continued)

Station	Date	*M. nimbosa* No. Caught	*M. nimbosa* Mean Size	*M. campechiensis* No. Caught	*M. campechiensis* Mean Size	*S. raveneli* No. Caught	*S. raveneli* Mean Size	Effort Clams/15 Min
7	2-22-68	+						
	3-19-68	+		+				
	5-22-69			100*				50
	7-23-69	15	57	83	64			74
8	11-14-68	166	81	111	73			30
	11-15-68	110	86	90	77			25
	3-28-69	52	94	124	96			38
	4-21-70	9	75	14	113			35
9	3-18-68			192	75			225
	3-26-68			265	63			195
11	3-20-68	+		41	79			15
	12-20-68	142	60	65	43			21
	1- 8-69	185	62	97	40			24
	3- 7-69	8	62	4	30			18
	4-21-70	10	53	3	46			24
32	5-22-68	148	76	165	93			26
	5-31-68	196*		150*				88
	9- 5-68	130*		700*				104
	9-11-68	314	90	16	47			60
33	5-28-68	51	78	256	68			26
34	5-31-68			+				
35	5- 6-69	16	109	11	91			7
37	5-22-69	57	112	34	102			136
	7-23-69	128	73	80	53			156
56	7-24-69	199	101					20
	2-18-70	6	47	3	100			14
58	2-18-70			28	76			42
59	2-18-70	24	80					36
AREA III								
10	3-20-68	246	95	+				120
24	4-10-68	192	111	120	65			156
26	4-10-68	+		+				
27	4-10-68	+						
28	5-14-68	190	96	+				97
29	5-14-68	55	96	216	68			60
30	5-14-68			200	71			75
	6-14-68			225	70			75
	4-15-69			399	68			67
	4-17-69			397	65			70
	5- 1-69			215	66			130
	5- 7-69			447	66			75
	4-23-70			50	67			132

TABLE 11(continued)

Station	Date	*M. nimbosa* No. Caught	*M. nimbosa* Mean Size	*M. campechiensis* No. Caught	*M. campechiensis* Mean Size	*S. raveneli* No. Caught	*S. raveneli* Mean Size	Effort Clams/15 Min
AREA IV								
12	3-26-68	6						3
17	3-29-68	+		223	58			105
18	3-29-68	+		176	92			90
22	9- 5-69	2	121			366	40	61
	6-18-69					257	39	387
23	4- 2-68	4		7				11
36	5-21-69	57	112	+				3
	5-29-69			13	80			7
	5-30-69			144	76			7
	6- 3-69			26	69			20
	6- 6-69			48	80			24
	4-22-70			10	66			10
38	6-10-69	3	117			24	43	42
39	6-10-69	6	120			2	36	12
40	6-10-69					10	38	15
41	6-10-69					15	34	23
43	6-13-69			13	54			20
44	6-13-69	1	98					2
45	6-13-69	2	128					3
46	6-13-69	1	153					2
47	6-13-69	3	135					5
49	6-18-69	1	130			224	41	336
50	6-18-69	2	96			43	40	68
51	6-18-69	1	59			85	40	128
52	6-20-69			1				5
54	6-20-69	1	80					—
55	6-20-69	2	48					—
57	8-22-69	12	79			166	42	166
	8-23-69	5	121			149	44	75
	8-26-69	10	108			113	42	28
	4-22-70	3	50					5

+ = present

* = quantity estimated from volumetric measure

of the program to establish precise sampling techniques and to familiarize personnel with operation of the R/V *Venus*. Station TB13 off Papys Bayou was the most productive for this area. Sunrays and quahogs were collected in almost equal quantities with an effort value of 88 total clams per quarter hour. Stations TB14, TB15, and TB16 produced both sunrays and quahogs, while Station 14, just south of Gandy Bridge, yielded 32 sunrays and 1 quahog in 15 minutes.

Area II

The greatest density of quahogs sampled during this program was at Station TB9 of Area II (Table 11). This station, sampled twice in March 1968, yielded effort values of 225 and 195 clams per quarter hour. These quahogs were of cherrystone size, averaging 63-75 mm. High effort values were also encountered in this area at Stations TB32 and TB37, south of Pinellas Point. Sunrays and quahogs were not equally distributed at these stations; sunrays occurred on bare sandy substrates and quahogs predominated on grassy bottoms. Although some commercial populations occur in this area, the shellfish cannot be harvested because of Pinellas County Health Department regulations.

