BIOLOGICAL EFFECTS OF DREDGING IN AN OFFSHORE BORROW AREA.

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Abstract: *Changes in benthic fauna were monitored following excavation of an offshore borrow area in the vicinity of Fort Pierce Inlet, Florida. Sampling stations were established along 2 transects located in the borrow area, 1 control transect north of the borrow area, and 1 control transect south of the borrow area. Results suggest that relatively larger reductions in abundance, but not number of species, of the benthic fauna occurred in the borrow area following dredging as compared with the controls. Therefore the decrease observed appears greater than can be accounted for on the basis of seasonal changes alone. Both parameters returned to pre-dredging levels in from 9-12 months. Species composition, however, was altered in the borrow area and had not returned,to the pre-dredging composition after 12 months. It is probable that this species shift is not detrimental in that it resembles the species composition at other undisturbed locations in this region.*

In Order to alleviate serious beach erosion in areas where loss of valuable beach front developments is threatened, the solution of choice in Florida has been the nourishment of the eroded beach with sand which is either trucked in or pumped onto the beach. In the latter case, the source of the nourishment sand is generally an area of the bottom located offshore and in proximity to the nourishment area. The dredging activities result in a considerable local disturbance for the sand bottom animal communities in which a sizeable portion of the extant community is removed and the topography and sedimentary characteristics of the disturbed area are radically changed. It is therefore a matter of concern as to whether these alterations of the environment result in any serious permanent alterations of the biological communities in the affected area.

In August, 1980, the U.S. Army, Corps of Engineers carried out a beach erosion control project along an eroded section of beach in an area of the Florida east coast just south of Fort Pierce Inlet, Fort Pierce, Florida. This project consisted of beach fill and nourishment with approximately 285,000 m^3 of sand removed from a borrow area located approximately 1.6 km directly offshore. In conjunction with this project, data were collected and analyzed concerning the biological impact of the dredging activities in the borrow area on the benthic fauna present in this region. This report provides a description of the benthic fauna present in the borrow area and at a control location at the time of dredging and documents some changes in the fauna over the one-year period following dredging.

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MATERIALS AND METHODS—The study area is located on the Atlantic coast of Florida in the vicinity of Fort Pierce Inlet (27° 28′ 15″ N, 80° 17′ W, Fig. 1). Nourishment sand was provided by a dredging operation directly offshore from the beach fill area, which created a trench approximately 0.8 km long by 130 m wide. The bottom of the trench was approximately 3.5 m deeper than the surrounding bottom, which had a depth of approximately 7 m.

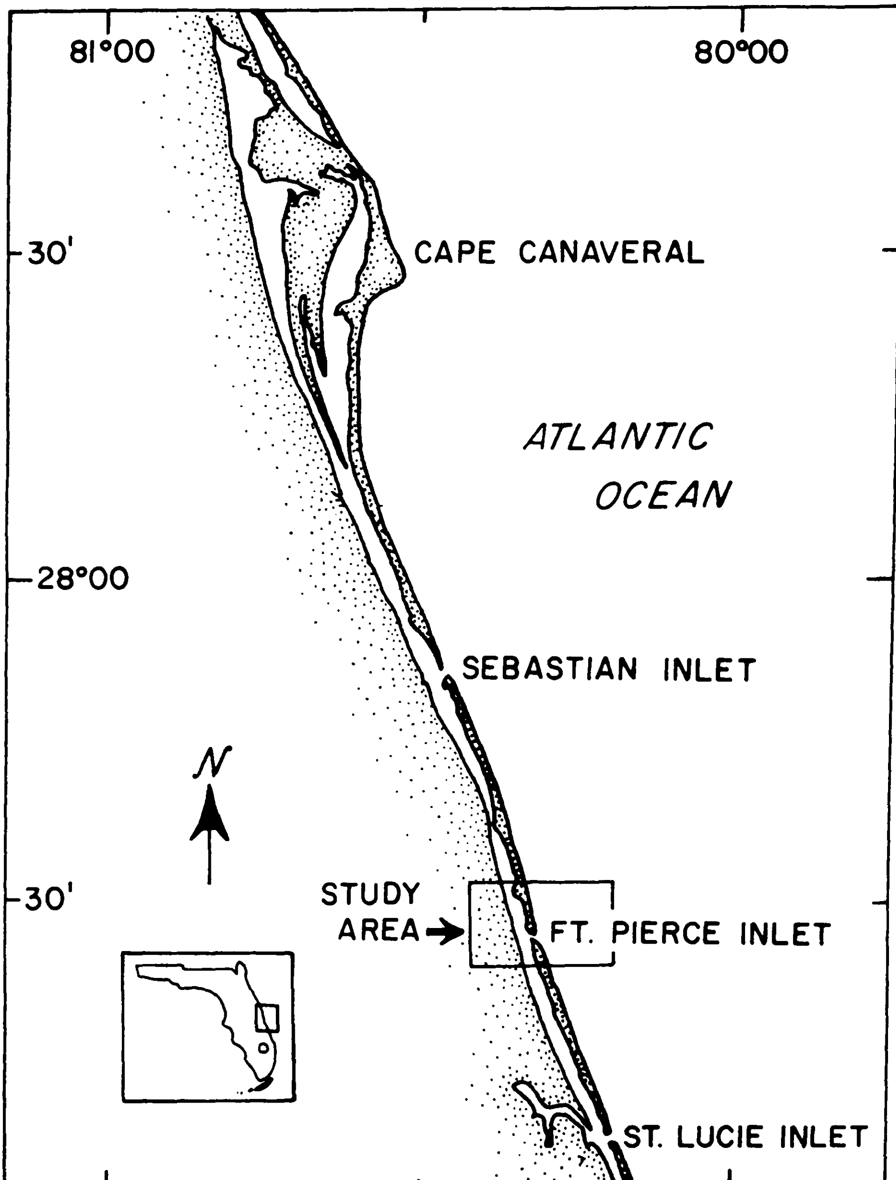

FIG. 1. Map indicating the location of the study area on the Florida east coast.

