THE ECOLOGICAL CONSEQUENCES OF CHANNEL DREDGING IN D'OLIVE BAY, ALABAMA

FINAL REPORT

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INTRODUCTION

D'Olive Bay lies at the northeast edge of Mobile Bay, in Baldwin County, Alabama (Fig. 1). The bay is about one mile (1.6 km) long and 0.4 miles (0.6 km) wide; its axis is oriented north to south. The average depth of D'Olive Bay is three feet (0.9 m). Extensive shoal areas occur in the upper half of the bay, and surround the tip of the peninsula separating Blakeley River and D'Olive Bay (Fig. 2). D'Olive Creek enters the bay at the northeast corner; Blakeley River water enters the bay at the northwest and southwest corners. The shallowness and orientation of D'Olive Bay make it especially susceptible to tidal, wind and river influences.

D'Olive Bay is of ecological interest as the site of new channel dredging in a previously undisturbed section of the Mobile Bay estuary. The channel project area is shown in Fig. 2; it extends from the 7-foot hydrographic contour in Blakeley River to the eastern edge of D'Olive Bay. Dredging was started in June of 1972; an 8-inch hydraulic dredge was used until July 23, when a larger dredge was brought into the bay. Spoil from the channel was pumped into an adjacent diked land

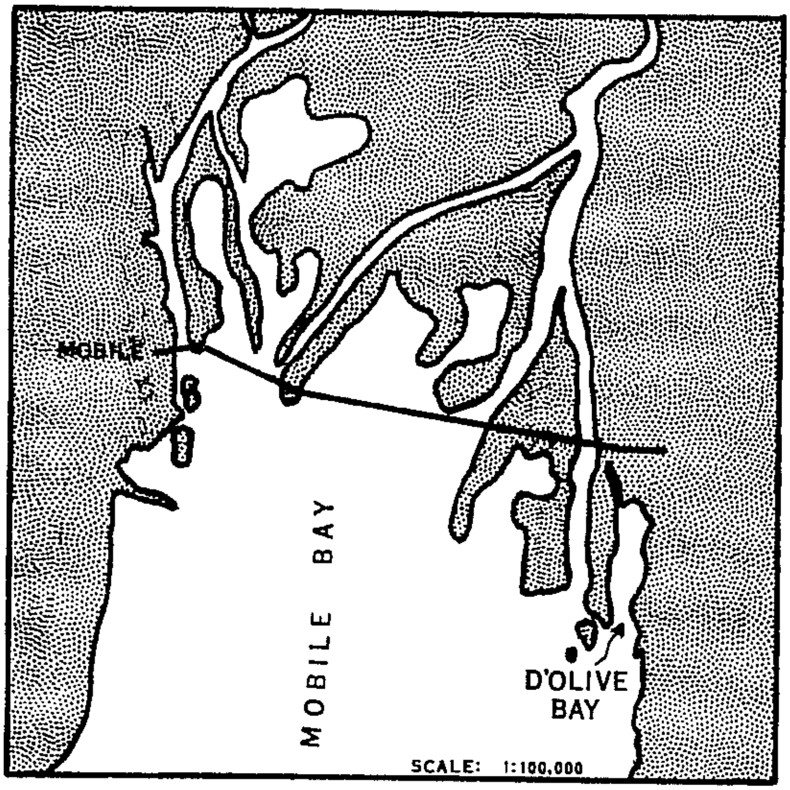

FIG. 1. D'OLIVE BAY VICINITY MAP.