Area III

From McGill Bay to Cockroach Bay large quantities of clams were encountered during sampling conducted early in the program (Table 11). Combined effort values of 75 to 132 clams per quarter hour were obtained for sunrays and quahogs. The average size of quahogs taken from these stations ranged from 65-71 mm (cherrystone size). In this area, as in others, quahogs predominated on sea grass and algae covered bottoms and sunrays on bare sandy substrate.

Area IV

In lower Boca Ciega Bay, where sea grasses are prevalent, sunrays were scarce, while quahogs were dominant (Table 11). Stations TB17, TB18, TB19 produced almost all of the quahogs from this area. Effort values for Stations TB17 and TB18 are high, 105 clams and 90 clams per quarter hour, and comparable with values from Areas II and III.

On the Gulf side of Mullet Key and Egmont Key catches of surf clam, *Spisula raveneli*, were considerable. At Station TB22 a ten-minute sample yielded 157 of these clams for an effort value of

387 clams per quarter hour. An equivalent sample at Station TB49 yielded 224 clams for an effort value of 336 clams per quarter hour. All of these catches were made in June 1969. In August 1969, Hurricane "Camille" passed offshore, generating high seas and causing considerable surf on Mullet Key and Egmont Key shoals. An attempt to locate *Spisula* at Station TB22 failed after the effects of the storm subsided. In early September, 1.5 hours of dredging at this station produced 366 *Spisula* for an effort value of 61 clams per quarter hour, an 82% decrease in production. Diving observations after the storm revealed many hinged and single *Spisula* valves littering the bottom. Considerable quantities of dead *Spisula* shell were also washed onto the beach.

Continued dredging of Station TB57 from 22-26 October 1969 yielded decreasing effort values. At the second visit (22 October) effort per quarter hour decreased to 166; at the third visit (26 October) it decreased to 28.

CEDAR KEY CLAM SURVEY

Southern quahogs were produced in greatest numbers at the southern end of Suwannee Reef, north of Steamboat Gap (Table 12). At this Area VI location, Stations CK 43 and CK 49 produced 15 and 16 clams per quarter hour, comprising 65% of Area VI quahogs and 61% of all the quahogs collected during the Cedar Key survey. Another Area VI station, CK 31, produced the second largest effort value of 9 clams per quarter hour. Catches from all other stations were negligible.

Dense populations of live quahogs were spotty and located primarily on grass flats, whereas dead quahog shells were ubiquitous. Collections of dead shell from North Key to north Suwannee Reef suggest that this area at one time was a most productive quahog bed. Conversations with local fishermen who occasionally harvested these clams support this, former production also being substantiated by earlier reports (Tiller, Glude and Stringer, 1952). A study of this decline and that of the Ten Thousand Islands bed could prove useful to shellfish interests in Florida.

Nineteen of the 49 stations sampled during the Cedar Key survey produced 133 sunrays. Sixty-three percent of these were harvested from Stations CK 16, CK 17, and CK 18 on Seahorse Reef. A

TABLE 12. NUMBER AND MEAN SIZE (MM) OF *MACROCALLISTA NIMBOSA*, *MERCENARIA CAMPECHIENSIS*, AND *SPISULA RAVENELI*, COLLECTED FROM WACASASSA BAY TO STEINHATCHEE (AREAS V-VII)

Effort Values Are Based on Total Clam Production Per 15 Minute Dredging

		M. nimbosa		*M. campechiensis*		*S. raveneli*		
Station	Date	No. Caught	Mean Size	No. Caught	Mean Size	No. Caught	Mean Size	Effort Clams/15 M
CK 5	9-23-69	3	55					2
CK 7	9-24-69	2	70	1	98			2
CK 8	9-24-69	7	78					6
CK 9	9-24-69	1	64					3
CK10	9-24-69	7	66					4
CK12	9-24-69	1	60					3
CK13	9-25-69			2	130			1
CK14	9-25-69	1	70					3
CK16	9-26-69	50	114			48	67	8
CK17	10-11-69	29	123					7
CK18	10-11-69	5	125			11	62	5
CK19	10-13-69					2	36	1
CK23	10-14-69	1	68					1
CK34	11-19-69	1	70	5	128			
AREA VI								
CK30b	11-11-69	4	95	1	83			2
CK31	11-11-69			17	92			9
CK33	12- 5-69	6	39	4	67	3	34	3
CK36	11-19-69			9	65			5
CK42	11-26-69			6	47			6
CK43	11-26-69	4	88	30	103			15
CK47	12- 5-69	3	104					1
CK48	12- 6-69	1	70	2	81	1	37	3
CK49	12- 6-69			42	83	2	39	16
AREA VII								
CK25	11- 7-69	3	74					
CK28	11-11-69			2	37			6
CK29a	11-11-69	4	67					2