Three transects, each consisting of 5 stations which were located approximately 61 m apart, were established in the study area (Fig. 2). Transects I and II were oriented perpendicular to the long axis of the borrow area and the shore line. Transect III was located to the north of the borrow area as specified by contract guidelines and was to serve as a control area. However, this location is on the north side of the Fort Pierce Inlet and has a substantially different bottom topography and composition which includes substantial areas of worm reef *(Phragmatapoma lapidosa)* as compared with primarily flat sand bottom in the area of Transects I and II. Therefore, subsequent to the initial sampling, an additional transect consisting of 2 stations was established to the south of the borrow area in a sand bottom area more suitable as a comparative location. Each of the 2 transects in the borrow area, as well as the north control were sampled once at the time of the dredging (August 15, 1980) and on 4 occasions (November 18, 1980; February 20, May 21, August 4, 1981) at approximately 3-month intervals following the dredging. Because the contract for this study was received at the last minute, dredging had begun before a set of pre-dredging samples could be taken. Therefore, the first set of samples were taken just south of the operating dredge (designated sample areas A and B). Current direction during the dredging was south to north and it is reasonable to assume minimal dredge disturbance at these locations. Subsequent sampling was moved to the borrow pit locations indicated (Fig. 2). The initial samples from the borrow area can therefore unfortunately serve only as an indication of general pre-dredging conditions at Transects I and II. On each of the 2 borrow area transects for the post-dredging sampling, station locations were arranged so that stations 1 and 5 were outside the trench created by dredging while sites 2,3 and 4 were inside the trench (Fig. 2).

Benthic grab samples—Three replicate bottom grabs were taken at each station using a Smith-McIntyre grab operated from the R.V. *Tursiops*. This device can take a maximum volume of sediment of approximately 12 liters with a surface area of 1000 cm^2. Stations were located initially with Loran C. Due to the limits of resolution of this method and the close spacing of the stations, some variability in station locations is to be expected between consecutive sampling dates. Fathometer readings helped to fix transect locations. Depths of each station are given in Johnson (1982). On the final sampling, station locations were fixed with radar sites on shore targets that provided increased accuracy (coordinates in Johnson, 1982). Station locations are given approximately in Fig. 2.

Processing for all benthic grab samples was the same. The volume of each sample was first determined by placing it in a calibrated container. Samples were then washed on a 505 micron sieve with the retained portion being fixed in a 7% formalin and seawater solution. Preserved samples were transported in sealed plastic containers to the laboratory where they were re-sieved through a 600 micron (U.S. Standard No. 30) sieve. Rose-bengal stain was then added to the material retained to aid in sorting. Samples were then sorted by hand, with all animals present being transferred to 70% ethanol pending further sorting. Following this process, all animals collected were counted and identified to the lowest possible taxonomic level. In most cases, species level identifications were possible, although the polychaete worms were only identified to the level of family because of the limited present taxonomic knowledge for the inshore polychaetes of this area of Florida.

On the 4 sampling dates following the dredging operation, sediment samples were obtained for sediment grain size analysis. One sediment sample was obtained from the south control area, the north control area and from the dredged trench on Transect I. All sediment samples were analyzed with standard dry sieve techniques (Folk, 1974). Grain size distributions were made and were plotted by computer.

Sample value for number of individuals and number of species were compared between Transects I and II for both the trench and non-trench stations using one-way analysis of variance (ANOVA) and where significant differences were not observed ($p > 0.05$), data were pooled within these 2 categories. The only exception to pooling was the number of species for the November, 1980 sample. ANOVA was then used to compare values of the 2 community parameters among trench, non-trench, Transect III, and south control locations. Where significant values of the F statistic were obtained from ANOVA, the a posteriori Student-Newman-Keuls procedure (Sokal and Rohlf, 1969) was used to determine which means were significantly ($p < .05$) different from one another. In all cases, assumptions of homogeneity of variances were checked using the F-max test and data adjusted by transformation where necessary.

RESULTS—Sediment grain sizes, measured in phi units for the south control, north control and trench areas are given (Figs. 3-5). Although no pre-

