SUPPLEMENTARY REPORT: PHASE IV OF THE ECOLOGICAL CONSEQUENCES OF CHANNEL DREDGING IN D'OLIVE BAY, ALABAMA

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SUPPLEMENTARY REPORT:[1] PHASE IV OF THE ECOLOGICAL CONSEQUENCES OF CHANNEL DREDGING IN D'OLIVE BAY, ALABAMA[2]

INTRODUCTION

Channel dredging in D'Olive Bay, Alabama was responsible for some major changes in local benthic communities, within two months of completion of the project. It was also determined that construction not related to the dredging operation under study was responsible for high turbidity and rapid siltation.

The fourth and final phase of the University of Alabama's D'Olive Bay study was designed to identify any long-term consequences of the channel dredging project on the bay ecosystem. Phase IV was conducted during the first week in May, 1973, 8 months after completion of the dredging operation. Extremely bad weather prevented earlier completion of Phase IV.

MATERIALS AND METHODS

Study locations shown in Figs. 1 and 2 of the final report of 1 December 1972, were examined in Phase IV also.

Parameters measured during Phase IV were water temperature, salinity, turbidity and dissolved oxygen, phytoplankton abundance and primary productivity, submerged plant standing crop, and benthic

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[1]This report is a supplement to the final project report presented to the Mobile District Corps of Engineers, 1 December 1972.

[2]Appreciation is expressed for the cooperation of Diamondhead Corporation during this study. The assistance of Dr. G.F. Crozier, Tom Olsen, Perry Hubbard and Sandra Vittor is gratefully acknowledged.

animal abundance, biomass and species diversity. Complete dissolved oxygen data were not obtained during the 24-hour diurnal survey conducted 2 May, due to failure of the oxygen meter.

Techniques for collection of the above data are given in the earlier report, and will not be repeated here.

RESULTS

Temperature

Water temperatures were very uniform during the 24-hour survey, as shown by mean temperature in Table 1. Further, conditions were similar in Phases I and IV (refer to Fig. 3 of the earlier report). Dissolved oxygen was not adequately measured on 2 May, but data obtained between 1000 and 1400 hours on 9 May indicated that the surface was nearly saturated with respect to dissolved oxygen.

Salinity

Surface and bottom salinities were zero throughout Phase IV. River flow in Blakeley River was greater during this period than during Phase I; zero salinities were also observed at that time.

Turbidity

Surface turbidities are summarized in Table 2. Measurements ranged from 31 to 68 JTU during Phase IV, and were more uniform than during any other phase of the study. Mean turbidities were similar to those recorded during Phase I, and higher than measurements made in Phase III.

Table 1. Mean water temperature at ten stations in D'Olive Bay, during Phase IV.

Time (Hrs.)	Temperature (°C)
1200	20.4
1400	20.9
1600	22.3
1800	22.2
2000	21.9
2300	21.3
0200	20.5
0600	20.4
0800	20.1
1000	20.2

Table 2. Summary of Phase IV turbidity data in D'Olive Bay. Turbidity expressed as JTU.

Time (Hours)	Station									
	1	2	3	4	5	6	7	8	9	10
1200	56	61	47	49	38	36	49	50	52	40
1400	68	63	52	52	54	47	--	52	58	--
1600	61	39	48	40	48	48	47	47	64	52
1800	56	42	55	49	38	49	51	53	48	47
2000	48	33	50	32	33	37	36	38	39	36
2300	32	52	33	28	36	35	37	40	41	36
0200	33	34	31	31	35	36	37	38	37	36
0600	44	54	42	54	62	57	55	62	58	62
0800	46	53	44	52	59	62	61	67	66	61
1000	52	65	51	33	38	34	37	39	47	36
$\bar{X}$	49.6	49.6	45.3	42.0	44.1	44.1	45.6	48.6	51.0	45.1
SD	11.5	11.9	7.8	10.2	10.7	10.0	9.2	10.2	10.3	10.9

Stations 1 and 9 are of particular interest with regard to turbidity. The former is greatly affected by silty runoff from freeway construction near the head of D'Olive Bay, while the latter was covered by approximately 45 cm of fine mud by the spoil area dike break in August of 1972. Water turbidity at station 1 was unchanged between Phase I and Phase IV, while station 9 experienced an increase from 41.4 to 51.0 JTU during that period. Station 9 was the most turbid station during Phase IV, and also during Phase III, when a mean of 39.9 JTU was estimated.

Sedimentation

Red clay sediments described earlier at the uppermost end of D'Olive Bay had migrated southward as far as station 13 by 2 May 1973. Reduced sediments were observed below the top 5 to 10 cm at station 1 on that date.

Mud accumulation reported at stations 8 and 9 prior to Phase III was not in evidence during Phase IV. Of the estimated 45 cm of mud at the latter station in October, only 2 to 3 cm remained by the following May. The removal of this mud by currents has lessened the problem of wind-induced turbidity.