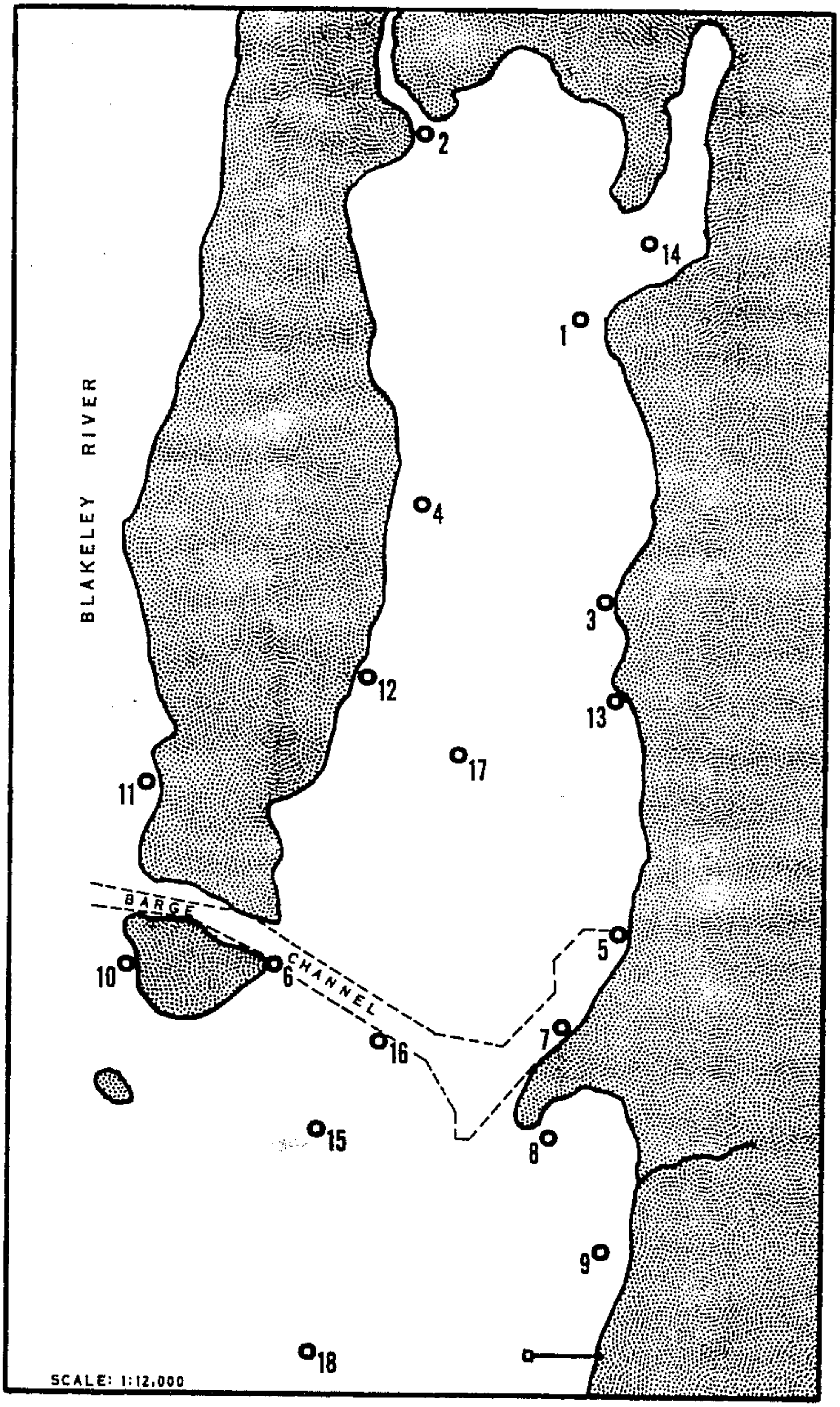

FIG 2. SAMPLE STATIONS IN THE D'OLIVE BAY PROJECT AREA.

area. This site had been vegetated by scattered cypress, oak, bay, maple, pine and various shrubs and herbaceous plants. No salt marsh was affected by spoil disposal. A weir discharged spoil effluent from the diked area into D'Olive Bay, between stations 5 and 7 (see Fig. 2).

This investigation was concerned with identifying and describing the impact of the dredging project on the estuarine environment of D'Olive Bay, with respect to the water quality effects of spoil effluents and mechanical disruption of benthic habitats. Comprehensive studies on channel dredging in Mobile Bay have not been performed previously. Such studies have been conducted in Florida, especially in Boca Ciega Bay (Taylor and Saloman, 1968; Sykes, 1971) and Chesapeake Bay (Chesapeake Bay Laboratory, 1968). Sedimentation effects of channel dredging in Bon Secour Bay, Alabama, have been studied (Corps of Engineers, 1968). Other studies have focused on the effects of sediment resuspension on primary productivity (Krone, 1966), and chemical and biochemical oxygen demand (Seattle University, 1970).

This research was conducted by the staff of the University of Alabama Marine Science Program. The D'Olive Bay investigation consisted of four phases: Phase I was completed two months prior to dredging

(April); Phase II was completed while channel dredging was in progress (July); Phase III was conducted after dredging was completed (October); Phase IV will be executed in March 1973, as a long-range test of dredging effects. The results of the March survey will be presented as a supplement to this final report.

MATERIALS AND METHODS

The following parameters were measured during the study: water temperature, dissolved oxygen, salinity, turbidity and current direction; sediment particle size distribution and sedimentation rates; phytoplankton abundance and primary productivity; sub-aquatic plant biomass; and benthic animal abundance, standing crop and diversity.

Survey stations were located at 18 sites in the bay and at the edge of Blakeley River (Fig. 2). Stations 1 through 18 were sampled for benthic communities; stations 1 through 10 were also surveyed during 24-hour studies of water conditions. Selected stations were also used for sediment, productivity and standing crop measurements.