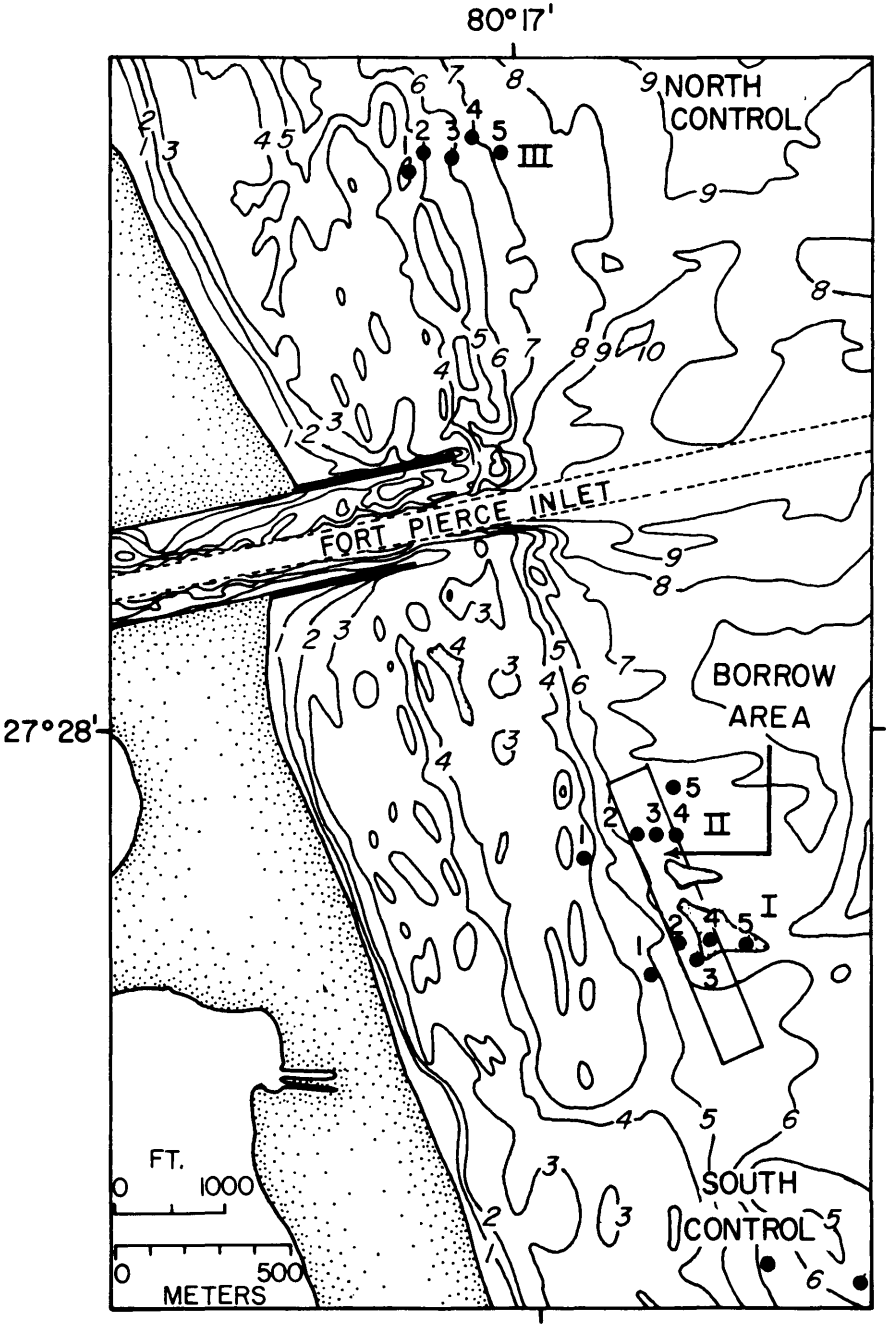

FIG. 2. Location of sampling transects and stations in the study area. Depth contours are given in m.

dredging sample is available for the trench area, it is likely that the mean grain size would have been very similar to that for the south control, i.e. medium sand. The north control resembled the trench area, with mean sediment size being a very fine sand. The decrease in mean grain size in the trench is presumably due to the trapping of finer sediments by the trench. By 12 months following dredging, mean sediment size within the trench had returned to a medium sand, possibly due in part to slumping of the trench wall and deposition of this coarser material in the trench (Fig. 5.). Some indication of filling of the trench was seen in the change of depth over time at the trench stations as recorded by the depth sounder on the R.V. *Tursiops* (Johnson, 1982).

A total of 83 stations were sampled during the study period with a grand total of 249 benthic grab samples being collected. Some 20,137 individuals consisting of a minimum of 188 taxa were collected in these samples. Because

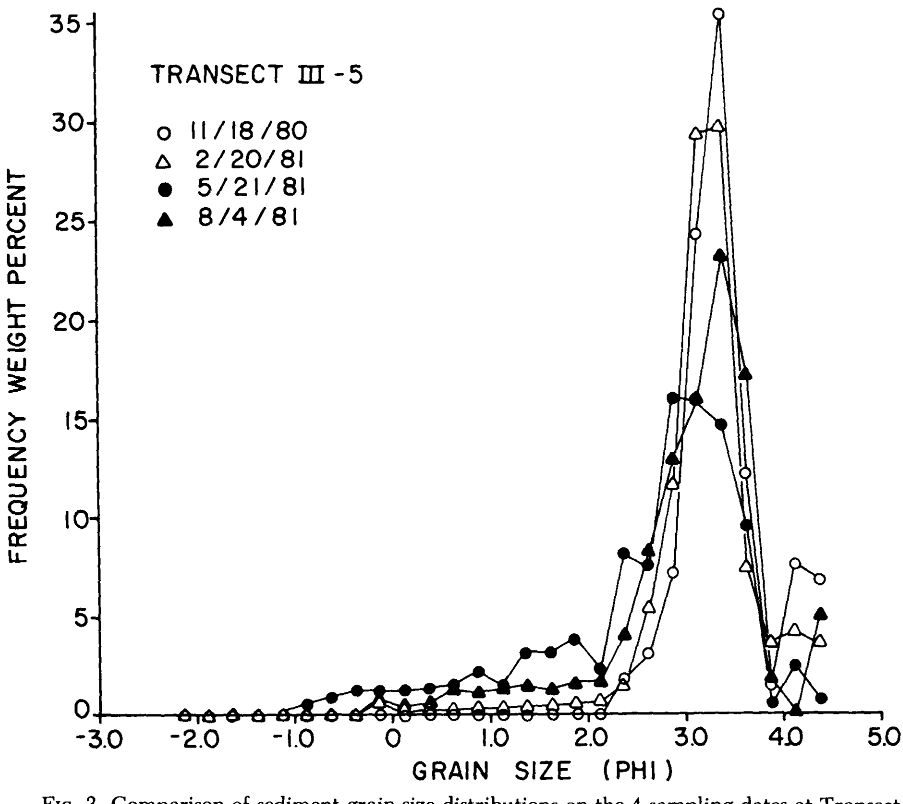

FIG. 3. Comparison of sediment grain size distributions on the 4 sampling dates at Transect III site 5.

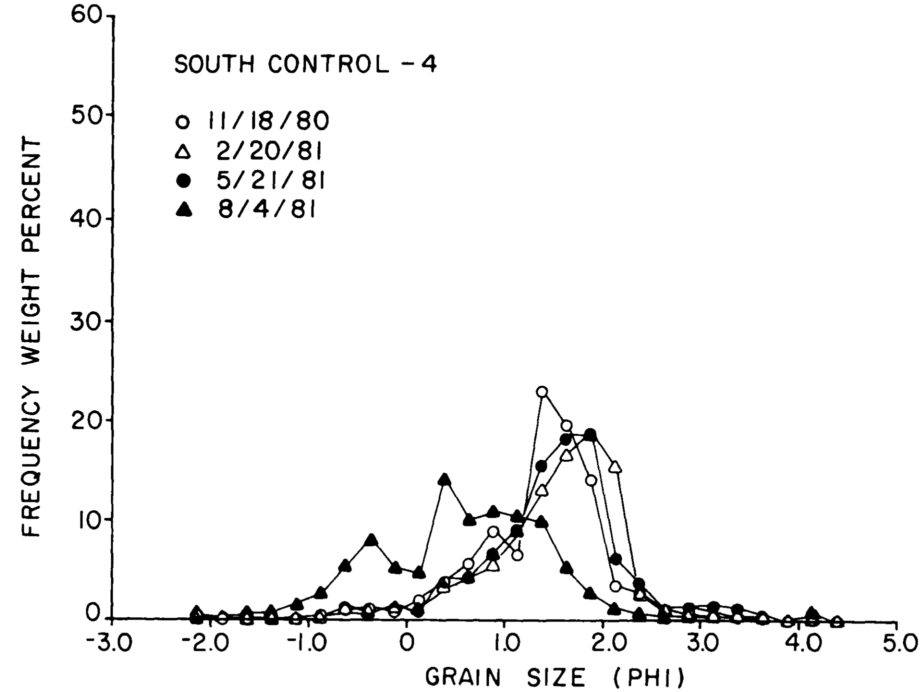

FIG. 4. Comparison of sediment grain size distributions on the 4 sampling dates at south control site 4.

of difficulties encountered with polychaete indentification, the actual number of species sampled is considerably greater. A complete listing of taxa encountered and their abundances in each sample is given in Johnson (1982).