total of 6.5 hours dredging time produced 84 sunrays for an average effort value of 4 clams per quarter hour. A survey was conducted at Seahorse Reef in early 1970 by the Florida Department of Natural Resources research vessel, *Hernan Cortez*, using a Nantucket clam dredge. Results of this survey are in manuscript.

Frequency of small sunrays collected from inshore stations suggests an inshore/offshore movement, as proposed by Stokes *et al.* (1968) and by Joyce (1971) or may simply reflect disjunct settlement of different year classes. Studies are currently under way in the St. Joe Bay area to further investigate possible migratory behavior.

The Florida west coast surf clam, *Spisula raveneli*, was collected at only six stations during the Cedar Keys survey. Eighty-eight percent were captured at Stations CK 16 and CK 18. Station CK 17, just one mile north of these Seahorse Reef stations, produced no *Spisula* in more than one hour of dredging. Stations CK 16 and CK 18 yielded approximately 4 surf clams per quarter hour of dredging. Although the surf clam has been infrequently harvested commercially from Florida waters it represents a potential commercial resource.

Limestone outcroppings predominate in the Horseshoe Pt. to Steinhatchee and the Wacasassa Bay areas, providing unsuitable habitat for clams. Few were collected in these areas and dredging attempts often resulted in damage to equipment.

Fauna collected with the R/V *Venus* at Cedar Keys stations is listed in Table 7. During the survey a few oyster bars were sampled very effectively with the R/V *Venus* but attempts to sample bay scallops, *Argopecten irradians concentricus*, did not prove feasible because dense sea grass growth clogged the dredgehead and impeded harvesting.

TARPON SPRINGS AND VICINITY SURVEY

Twenty-two sunrays were collected at Station TS1, two miles north of Anclote Key for an effort value of 22 clams per quarter hour (Table 13).

At Station TS3, on the bank south of Anclote Key, 6 quahogs and 7 sunrays were taken to yield an effort value of 9 clams per

TABLE 13. NUMBER AND MEAN SIZE (MM) OF *MACROCALLISTA NIMBOSA*, AND *MERCENARIA CAMPECHIENSIS* COLLECTED FROM TARPON SPRINGS TO CLEARWATER (AREA VIII)

Effort Values Are Based on Total Clam Production Per 15 Minute Dredging

		M. nimbosa		*M. campechiensis*		
Station	Date	No. Caught	Mean Size	No. Caught	Mean Size	Effort Clams/15 Min.
AREA VIII						
TS 1	12-18-69	21	120			22
TS 3	12-18-69	7	74	6	69	9
TS 4	12-18-69			30	99	45

fifteen minutes. Clams at Station TS3 were small, with quahogs ranging from 61-80 mm and sunrays from 49-90 mm. Highest effort value in this area was 45 clams per 15 minutes from Station TS4, where 30 quahogs (45-120 mm, average 99 mm) were collected in 10 minutes from this sandy-mud station.

CONSIDERATIONS AND RECOMMENDATIONS

The escalator hydraulic dredge has been a significant tool in developing the soft-shell and hard clam fisheries. In 1952, seven escalator dredges operated in the soft-shell clam fishery of Maryland and contributed significantly to the production of 252,000 lb of meats valued at $173,000 (Anderson and Power, 1957). As more hydraulic dredges were licensed and entered the fishery, production increased to 7.9 million pounds of meats valued at $2.8 million for 1969 (U.S. Fish and Wildlife Service, 1970). In addition to the soft-shell clam industry, 52 hydraulic dredges operating in Maryland's new hard clam fishery produced 794,600 lb of meats valued at $465,000 for 1969. Since their inception in the early 1950's, escalator harvesters have been incorporated into the fisheries of Canada, New York, Virginia, Rhode Island, and Washington State (Manning, 1959).

This widespread and increased use of harvesters has led to investigations into their effects on the marine environment. Such studies were conducted in Maryland (Manning and Dunnington, 1955; Manning, 1957; Manning and Pfitzenmeyer, 1958; Manning and McIntosh, 1960; Pfitzenmeyer and Drobeck, 1967), Canada (Dickie and MacPhail, 1957; Medcof, 1958, 1961; MacPhail, 1961), and recently Virginia (Haven, 1970). These have considered substrate alteration, effects on benthic flora and fauna, and the efficiency and versatility of escalator harvesters.