Physical and chemical water data were obtained during three diurnal surveys; these were made March

27-28, July 22-23 and October 10, 16. Temperature, oxygen, salinity and turbidity were measured at 2- or 3-hour intervals except when inclement weather forced postponement. Current direction was observed during high and low tides in Phases I and II.

Sediment particle size distribution was determined at stations 2, 3, 4, 7, 9 and 10, from cores taken July 23. Sedimentation rates were measured at stations 2, 3, 9 and 10 during the period April 11-June 10 (60 days). Silt accumulation on top of beds of red aquarium gravel was measured using a ½-inch glass tube. Two additional stations were equipped with settling beds, but were lost due to removal of markers.

Phytoplankton tows were made with a 15 cm #10 mesh nylon net at the beginning of each 4-hour primary productivity measurement, in order to estimate algal abundance. Densities were estimated as number of cells per liter of water. Primary production was measured during daylight hours, using a light- and dark-bottle oxygen evolution technique. Bottles were suspended about 20 cm below the water surface, at stations 2, 3, 7, 9, and 10.

Standing crop of sub-aquatic grass and filamentous algae was measured at stations 3, 9 and 10. All plant material within 1.0 m^2 quadrats was collected by hand, dried and weighed. There was some loss of plant material during these collections.

Benthic faunal community structure was determined on the basis of core samples collected at all stations. Each was a composite of three replicate 44 cm^2 cores, each 20 cm deep. Each sample was washed through a 2mm mesh screen, and all macroscopic animals removed. Invertebrate identifications were made using several keys and publications, including Hartman (1951), Barnes (1962), and Bault (1971). After identification and enumeration of species, each was dried at 105°C for 8 hours, then weighed. Shells were not included in biomass estimates of molluscs, but exoskeletons were included in weights of arthropods. Species diversity was estimated from biomass information rather than species abundance, because the contribution of species to a community is more dependent on the mass of its members than their numbers. Diversity was calculated as

$$H' = - \Sigma p_i \log p_i$$

where p_i is the proportion of total biomass represented by species i.

Additional observations on wildlife populations in

D'Olive Bay were made during the several days spent on the bay.

RESULTS

Temperature and Dissolved Oxygen

Diurnal water surface temperature and dissolved oxygen data are summarized in Fig. 3. (Each point represents the mean of stations 1 through 10.) The significant patterns in these data are as follows:

(a) Dissolved oxygen levels fell below the recently-announced Alabama Water Improvement Commission standard of 5.0 ppm 50% of the time in the daytime (30 of 60), and 83% of the time at night (33/40) during Phase I. During Phase II, 62% (45/72) of the daytime and 75% (54/72) of the night-time levels were below 5.0 ppm. In Phase III, dissolved oxygen was consistently low: 65% (26/40) of the daytime and 100% (30/30) of night-time levels were below 5.0 ppm.

(b) Temperatures were generally higher in July than in either March or October, as expected. Surface temperatures averaged about 20°C in Phase I, 30°C in Phase II and 27°C in Phase III.