The effect of dredging on abundance is suggested in Fig. 6. Following dredging, mean number of individuals/station decreased by 72% on Transects I and II as compared with the initial samples at sites A and B (Table 1), while abundance showed a decrease on Transect III of only 20%. Given the location of Transect III it is unlikely this decrease was a result of the dredging and thus may provide an estimate of the seasonal component of the change observed. All stations on Transects I and II appeared to be affected, although the decrease was somewhat greater for the trench stations (80%) than for the non-trench stations (59%) (Johnson, 1982). The temporal pattern of abundance was relatively similar for all four types of samples. Abundance remained low through the February sample, began to increase in the May sample, and continued to increase in the August sample, by which time densities in the dredged areas had approximately returned to the levels found at the time of dredging one year earlier. Abundance at the trench stations was significantly lower than for the north control on the February and August, 1981 sample dates, but was never significantly different from the undredged south controls.

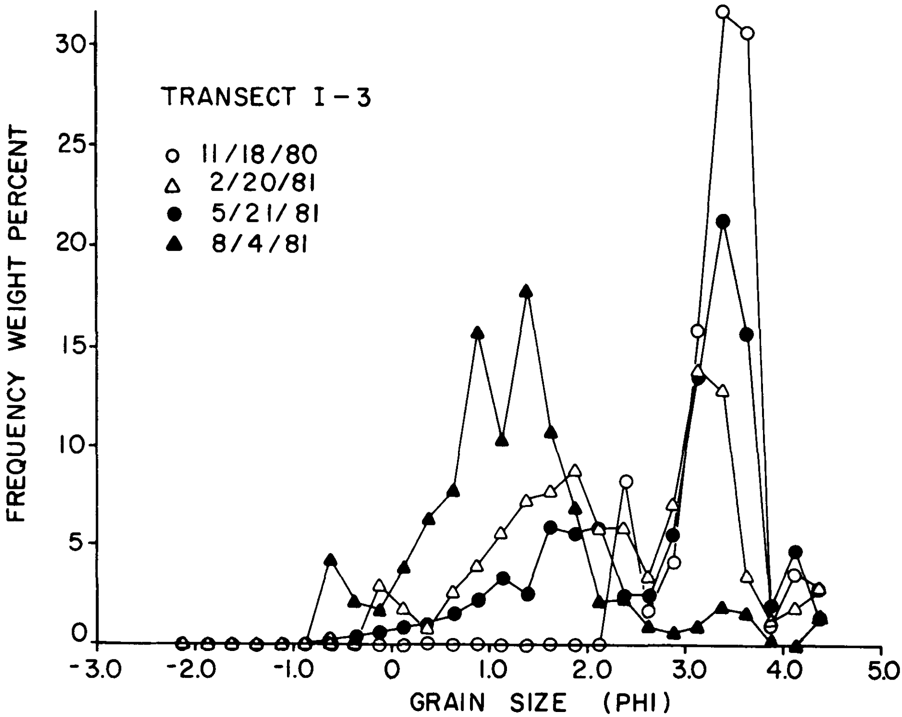

FIG. 5. Comparison of sediment grain size distributions on the 4 sampling dates in the trench at Transect I site 3.

Following dredging (November, 1980), a decrease of 42% in number of taxa was observed for Transects I and II as compared with the average of the samples taken initially. A decrease of 36% was observed at Transect III, suggesting much of the decrease in taxa was due to seasonal factors. Throughout the study, ANOVA indicated no significant differences between the mean number of taxa per station in the dredged trench versus the three groups of non-dredged stations (Fig. 7). Number of taxa in the dredged area reached values equal to the initial sampling within 9 months.

Patterns in species composition in relation to dredging are discussed below. All patterns described were confirmed by numerical classification analysis (Bray-Curtis Similarity Index and flexible sorting, Johnson, 1982). We have chosen to omit the cluster dendrograms in favor of tables of dominant taxa because this more clearly shows the types of compositional changes taking place.

The dominant taxa (the top 10 species in total abundance) at the 3 sample areas at the time of dredging are broadly similar between sample area A and B while Transect III, the north control, appears quite different (Table

TABLE 1. Mean values of abundance and number of taxa per station (± 1 std. dev.) for all transects and sample dates.

Date	Transect I	Location Transect II	Transect III	South Control
8/15/80				
No. Individuals	408.0(69.9)[1]	223.6(61.7)[1]	107.2(18.5)	—
No. Taxa	29.0(2.9)[1]	26.6(3.7)[1]	19.0(6.2)	—
11/18/80				
No. Individuals	66.0(38.4)	110.6(79.0)	82.0(50.7)	99.0(33.9)
No. Taxa	12.0(4.8)	19.8(4.1)	12.4(6.4)	20.0(0.0)
2/20/81				
No. Individuals	78.8(33.4)	41.8(18.6)	134.8(35.3)	114.0(62.2)
No. Taxa	16.4(4.3)	12.6(5.3)	9.4(1.1)	13.50(0.7)
5/21/81				
No. Individuals	161.6(26.9)	160.0(56.4)	258.0(128.4)	127.5(33.2)
No. Taxa	25.6(2.9)	26.0(5.2)	22.4(5.0)	25.0(1.4)
8/4/81				
No. Individuals	284.0(116.3)	593.2(441.8)	1033.6(255.5)	288.0(72.1)
No. Sp.	27.4(12.8)	30.0(8.6)	27.0(8.1)	27.5(2.1)

1. Values for samples taken near the borrow area while dredging was underway. Subsequent samples for Transects I and II were taken at the locations given in Fig. 2.

2). Sample areas A and B (8 of 10 taxa in common) were dominated by bivalves and amphipod crustaceans with a lesser abundance of polychaetes. Transect III was generally dominated by polychaetes, although the second and third most abundant species were a bivalve and an amphipod.

Following the dredging (November, 1980), species composition of trench stations (2,3,4) on Transect I showed an absence of 3 of the 10 most abundant species at the non-trench stations (1,5) (Table 3). These were the bivalve *Crassinella martinicensis*, the sand dollar *Melita* sp. (juveniles), and the amphipod *Bathyporeia parkeri*. The first two species were dominant forms at both sample areas A and B in the initial sampling. Other amphipod species showed reduced abundance and there was an increase in the importance of polychaetes at the trench stations. At Transect II, *C. martinicensis* was again absent from the trench stations and the importance of bivalves was generally reduced. The high abundance of sabellarid polychaetes at the non-trench stations was due to the fact one grab encountered worm rock. With the exclusion of the sabellariid polychaetes from this sample, the trench stations show a much greater importance of polychaetes and a reduced importance of bivalves. At the north control, Transect III, polychaetes continued to be an important faunal component. Species composition at the south control site was similar to that for the non-trench samples on Transects I and II, and was comparable to the initial sampling. Dominant species were *C. martinicensis* and the sand dollar *Melita quinquiesperforata*.