Virtually everything in the path of the escalator dredge is collected, provided it does not pass through the mesh of the conveyor belt. Little breakage of captured organisms occurs and clams are conveyed to the pilot house free of sediments. Hydraulic dredging is much more efficient than hand tools, inflicts fewer mortalities (Manning, 1957; MacPhail, 1961), and can bring into production clam beds of marginal population densities. The escalator harvester is an efficient sampler of mollusks and polychaetes, but active swimmers (e.g., flatfishes and decapod crustaceans) are not readily captured.

The dredgehead may also be modified to harvest oysters (MacPhail, 1961). Predators such as starfish, whelks, conchs, drills, and moon shells may be controlled by culling them with the clam catch.

In the present study dredgehead water jets penetrated the substrate to a depth of 18 inches and sea grasses and benthic algae were uprooted. Traces of dredge tracks were visible from 1 to 86 days after dredging, and while in most cases the substrate hardened within a month, some spots remained soft for over 500 days. Trenches in grass bed stations remained visible longest while those in sandy areas filled in almost immediately. They were deepest in shallow areas where prop wash scoured loose sediments from dredge troughs and prevented redeposition of suspended sediments. Two stations showed a decrease of silt/clay particles immediately after dredging, but only one of these showed a sustained decrease. Observed differences between the silt/clay content from experimental and control test sites immediately after dredging became negligible within a year.

Haven (1970) and Manning (1957) concur that deposition of suspended sediments is negligible 75 ft down current from a working dredge. Manning also observed that oysters within the immediate dredging vicinity sustain complete mortalities, that significant oyster mortalities occurred within 25 ft, and that there is a possibility of oyster spat mortalities within 75 ft of an operating dredge.

Studies were conducted in Virginia to ascertain if "working" the bottom with an escalator dredge significantly increased the set of hard or soft-shell clams (Haven, 1970). Both types of clam beds were dredged prior to their respective spawning seasons. A comparison of Petersen grab and hydraulic dredge samples from control and experimental plots at one year and two years after initial dredging failed to reveal an increase of small hard clams on the dredged plot. Similarly, no increase in soft-shell clam recruitment was detected one year after dredging. However, seed clams (1/25 to 1 inch) planted on bottoms covered with aggregates of crushed oyster shell, stone, or stream bed gravel exhibited an average of 20% mortalities during one growing season, while plots seeded without aggregates showed an average of 84% mortalities, no doubt due to increased predation (Castagna, 1970). Shell particles exposed by hydraulic dredging might create similar favorable conditions for decreased mortality. In addition, unpublished catch data from the Long Island Sound hard clam fishery indicates that continued use of escalator harvesters increased the catches of smaller littleneck and cherrystone clams, while catches of large chowder clams declined. No increased set was observed in any of our test areas, shell usually being reburied within two months after dredging.

Analyses of trynet hauls from experimental stations showed no faunal variations between experimental and control plots at any time after dredging.

Except for Station 27, benthic plug samples revealed no marked differences between fauna from control and experimental plots. Redredging of Station 5 with the R/V *Venus* showed a marked decrease in quahogs on the dredged side compared to the control side of 132 and 512 days after dredging. Redredging of other experimental stations revealed no similar declines.

Based on the results of this study the following modifications to the harvester would increase efficiency and lessen damages:

1. The addition of slats to the conveyor felt would prevent clams from sliding down the belt. This is especially important when working at maximum depth and when catching the smooth sunray venus clams and large quahogs.
2. A propeller guard such as that described by MacPhail (1961) would prevent scouring of sediments from dredged trenches.

The importance of estuaries and nearshore grass areas as nursery grounds for the majority of Florida's sport and commercial species must not be overlooked. Therefore, the failure of sea grasses *Thalassia testudinum* and *Syringodium filiforme* and the alga *Caulerpa prolifera* to recolonize dredged areas necessitates the prohibition of dredging on these substrates. Dredging on other substrates, where little if any damage occurred should be permissible. In the interest of safety, dredges should operate a sufficient distance from public recreational areas. It is suggested that escalator dredges be regulated by the Florida Department of Natural Resources on a permit basis only, with a performance bond posted for each harvester.

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