(c) Lowest dissolved oxygen levels were observed at

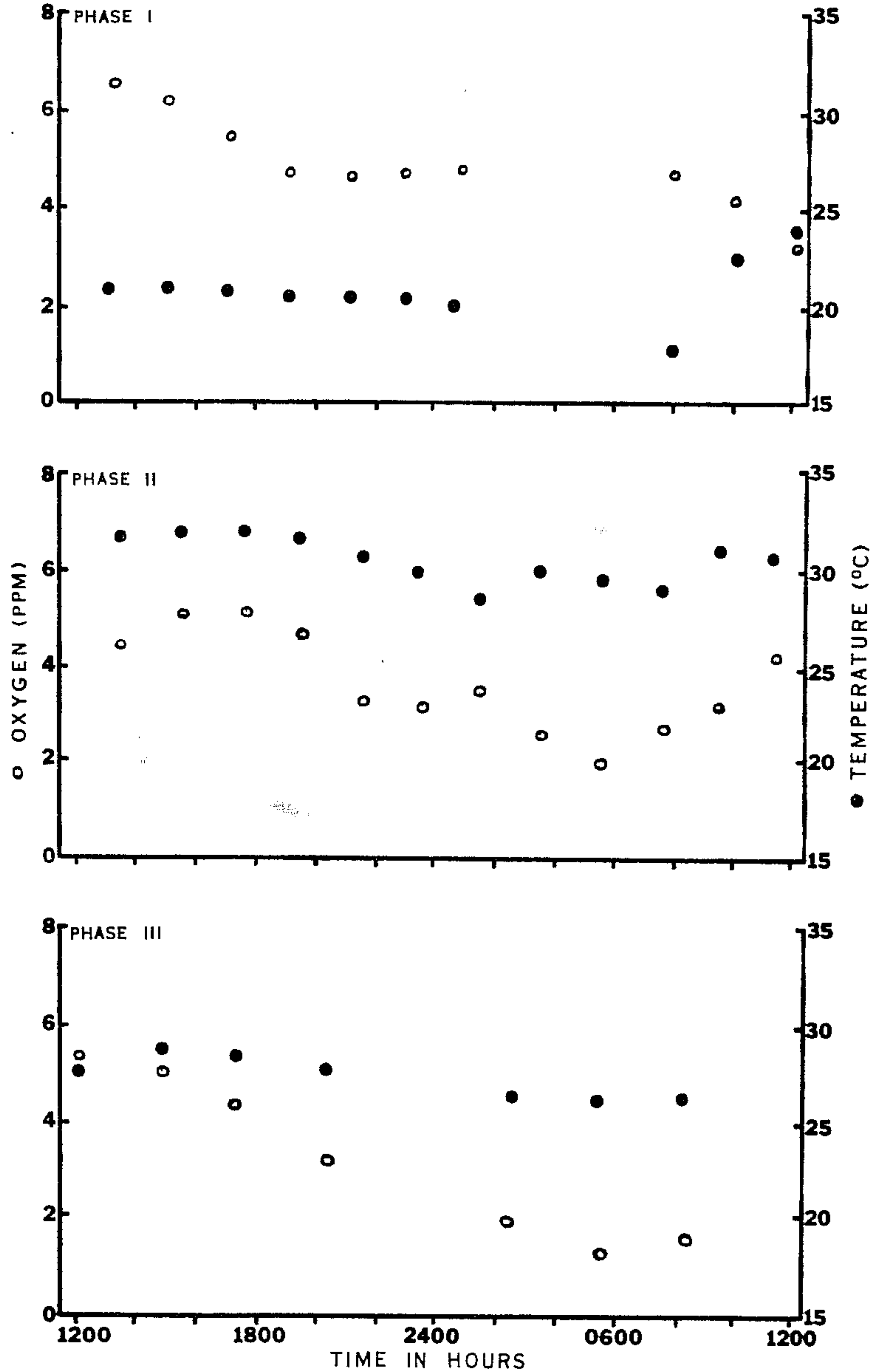

FIG. 3. MEAN SURFACE OXYGEN AND TEMPERATURE AT TEN STATIONS IN D'OLIVE BAY.

midday during Phase I. In Phases II and III, lowest levels were observed before sun-rise; biological activity accounted for this pattern, as described in a following section.

(d) Highest dissolved oxygen levels occurred during periods of high winds during Phases I and III, and in the early afternoon in Phase II.

(e) The shallowness and effective mixing of D'Olive Bay waters precluded any stratification with respect to temperature or oxygen. During Phase II, however, bottom levels exhibited consistently lower oxygen concentrations.

(f) In Phase III, low dissolved oxygen levels were observed throughout the survey period at stations 8 and 9, where a large mud flow (Fig. 4) had covered several acres of bottom.

Salinity

Salinity was about 0.0 parts per thousand (o/oo) at all stations during Phase I. A heavy rain fell between 0200 and 0600 hours during that survey. In Phase II, stream discharge was low from D'Olive Creek and Blakeley River: salinity varied from 0.0 to 5.0 o/oo. Stations at the head of the bay showed generally lower salinities than at the mouth of the bay. Phase II salinities were consistently higher than during previous surveys. Upper bay salinities ranged from 6 to 12 o/oo, while lower bay salinities were from 8 to 13 o/oo. Station 10, at the edge of Blakeley River had levels of 7 to 10 o/oo.

Turbidity

Turbidity data are summarized in Tables 1 through 3. The important patterns in these data are as follows:

(a) All parts of D'Olive Bay experienced turbidity increases due to sudden winds, as between 1300 and 1600 hours in Phase I. During Phases I and II the greatest fluctuation in turbidity occurred at stations 4 and 5. Station 5 waters were turbid during Phase I probably because of on-shore construction there. Stations 8 and 9 experienced a wide range of turbidities during Phase III due to the rapid resuspension of mud flow sediments there. Stations 6 an 10 had low turbidity and low variability. Station 1 waters were very turbid as a result of rainfall runoff from highway construction near D'Olive Creek.

(b) Night-time turbidities were very low, due to calm wind conditions. In general, turbidity increased soon after sunrise, due to increased wind.