By 6 months following dredging (February, 1981), composition of the dominant taxa in the trench had become somewhat more similar to the non-

TABLE 2. Lists of the 10 most abundant taxa found on each transect on the August 15, 1980 sampling. Taxon codes are: A–Amphipoda, B–Bivalvia, C–Cumacea, D–Decapoda, E–Echinodermata, G–Gastropoda, I–Isopoda, M–Mysidacea, N–Nemertinea, P–Polychaeta, S–Sipuncula.

Rank	Taxon	Code	Abundance
	Sample Area A–8/15/80		
1	*Crassinella martinicensis*	B	492
2	*Acanthohaustorius shoemakeri*	A	262
3	*Protohaustorius wigleyi*	A	185
4	*Melita* (juv.)	E	174
5	Opheliidae	P	104
6	*Eudevenopus honduranus*	A	101
7	*Donax* sp.	B	80
8	*Tellina* sp.	B	63
9	Syllidae	P	43
10	*Tiron tropakis*	A	32
	Sample Area B–8/15/80		
1	*A. shoemakeri*	A	253
2	Opheliidae	P	121
3	*E. honduranus*	A	113
4	*Tellina* sp.	B	107
5	*C. martinicensis*	B	59
6	*T. tropakis*	A	54
7	*P. wigleyi*	A	47
8	Onuphidae	P	31
9	*Melita* (juv)	E	30
10	Spionidae	P	24
	Transect III–8/15/80		
1	Cirratulidae	P	115
2	*Tellina* sp.	B	101
3	*A. shoemakeri*	A	63
4	Oweniidae	P	46
5	Nemertinea	N	27
6	Opheliidae	P	17
7	Onuphidae	P	14
8	Nereidae	P	12
9	Magelonidae	P	11
10	Sipuncula	S	11

trench stations on Transect I, although 2 dominant trench taxa, the mysid *Bowmaniella* sp. and a polychaete (Arenicolidae), were only minor constituents of the non-trench stations (Table 4). At Transect II, dominant taxa in the trench remained largely different from the non-trench stations. Molluscs had increased their abundance relative to the preceding sampling date. Polychaetes of the family Oweniidae continued to be the most abundant group at Transect III.

Similarity in dominant taxa between trench and non-trench stations on Transect I was approximately the same in the May (1981) sampling as it had been in the February (1981) sampling (Table 5). Five taxa of the top 10 were the same for the 2 sets of stations. Only 4 of 10 taxa were in common between the trench and non-trench stations at Transect II. These 4 were also abundant at the south control stations at this time, suggesting a tendency towards development of a species composition more similar to an undisturbed situation. Taxonomic composition at the north control remained somewhat different from the other stations, being dominated by polychaetes of the family Oweniidae and the brittle star *Ophiophragmus wurdemani.*

On the final sampling date (August 1980), trench stations at Transect I were more strongly dominated by polychaetes than the non-trench stations, although polychaete abundance had increased at these sites as well (Table 6). Both trench and non-trench stations at Transect II were heavily dominated by polychaetes as well. Extremely high densities of organisms were obtained from the north control at this sample period, divided mainly between polychaetes of the families Oweniidae and Opheliidae, and the bivalves *Barbatia candida* and *Tellina* sp. Taxonomic composition at the south control remained largely similar to previous sample dates.

Discussion—If it can be assumed that the initial samples from areas A and B give a reasonable estimate of pre-dredge conditions at Transects I and II, then it can be suggested that effects of the dredging were observed with respect to number of individuals per station at the dredged sites. The reduction in abundance (72%) observed is comparable to values reported from other studies of dredging impact on benthic communities. Oliver and Slattery (1976) describe an 86% reduction in abundance and a 60% decrease in number of species in a dredged area in Monterey Bay, California. Kaplan and coworkers (1974) similarly report a 79% reduction in number of individuals following dredging in a semi-enclosed embayment on Long Island. McCauley and coworkers (1977) recorded decreases of 74-88% in abundance during maintenance dredging within an Oregon estuary. However, in the present case, complete evaluation of the effects of dredging is complicated by the fact that comparisons of the stations in the borrow area with the north controls (Transect III) indicates that seasonality may play some role in the decreases in species abundance observed and a possible dominant role in the decrease in number of taxa observed. Comparison of the magnitude of the changes at the north control with those in the borrow area suggest a gross estimate of 50% of the decline in numbers being attributable to dredging as distinguishable from seasonal decreases. Only 6% of the decreases in number of taxa could be similarly attributed to dredging, suggesting little effect of dredging on total taxonomic richness.

Disturbance effects due to the dredging did not appear to be limited to the dredged trench area alone. On both transects in the dredged area, decreases in abundance and number of taxa at non-dredged stations were observed, although these decreases were not as extreme as those observed in the trench. Such effects may have been due to increased sedimentation resulting from the dredging. McCauley and coworkers (1977) have also

TABLE 3. Lists of the 10 most abundant taxa found on each transect on the November 18, 1980 sampling date. Lists are provided for both non-trench (1,5) and trench (2,3,4) stations. Taxon codes are the same as for Table 6.