Primary Productivity

The relationships between phytoplankton density, turbidity and total organic production are summarized in Table 3. Pelagic algae were more abundant during Phase IV than during Phase I, and primary produc-

Table 3. Relationships between phytoplankton density, turbidity and total organic production of the water column in D'Olive Bay, during Phase IV.

Station	Phytoplankton Density (cells/liter)	Mean Turbidity (JTU)	Total Organic Production ($mg \cdot liter^{-1} \cdot hour^{-1}$)
3	14,500	45	0.357
7	25,500	46	0.312
9	10,000	51	0.125
10	10,000	45	0.250

tivity was generally high as well. These increases may be partially attributed to a probable increase in nutrients in D'Olive Bay. There was no consistent correlation between mean turbidity and production in Phase IV, although photosynthetic activity could continue to be limited by silt remaining at station 9.

Submerged Plant Standing Crop

Table 4 summarizes submerged grass dry weight biomass at four stations during Phases I-IV. A strong seasonal pattern is evident: lowest standing crops are observed in early spring, while a peak is reached during the early summer bloom. Except for station 9, Phase IV grass beds were similar to those observed prior to dredging. Station 9 still exhibited the damaging effects of the dike break mud flow, nine months after it occurred. The low Phase IV standing crop at station 10 reflects an absence of filamentous algae, probably caused by unusually high flow in Blakeley River.

Benthic Animal Communities

Macroinvertebrates collected in Phase IV were generally the same as those observed during earlier surveys. Three incorrect identifications were reported in the earlier paper: the isopod Cyathura polita was incorrectly identified as Cleantis sp., and the two species of Aschelmenthes should be assigned to Phylum Rhynochocoela. During Phase IV, no Neanthes succinea were collected, but large numbers of Lycnereis culveri were present. The latter was the dominant species at most locations in D'Olive Bay.

Table 4. Submerged plant standing crop (g/m^2 dry weight) in D'Olive Bay during Phases I-IV.

Phase	Station 3	Station 9	Station 10
I (April 1972)	17.9	25.9	29.6
II (July 1972)	20.2	156.3	121.9
III (October 1972)	19.3	0.0	36.6
IV (May 1973)	19.4	3.5	18.0

Another change in the benthic fauna was the appearence of many juvenile marsh clams (Rangia cuneata) in May of 1973. Most did not exceed one centimeter in length. Several large adults had been found in each of the earlier surveys, but only one was collected in Phase IV. At the same time, very few small individuals were observed earlier. This shift in population age distribution is probably not related to dredging activities in the bay, but raher is a natural phenomenon.

Additional species first observed in Phase IV included a second genus of isopod, larvae of the mayfly (Ephemera), and the mud crab, Micropanope sculptipes.

Phase IV benthic species biomass and diversity were calculated including all animals collected at each station, and are described in Table 5. As shown in Table 6, invertebrate biomass was lower in stations adjacent to the channel project than in those unaffected by it. (Refer to Fig. 2 of the original report for station locations.) This difference was tested by the Kruskal-Wallis H test and found significant at the 1% level of significance ($X^2 = 16.6$). Species diversity also appeared lower in affected stations, but this difference was not statistically significant ($X^2 = 1.3$).

A comparison of average species biomass and diversity in Phases I-IV is provided in Table 7. Biomass estimates varied from 0.23 g/m^2 in Phase III to 18.13 g/m^2 in Phase II. Seasonal influences are evident in this variation, and correspond to seasonal changes in primary

Table 5. Benthic species biomass and diversity estimates in D'Olive Bay, during Phase IV. Both estimates made using all animals collected. Biomass determined as dry weight.

Station	Biomass (g/m^2)	Diversity (H')
1	5.53	0.32
2	2.80	0.60
3	5.68	0.17
4	9.54	0.06
5	0	0
6	16.56	0.24
7	0.15	0
8	1.36	0.29
9	1.29	0.29
10	15.98	0.41
11	7.58	0.37
12	17.54	0.14
13	1.82	0.54
14	1.21	0.54
15	9.32	0.44
16	1.52	0.47
17	3.26	0.20
18	8.26	0.63
Mean	6.08	0.32
SD	5.78	0.20

Table 6. Comparison of stations in the dredge-affected area with those unaffected by dredging in D'Olive Bay, during Phase IV.

Station		Biomass (g/m^2)		Diversity ($\bar{H}'$)
Unaffected:				
1		5.53		0.32
2		2.80		0.60
3		5.88		0.17
4		9.54		0.06
10		15.98		0.41
11		7.58		0.37
12		17.54		0.14
13		1.82		0.54
14		1.21		0.54
17		3.26		0.20
18		8.26		0.63
	$\bar{x}$ =	8.11	$\bar{x}$ =	0.36
Affected:				
5		0.0		0.0
6		16.56		0.24
7		0.15		0.0
8		1.36		0.29
9		1.29		0.29
15		9.32		0.44
16		1.52		0.47
	$\bar{x}$ =	4.31	$\bar{x}$ =	0.25

Table 7. Benthic species biomass and diversity in D'Olive Bay, during Phases I-IV.