Table 1. Summary of Phase I turbidity data in D'Olive Bay. Turbidity expressed as JTU.

Time (Hours)	Station 1	2	3	4	5	6	7	8	9	10
1300	50	89	92	104	59	53	54	55	54	39
1500	45	67	65	53	43	39	44	60	47	38
1700	44	42	45	47	35	28	36	44	37	32
1900	60	33	32	30	33	19	47	47	38	27
2100	47	38	42	34	33	23	33	42	29	41
2300	56	39	38	27	32	38	31	33	35	41
0100	27	33	38	22	32	35	32	28	32	35
0700	62	47	57	93	135	38	62	66	47	35
0900	62	57	76	38	135	37	45	32	58	31
1100	53	47	38	31	100	28	41	42	37	28
Mean	50.6	49.2	52.3	47.9	60.5	33.8	42.5	44.9	41.4	34.7
s	10.7	17.8	19.7	28.3	47.9	9.9	10.1	12.4	9.6	5.1

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

Time (Hours)	Station 1	2	3	4	5	6	7	8	9	10
1300	85	33	55	36	75	62	76	52	45	63
1500	94	19	30	27	100	22	78	47	42	52
1700	95	40	45	44	90	63	85	70	66	50
1900	94	8	18	7	17	17	20	27	7	31
2100	38	7	38	7	17	20	18	8	13	32
2300	45	8	42	7	22	17	16	11	11	27
0100	33	5	27	8	29	16	16	6	6	42
0300	26	8	18	7	13	13	13	8	10	42
0500	22	6	20	9	12	12	13	11	14	35
0700	47	35	29	28	38	28	28	21	24	60
0900	45	55	40	40	39	38	44	33	34	65
1100	74	38	45	50	64	77	87	70	60	44
Mean	58.3	21.7	33.9	23.3	43.0	32.1	41.2	30.3	27.7	45.2
s	28.0	17.5	12.0	18.5	31.1	22.7	31.1	24.1	21.3	13.1

Table 3. Summary of Phase III turbidity data in D'Olive Bay. Turbidity expressed as JTU.

Time (Hours)	Station 1	2	3	4	5	6	7	8	9	10
1200	49	33	45	31	44	35	38	83	120	25
1500	65	37	38	31	27	38	37	60	72	24
1730	20	24	18	31	24	11	20	43	22	12
2030	11	13	10	15	11	5	8	8	13	5
0230	8	9	14	13	14	9	10	13	9	7
0530	12	10	13	10	13	8	8	9	12	10
0830	12	15	19	20	20	13	11	36	31	12
Means	25.3	20.1	22.4	20.1	21.9	17.0	18.9	36.0	39.9	13.7
s	22.5	11.3	13.6	8.3	11.4	13.5	13.4	28.5	41.4	8.1

(c) Turbidities, and stream discharge, were lowest during Phase III.

(d) There was no general increase in bay turbidity due to dredging, except at stations 8 and 9, as noted above. Stations above and below the channel operation (3 and 7, respectively) did not experience unusually high turbidities during or after dredging.

(e) Turbidities around the dredge on June 10 (Table 4) were higher within a distance of 300 feet (90 m) in the direction of tidal flow. No increase in turbidity resulted from discharge from the weir at the times when samples were taken.

Table 4. Surface turbidity levels around the channel dredge operation June 10. (Dredge located about 50 feet NNW of station 7.)

Distance from Dredge		Turbidity (JTU's)
100 feet	W	15
75	W	18
100	S	15
75	S	22
75	N	47
100	N	42
300	N	55
600	N	29