	Non-Trench			Trench		
Rank	Taxon	Code	Abundance	Taxon	Code	Abundance
			Transect I–11/18/80			
1	*A. shoemakeri*	A	71	Orbiniidae	P	25
2	*C. martinicensis*	B	22	*Semele proficua*	B	23
3	*Eurydice littoralis*	I	21	*A. shoemakeri*	A	17
4	*Melita* (juv)	E	18	*P. wigleyi*	A	9
5	*P. wigleyi*	A	14	*Metharpina floridana*	A	9
6	Glyceridae	P	9	*E. honduranus*	A	8
7	*Bathyporeia parkeri*	A	8	*Tellina* sp.	B	8
8	Orbiniidae	P	6	Onuphidae	P	6
9	*Heteromysidopsis* sp.	M	5	Opheliidae	P	3
10	Nephthyidae	P	5	Syllidae	P	3
			Transect II–11/18/80			
1	Sabellaridae	P	122	Nereidae	P	48
2	*C. martinicensis*	B	37	Orbiniidae	P	23
3	*Cardiomya costellata*	B	24	*E. honduranus*	A	21

			Transect III–11/18/80
1	Oweniidae	P	197
2	Cirratulidae	P	102
3	*Ophiophragmus wurdemani*	E	11
4	*P. wigleyi*	A	10
5	Nemertinea	N	9
6	*Barbatia* sp.	B	8
7	*A. shoemakeri*	A	7
8	*Heteromysidopsis* sp.	M	7
9	Glyceridae	P	6
10	Sipuncula	S	6
			South Control–11/18/80
1	*C. martinicensis*	B	43
2	*M. quinquiesperforata*	E	19
3	*A. shoemakeri*	A	17
4	*P. wigleyi*	A	14
5	*Chiridotea coeca*	I	12
6	*M. floridana*	A	10
7	*Neohaustorius* sp.	A	9
8	*Heteromysidopsis* sp.	M	8
9	*E. honduranus*	A	7
10	*T. tropakis*	A	6

TABLE 4. Lists of the 10 most abundant taxa found on each transect on the February 20, 1981 sampling date. Lists are provided for both non-trench (
and trench (2,3,4) stations. Taxon codes are the same as for Table 6.

	Transect I–2/20/81					
	Non-Trench			Trench		
Rank	Taxon	Code	Abundance	Taxon	Code	Abundance
1	*A. shoemakeri*	A	46	*Bowmaniella* sp.	M	73
2	*P. wigleyi*	A	27	Arenicolidae	P	46
3	*M. quinquiesperforata*	E	24	*A. shoemakeri*	A	11
4	*Melita* (juv)	E	14	*Tellina* sp.	B	11
5	*C. martinicensis*	B	10	*Olivella floralia*	G	8
6	*M. floridana*	A	6	*C. martinicensis*	B	7
7	Cirratulidae	P	5	*Ancinus depressus*	I	6
8	Polynoidae	P	3	*O. wurdemani*	E	5
9	*Bowmaniella* sp.	M	3	*Melita* (juv)	E	4
10	*Tellina* sp.	B	2	*M. floridana*	A	4
	Transect II–2/20/81					
1	Sabellariidae	P	28	*Tellina* sp.	B	36
2	*Caprella penantis*	A	6	Orbiniidae	P	11
3	Glyceridae	P	6	Glyceridae	P	8
4	*P. wigleyi*	A	4	Spionidae	P	8
5	*C. martinicensis*	B	3	Goniadidae	P	7

			Transect III–2/20/81
1	Oweniidae	P	357
2	*O. wurdemani*	E	140
3	*Bowmaniella* sp.	M	101
4	*C. coeca*	I	26
5	*D. polita*	C	9
6	*A. shoemakeri*	A	8
7	*Tellina* sp.	B	6
8	*P. wigleyi*	A	5
9	*O. floralia*	G	5
10	*S. proficua*	B	4
			South Control–2/20/81
1	*C. martincensis*	B	86
2	*Melita* (juv.)	E	44
3	*P. wigleyi*	A	17
4	*M. quinquiesperforata*	E	13
5	*A. shoemakeri*	A	11
6	*S. proficua*	B	10
7	*Heteromysidopsis* sp.	M	5
8	*Tellina* sp.	B	3
9	Nemertinea	N	3
10	*T. tropakis*	A	2

TABLE 5. Lists of the 10 most abundant taxa found on each transect on the May 21, 1981 sampling date. Lists are provided for both non-trench (1 trench (2,3,4) stations. Taxon codes are the same as for Table 6.

	Transect I–5/21/81					
	Non-Trench			Trench		
Rank	Taxon	Code	Abundance	Taxon	Code	Abunda
1	*P. wigleyi*	A	64	*Heteromysidopsis* sp.	M	120
2	*A. shoemakeri*	A	54	Glyceridae	P	40
3	Glyceridae	P	42	Nemertinea	N	28
4	*Heteromysidopsis* sp.	M	24	*Tellina* sp.	B	28
5	Nemertinea	N	21	Orbiniidae	P	22
6	Opheliidae	P	20	Sipuncula	P	21
7	*T. tropakis*	A	14	Crustacean (juv)		18
8	*M. floridana*	A	14	*T. tropakis*	A	12
9	*M. quinquiesperforata*	E	12	*P. wigleyi*	A	11
10	*E. littoralis*	I	12	*Leptochela serratobita*	D	11
	Transect II–5/21/81					
1	Sabellariidae	P	88	*A. shoemakeri*	A	48
2	*Ampelisca abdita*	A	74	*Heteromysidopsis* sp.	M	36
3	*C. martinicensis*	B	31	*Bowmaniella* sp.	M	36

			Transect III–5/21/81
1	Oweniidae	P	321
2	*O. wurdemani*	E	233
3	*Heteromysidopsis* sp.	M	195
4	*Atylus urocarinatus*	A	61
5	*Lembos websteri*	A	50
6	Magelonidae	P	44
7	*Bowmaniella* sp.	M	31
8	*C. varians*	C	24
9	*Tellina* sp.	B	22
10	Sipuncula	S	16
			South Control–5/21/81
1	*C. martinicensis*	B	48
2	*M. quinquiesperforata*	E	28
3	*A. shoemakeri*	A	22
4	*Tellina* sp.	B	20
5	*P. wigleyi*	A	20
6	Opheliidae	P	16
7	Glyceridae	P	15
8	Nemertinea	P	11
9	*C. coeca*	I	10
10	*Heteromysidopsis* sp.	M	10

TABLE 6. Lists of the 10 most abundant taxa found on each transect on the August 4, 1981 sampling date. Lists are provided for both non-trench
trench (2,3,4) stations. Taxon codes are the same as for Table 6.