Phase	Biomass ($\bar{x}$ ± SD)	Diversity ($\bar{x}$ ± SD)
I	8.46 ± 13.73	0.32 ± 0.15
II	18.13 ± 41.60	0.26 ± 0.23
III	0.23 ± 0.30	0.27 ± 0.20
IV	6.08 ± 5.78	0.32 ± 0.20

production; Phase I and IV estimates are similar. No attempt was made to compare these data statistically, because of the large standard deviations within each survey. There may have been an overall reduction in Phase IV biomass (from 8.46 to 6.08 g/m^2), but most of this difference could be attributed to a decrease in the abundance of the marsh clam alone.

Species diversity data in Phases I-IV were compared with a randomized-block analysis of variance (Table 8). No statistical differences could be detected between the four surveys, relative to the amount of error variation within each survey. Similarly, differences between stations were not significant (however, refer to Table 6, and accompanying comments for an examination of Phase IV data alone).

DISCUSSION

Estuaries are characterized by extreme variation in temperature, salinity and oxygen. Most organisms found in areas such as Mobile Bay, and probably D'Olive Bay, are adapted to this fluctuating environment, but also exhibit physiological and populational responses to variations. For example, primary productivity is concentrated during the late spring-early summer bloom in D'Olive Bay (see Table 4). Subsequent decomposition of accumulated plant material has a damaging influence on animal populations, largely because of oxygen depletion. In general, benthic, non-motile invertebrates are most affected by such changes, as reflected by biomass data in Table 7. As conditions

Table 8. Randomized block ANOVA of benthic species diversity at 19 stations in D'Olive Bay, during Phases I-IV.

Source of Variation	df	Sum of Squares	Mean Square	F
Total	71	2.7126		
Between Phases	3	0.0530	0.0177	0.39*
Between Stations	17	0.3274	0.0193	0.42*
Error	51	2.3322	0.0457	

*NS at 10% level of significance

become more favorable, these populations are re-established.

In D'Olive Bay, this pattern of seasonality was partially interrupted by the channel dredging project. Thus, primary production by phytoplankton was high in Phase IV, except at station 9 (Table 3). Residual silt at this location was responsible for elevated turbidities, which limit photosynthetic activity. Furthermore, submerged plants were still not fully re-established in the path of the mud flow at station 9. In Phase II this area supported a lush growth of grasses and filamentous algae (156.3 g/m^2). Only scattered stems and rhizomes were found there in Phase III, and little standing crop was observed in Phase IV. Consequently, a major source for production in D'Olive Bay will be lost for at least one year. Futher studies will indicate whether this site recovers from the accidental dike break.

Benthic invertebrate standing crop was decreased by dredging, at several stations. In some of these cases (stations 5, 7, 16), this decrease was due to physical dredging removal of bottom sediments and organisms. Recolonization has not fully re-established populations there. At stations 8 and 9, the mud flow was responsible for a significant, prolonged loss of infauna biomass. Stations 6 and 15, on the edges of the channel, were not adversely affected by the dredging project. Overall, there was a 28% decrease in benthic invertebrate biomass. Most of this loss was accounted for by stations within the channel dredging site.

Benthic species diversity was not significantly lowered by

dredging, although two stations (5 and 7) had few or no organisms, and zero diversity. This ecological parameter seems to be of less importance as an indication of environmental quality than primary productivity (including submerged plant standing crop) and benthic species biomass.

The damaging effects of the D'Olive Bay channel project on the bay have persisted for at least nime months after dredging was completed, largely because of the lingering effects of the dike break mud flow. The dissipation of this mud flow may, however, suggest that this part of the bay ecosystem will recover. Continued monitoring of the area by the staff of the University of Alabama Marine Science Programs will provide further information on this problem.

CONCLUSIONS

The following conclusions include, and are developed from, those presented in the earlier report, and reflect the added information on long-term dredging effects obtained in Phase IV.

1. Channel dredging had temporary and localized direct effects on turbidity in D'Olive Bay. It had no effect on water temperature, dissolved oxygen, salinity or circulation.

2. The late-summer dike break caused a 7-acre mud flow which significantly reduced primary productivity of pelagic algae, and destroyed most submerged vegetation and benthic animals. These effects have persis-

ted for at least 8 months after the accident occurred.

3. Most benthic organisms in the channel site were removed and destroyed. Repopulation of most stations in this area was negligible within 8 months of completion of the project.

4. Wind-induced turbidity and wave action had a widespread adverse impact on grass beds in D'Olive Bay. This seasonal process was followed by re-establishment of apparently normal spring standing crop levels, except in the mud flow area.

5. Rainfall runoff from construction unrelated to dredging has had a significant effect on siltation and turbidity in the upper half of the bay, but has not affected benthic biomass or diversity.

6. Channel dredging has had no long-term effect on vertebrate wildlife populations in D'Olive Bay.