Current Flow

Current flow patterns are diagrammed in Fig. 4. Tidal

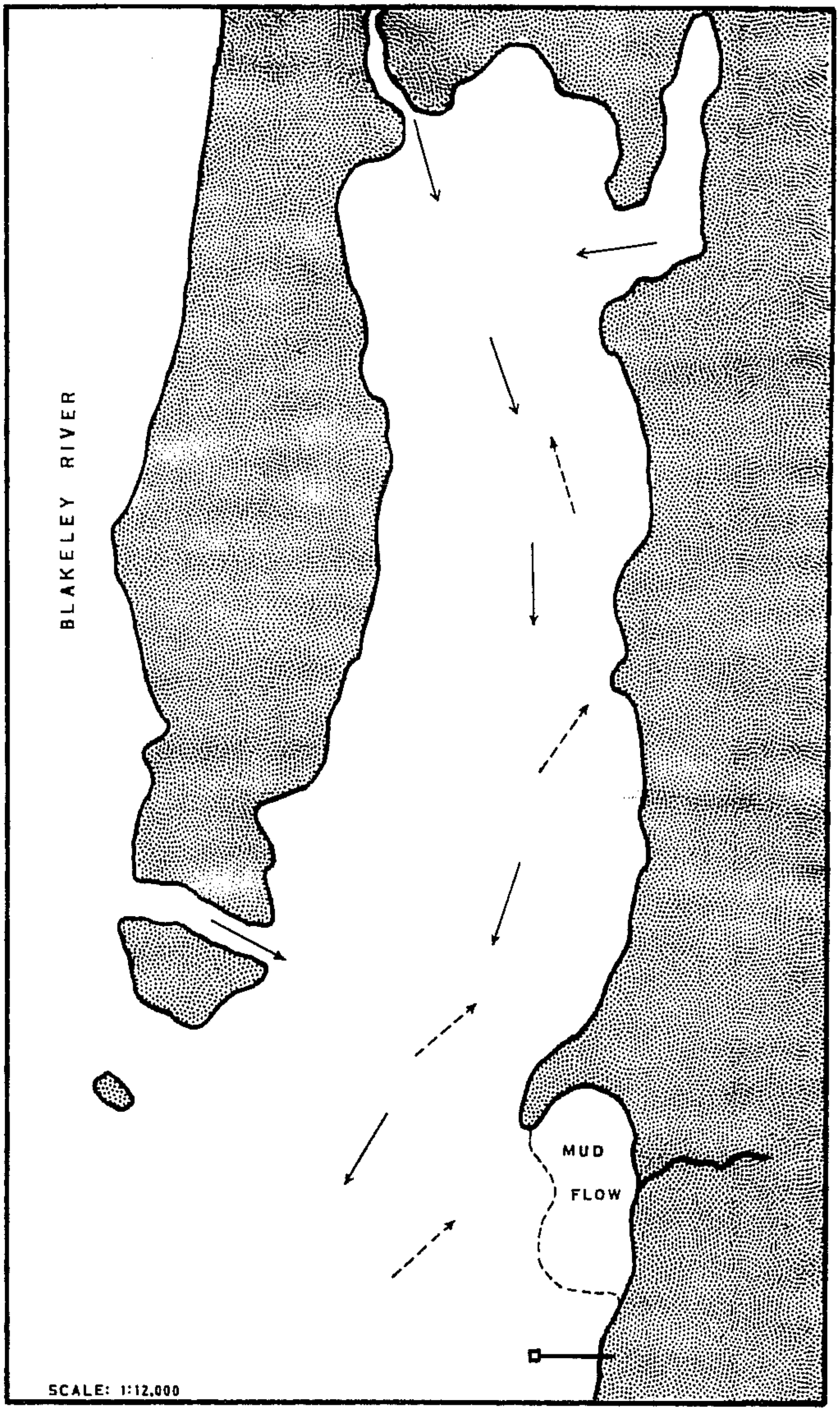

FIG. 4. CURRENT FLOW IN D'OLIVE BAY.

flow dominated; stream discharge was low during most of the study period. Currents are directed along the eastern edge of D'Olive Bay except at the northeast corner, where shoals and D'Olive Creek deflect flood-tide waters toward the middle of the bay.

Sedimentation

Sedimentation rates between April 11 and June 10 were as follows:

Station 2	0.053 mm/day
3	0.017
9	0.040
10	0.053

The smallest accumulation of silt occurred at station 3, which is characterized by well-sorted sand and gravel (see also Table 8). Prior to August 11, when the large dredge began working in the channel, station 9 experienced only moderate siltation. High sedimentation rates were observed in areas closest to stream discharges. This is partially due to the precipitation processes associated with the mixing of fresh and marine waters.

After the week of August 11, the spoil area dike failed at a point inland from station 8. The break resulted from either faulty construction or over-loading of the dike. The mud flow from the breach covered about 7 acres of bottom with 6 to 18 inches of fine silt and clay. Residents of the area reported a silt plume extending about 7 miles from the site to Fairhope.

Sediment Type

As seen in Table 8, the best-sorted sediments occurred at

Table 5. Relationships between phytoplankton density, turbidity, and total organic production of water column in D'Olive Bay.

Station	Phytoplankton Density (cells/liter)	Mean Turbidity (JTU)	Total Organic Production (mg liter-1 hour-1)
Phase I:			
3	10,000	47.3	0.031
7	4,000	42.3	0.094
9	<2,500	30.7	0.062
10	<2,000	32.3	0.062
Phase II:			
2	55,000	42.0	0.250
7	70,000	69.0	0.250
10	135,000	44.8	0.406
Phase III:			
3	15,000	22.4	0.155
7	4,000	18.9	0.095
9	<1,000	39.9	0.030
10	25,000	13.7	0.044

station 3. Low current velocity has created silty and clayey deposits at stations 2 and 4, while stations 7, 9 and 10 are characterized by silty sand sediments. The relationships of biological diversity and sediment type will be described below.