			Transect I–8/4/81			
	Non-Trench			Trench		
Rank	Taxon	Code	Abundance	Taxon	Code	Abund…
1	Sabellariidae	P	72	Arenicolidae	P	7…
2	*Barbatia cancellaria*	B	69	Opheliidae	P	6…
3	Opheliidae	P	61	Pectinariidae	P	6…
4	*C. martinicensis*	B	55	Nemertinea	N	6…
5	*M. floridana*	A	54	Glyceridae	P	5…
6	*P. wigleyi*	A	53	Magelonidae	P	5…
7	*Tellina* sp.	B	44	*Tellina* sp.	B	5…
8	Glyceridae	P	41	*C. martinicensis*	B	4…
9	*A. shoemakeri*	A	36	*M. floridana*	A	2…
10	Spionidae	P	21	*P. wigleyi*	A	2…
			Transect II–8/4/81			
1	Sabellariidae	P	1108	Oweniidae	P	13…
2	Oweniidae	P	501	Opheliidae	P	10…

			Transect III–8/4/81
1	Oweniidae	P	1236
2	*Barbatia candida*	B	763
3	*Tellina* sp.	B	496
4	Ophellidae	P	472
5	*C. varians*	C	207
6	*O. wurdemani*	E	131
7	*L. websteri*	A	105
8	*A. urocarinatus*	A	89
9	Spionidae	P	67
10	Cirratulidae	P	53
			South Control–8/4/81
1	*C. martinicensis*	B	213
2	*A. shoemakeri*	A	77
3	Glyceridae	P	54
4	*P. wigleyi*	A	42
5	*M. quinquiesperforata*	E	20
6	Spionidae	P	18
7	Opheliidae	P	14
8	Oweniidae	P	14
9	*Tellina* sp.	B	10
10	*M. floridana*	A	7

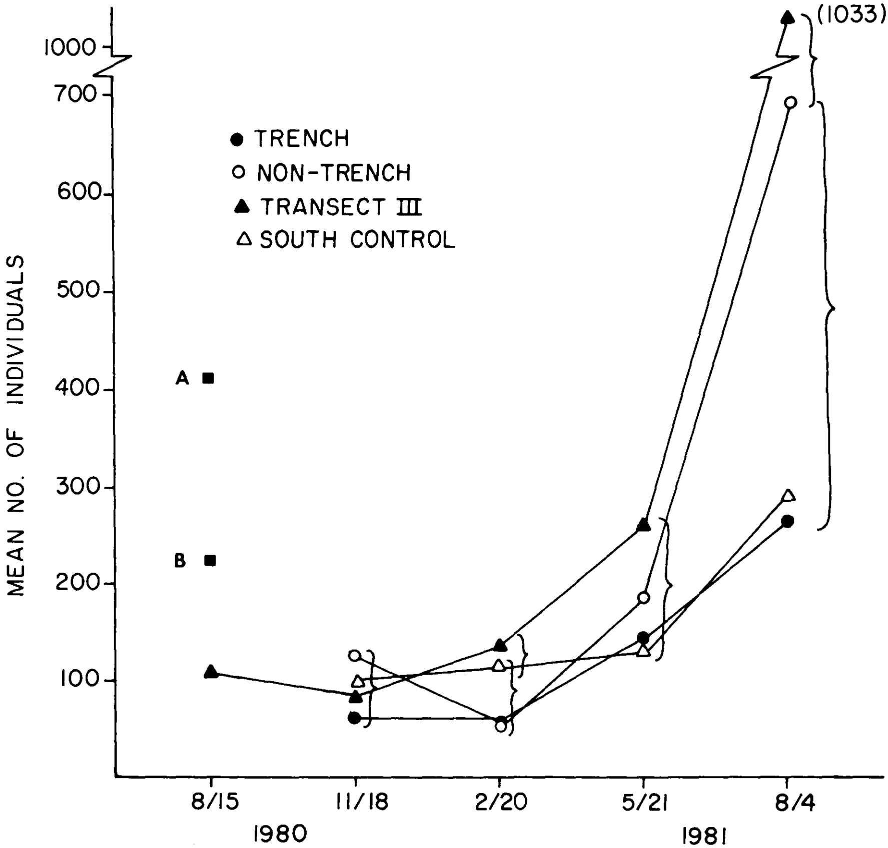

FIG. 6. Mean number of individuals per station for trench, non-trench, Transect III and south control groups of stations. A and B are the initial borrow area samples. Brackets indicate groups not significantly different from one another ($p > 0.05$, ANOVA and Student-Newman-Keuls test, error bars omitted for clarity).

observed that dredging effects can extend to other nearby areas, and have noted decreases in abundance that ranged from 34-70% at undredged stations within 100 m of a dredged area. In an enclosed embayment, the extent of the peripheral impact of dredging may be even more important and may affect abundance of benthic organisms throughout an estuarine area (Kaplan et al., 1974).

With respect to the originally designated control site (Transect III), the results clearly indicate that this area is almost entirely different from the dredged area to the south. The marked difference in species composition indicates this area was inappropriate to use as a comparison area for the dredge treatments, except possibly as an indication of seasonal effects. The temporal duration of the effects of dredging appears to be relatively limited in extent at both transects. Abundance and number of taxa had returned to initial levels within 12 months and 9 months, respectively, at Transect I, and both parameters had returned within 9 months at Transect II. Dredging had little effect on the distribution of individuals among species as measured by evenness at either of the 2 dredge transects (Johnson, 1982).

A recent study (Saloman et al., 1982) of faunal recovery in borrow pits off Panama City Beach, Florida has similarly indicated that recovery of the bottom community in dredged areas was rapid for both number of individuals and number of species, with total recovery occurring in from 8 to 12 months. A longer term study of the same dredged areas conducted 3-4 years after dredging detected no long-term adverse effects on the bottom fauna of the borrow pit dredging (Culter and Mahadevan, 1982).

The period required for readjustment of a dredged habitat will vary widely dependent on factors ranging from the extent of the dredging activity