Primary Productivity

Table 5 summarizes the relationships between total primary production, algal abundance and turbidity. Phytoplankton were most abundant during July, at all stations sampled. Productivity was highest at this time also: a maximum level of 0.406 mg organic matter per liter per hour was produced at station 10. There was no consistent relationship between turbidity and productivity, although production was very low at station 9 after the mud flow generated high turbidities there.

Sub-aquatic Plant Standing Crop

The major plant species in D'Olive Bay were observed to be *Heteranthera dubia*, *Najas guadalupensis*, *Potamogeton pusillus* and *Ruppia maritima*. Submergent grass and filamentous green algae biomass data are summarized in Table 6. The data reflect

Table 6. Sub-aquatic plant standing crop (g/m^2 dry weight) in D'Olive Bay during Phases I, II, and III.

Station	Phase I (April)	Phase II (July)	Phase III (October)
3	17.9	20.2	19.3
9	25.9	156.3	0.0
10	29.6	121.9	36.6

the sudden major bloom of sub-aquatic vegetation in June and July. Most of these plants grew from rhizomes which were also found in Phase I and III collections. In July a maximum standing crop of 156.3 g/m^2 dry weight was observed at station 9. A strong west wind blew on August 2-3, however, and by August 11, only 30% of the grass beds remained intact. Although it was not determined where the uprooted or covered vegetation went, there did appear to be a great deal of suspended and coarse organic matter in the water. By October, most sub-aquatic plants had died back to original levels; no plants were collected at station 9, which had been covered by mud in August.

Benthic Animal Communities

Animals collected in benthic core samples included the marsh clam *Rangia cuneata*, the snail *Neritina reclivata*, and unidentified tellinid clam, the mud crab *Panopeus* sp., the isopod *Cleantis* sp., two species of gammarid amphipods, dipteran larvae (*Chironomus*), the polychaete worms *Amphicteis gunneri*, *Laeonereis culveri*, and *Neanthes succinea*, an unidentified capitellid polychaete, two unidentified oligochaetous annelids, two unidentified species of Aschelmenthes, and the eel *Myrophis punctatus*. In all, eighteen different species were collected. The blue crab *Callinectes sapidus* was observed in D'Olive Bay, but was not collected.

The number of species taken varied from 3 to 10 per station. The greatest numbers of species were found at station 9, except in Phase III, when one animal was collected. Animal densities ranged from 76 to 4321 individuals per square meter. In general, fewer animals were obtained in cores taken in Phase III. Most of this decreased abundance was directly attributable to channel dredging (including the mud flow from the broken dike).

Biomass and diversity of benthic organisms are summarized in Table 7. In general, the greatest diversity occurred at stations characterized by muddy sand and gravel sediments. A comparison of two estimates of biomass and diversity is shown in Table 8. Estimates based on all specimens taken, including very large Rangia cuneata, were considerably different from those based on more common species. There was no significant correlation between sediment type and species diversity (Table 9).

Biomass estimates ranged from less than 0.01 g/m^2 to 152.97 g/m^2. Diversity ranged from 0.0 to 0.80. (Maximum diversity possible is 1.00). There was a marked decrease in both standing crop and diversity in Phase III. In October, two stations (8 and 15) had no macroinvertebrates and, of course, no diversity; two other stations (16 and 18) had only one species, and therefore no

Table 7. Benthic species diversity and standing crop estimates for Phases I, II and III in D'Olive Bay. Both estimates were made using all animals collected at each station.

Station	Phase I Biomass (g/m^2)	Phase I Diversity (H')	Phase II Biomass (g/m^2)	Phase II Diversity (H')	Phase III Biomass (g/m^2)	Phase III Diversity (H')
1	0.68	0.21	0.69	0.04	0.22	0.28
2	59.26	0.06	0.46	0.32	0.18	0.19
3	20.46	0.44	1.38	0.48	0.06	0.58
4	7.56	0.42	1.90	0.59	0.77	0.35
5	0.41	0.22	0.25	0.00	0.004	0.23
6	16.12	0.10	2.15	0.24	0.10	0.29
7	3.85	0.28	1.08	0.80	0.17	0.05
8	2.00	0.44	1.66	0.28	0.00	0.00
9	4.96	0.38	83.49	0.02	0.02	0.30
10	25.81	0.06	0.12	0.22	0.20	0.58
11	0.93	0.25	152.97	0.04	1.06	0.36
12	1.20	-.49	1.11	0.08	0.26	0.41
13	3.47	0.24	0.71	0.16	0.72	0.66
14	0.56	0.19	3.17	0.29	0.25	0.22
15	1.14	0.70	3.39	0.58	0.00	0.00
16	2.67	0.35	1.56	0.36	0.006	0.00
17	0.07	0.35	0.00	0.00	0.04	0.22
18	1.10	0.45	70.20	0.18	0.04	0.00
Means	8.46	0.32	18.13	0.26	0.23	0.27