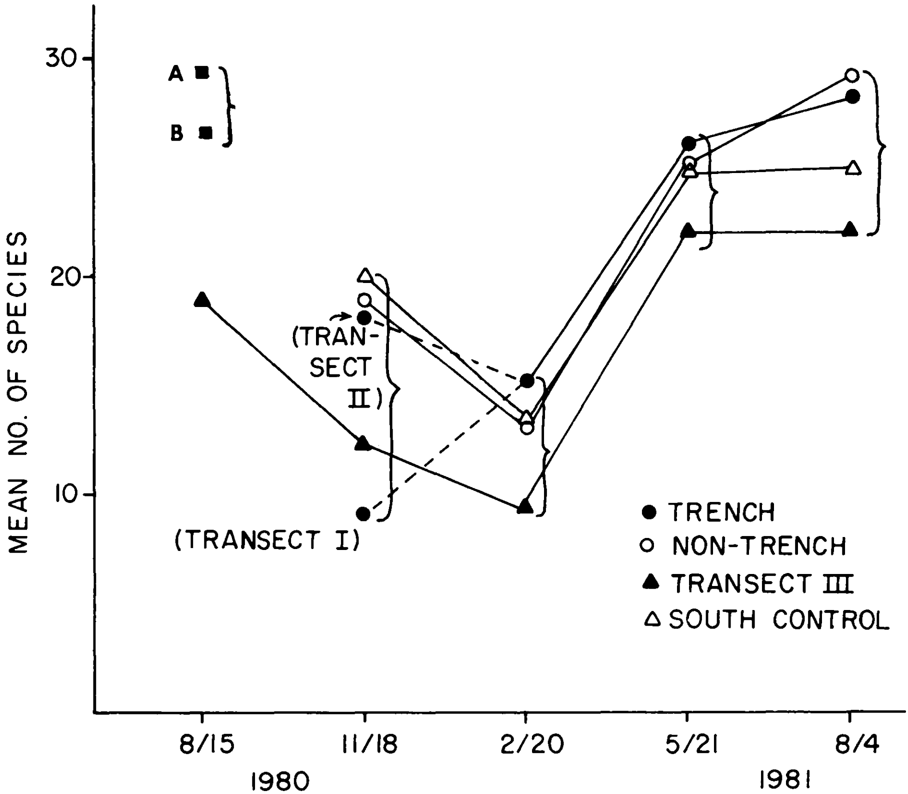

FIG. 7. Mean number of species per station for trench, non-trench, Transect III and south control groups of stations. Values for trench stations on 11/18/80 were significantly different ($p < 0.05$) and were therefore not pooled. A and B are the initial borrow area samples. Brackets indicate groups not significantly different from one another ($p > 0.05$, ANOVA and Student-Newman-Keuls test, error bars omitted for clarity).

to the type of species which compose the community. McCauley and coworkers (1977) have shown recovery of abundance and diversity to occur in only 14-28 days after a small dredging project which removed only 8000 yds^3 of material. They also suggested that the animals composing the benthic community at this site were adapted to continuous disturbance from propeller turbulence and frequent dredging, and thus recovered more quickly than might otherwise be the case. Recovery times on the order of 11 months have also been noted (Kaplan et al., 1974). In one instance, although H′ diversity after 1.5 years was lower than for the pre-dredging situations, both abundance and number of species had attained levels significantly greater than the pre-dredging level in 8 months (Oliver and Slattery, 1976). This was due to an increase in dominance by 1 species, a suspension feeding phoronid worm, *Phoronopsis viridis*.

Despite a recovery in terms of abundance and number of species, the disturbed community may not return to its original species composition. Oliver and Slattery (1976) have documented the transition from a burrowing deposit feeder assemblage composed mainly of crustaceans and bivalves to a post-dredging assemblage composed mainly of suspension feeding worms. The dredging resulted in a 2 step process during which the crustaceans and bivalves removed by dredging were initially replaced by opportunistic polychaetes which were then replaced by the suspension feeding worm *Phoronopsis* (Oliver and Slattery, 1976). This condition persisted for at least 1.5 years. In part this transition may be attributed to a transition in sediment grain size to finer particles. Sykes and Hall (1970) have shown that bivalve densities in dredged canals which possess fine bottom sediments (85% silt-clay) are a fraction of that found in undisturbed medium sands. Total densities collected were 5,631 bivalves from sand versus 16 from the silt-clay dredged channels (Sykes and Hall, 1970). In general, changes in sediment grain size composition will affect the choice of substrate by benthic organisms (Chang and Levings, 1976).

Turbeville and Marsh (1982) have recently concluded that five years after dredging of a borrow area off Hillsboro Beach, Florida, there is no indication of an adverse effect of the dredging. Borrow area communities showed no reduction in number of species, faunal abundance or species diversity as compared with adjacent undredged areas. Species composition, however, was found to be substantially different in the borrow area.

The Fort Pierce dredging project also shows evidence of a transition in species composition having occurred. Initial species composition in the borrow area (medium sand) was dominated by crustaceans, bivalves and the epifaunal sand dollar *Melita*. A similar and constant composition was observed for the south control sites (medium sand) throughout the study. The fine sand north control site showed a dominance of polychaetes throughout the course of the study. Following dredging, the percentage composition of crustaceans, bivalves and sand dollars greatly decreased while the percentage of polychaetes increased. One year after dredging, both Transects I and II, and in particular the stations located in the dredged trench, remained dominated by polychaetes. Community species composition at the dredged sites has undergone a transition despite return of community parameters to pre-dredging levels. The persistance of this alternate community will probably largely depend on the rapidity with which grain size within the trench returns to that typical of the surrounding bottom in this area. Sediment grain size data indicate that this process is well underway as of 12 months following dredging (Johnson, 1982), although the data of Turbeville and Marsh (1982) indicate such changes may persist as long as 5 years.

Whether the observed change in community composition has any larger ramifications within the nearshore ecosystem, particularly with respect to bottom feeding fishes, is not known at this time. Given the fact that the nearshore environment in the Fort Pierce region appears to be a spatial mosaic of different bottom types (e.g. Transect III), the transition community in the dredged trench may not be atypical of this area and may merely constitute an additional element in the pre-exisiting spatial mosaic of habitat types which characterize this region.

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REVIEW

Wendy B. Zomlefer. *Common Florida Angiosperm Families*, Part 1. Published privately at Storter Printing Co., Gainesville, Fla. 1983. Pp. iii-107, Soft cover. Price: $8.50.

THIS booklet was first a part of Ms. Zomlefer's M.S. thesis at the University of Florida, and was specifically written for use as a laboratory manual in Plant Taxonomy. In essence the text is a revision of the material covered by G.H.M. Lawrence in his classical *Taxonomy of Flowering Plants* (Macmillan, 1951), but with specific reference to the problems of teaching in Florida. As Ms. Zomlefer correctly indicates, the great majority of texts available in the United States are oriented toward some area other than our state. She has made a contribution toward directing some attention to the unique problems of our region.

Part I is unfortunately the only compilation yet available, particularly since Ms. Zomlefer's intent was to publish seventy-seven plant families. The first offering has thirty-four families with a variety of illustrations of different genera within each. While useful in its published form, it would have been more helpful to have had all of the families represented. The selection of families for inclusion was given considerable thought as perusal will show. Perhaps the most questionable aspect of the book is the adoption of Robert Thorne's classification scheme. Although Ms. Zomlefer admits that "This manual is experimental in using the family delimitations of Thorne..." many will question her choice. While there are many good things that may be said of Thorne's system, others may argue that he has simply substituted a new set of problems for the old ones.