Table 8. Summary of Phase I benthic species standing crop, and species diversity. Columns I and III estimated excluding large, rare animals; columns II and IV estimated including all animals

Station	Biomass 1 (g/m^2)		Species Diversity 2 (H')	
	I	II	III	IV
1	0.684	0.684	0.213	0.213
2	1.513	59.264	0.410	0.063
3	7.017	20.464	0.386	0.440
4	0.556	7.555	0.445	0.423
5	0.414	0.414	0.224	0.224
6	0.712	16.120	0.357	0.095
7	0.613	3.848	0.589	0.284
8	2.004	2.004	0.438	0.438
9	0.984	4.961	0.727	0.380
10	0.726	25.811	0.257	0.062
11	0.930	0.930	0.250	0.250
12	1.205	1.205	0.489	0.489
13	3.471	3.471	0.242	0.242
14	0.565	0.565	0.188	0.188
15	0.545	1.135	0.570	0.700
16	2.542	2.672	0.283	0.353
17	0.073	0.073	0.351	0.351
18	0.494	1.095	0.595	0.447

1 Estimated as dry tissue weight

2 $H' = - \Sigma p_i \log p_i$

Table 9. Relationship between particle size distributions of sediments and species diversity and biomass, 10 July, 1972.*

Station	Median Particle Size (microns)	Percent Smaller Than 44 Microns	Biomass (g/m^2)	Diversity (H')
2	21	72.7	0.46	0.32
3	177	18.6	1.38	0.48
4	34	65.4	1.90	0.59
7	250	33.4	1.08	0.80
9	125	22.3	83.49	0.02
10	354	22.8	0.12	0.22

*Regression coeffeiient, b= 0.00273; not significant at 10% level of significance (t_{4df}= 0.48)

diversity also. Stations 5, 6, 7 and 16 were in the channel site itself. Stations 8, 9, 15 and 18 were adversely affected by siltation and mud from the dredging operation. Further study of these sites in March, 1973 should indicate the extent to which affected benthic communities are re-established. These patterns were obscured by the large "error" mean square calculated on the basis of all benthic data. Consequently, analysis of species diversity data did not indicate significant differences between either sample stations or periods (Table 10).

Table 10. Randomized block ANOVA of benthic species diversity at 18 stations in D'Olive Bay during Phase I, II and III.

Source of Variation	df	Sum of Squares	Mean Square	F
Total	53	2.0554		
Between Phases	2	0.0325	0.0162	0.35*
Between Stations	17	0.4663	0.0274	0.60*
Error	34	1.5566	0.0458	

*Not significant at the 10% level of significance.

Wildlife Observations

The D'Olive Bay area supports a rich variety of wildlife. Several vertebrates observed there are considered endangered or rare by the State of Alabama. On one occasion, a very large Mississippi alligator (Alligator mississippiensis) was observed in Blakeley River, just above D'Olive Bay. Three smaller specimens were seen in D'Olive Bay itself in July. Also in July, a school of about 100 Atlantic sturgeon (Acipenser oxyrhyncus) were observed feeding in shallow water around station 10. The school appeared to be composed of individuals about 3 feet in length.

In October, over 150 great white herons (*Ardea occidentalis*) were seen feeding in the bay. Several great blue herons (*Ardea herodias*) were present in the bay throughout the study. Brown pelicans (*Pelecanus occidentalis carolinensis*) were moderately abundant also: about 40 individuals were observed in July and October. A large flock of white pelicans (*Pelecanus erythrorhynchos*) were observed in D'Olive Bay during October.

The marshlands west and north of D'Olive Bay support a large population of nutria (*Myocastor coypus*). These mammals feed on several marsh plant species, and cause considerable damage to the salt marsh. Debris from their feeding activity enters the bay as organic detritus. Stations most affected by accumulation of this detritus (2, 4, 6, 11 and 12) had only moderately abundant benthic faunal populations.

The high productivity of grass beds in D'Olive Bay provides food for a great variety of fish. Large schools of striped mullet (*Mugil cephalus*) and bay anchovy (*Anchoa mitchelli*) were seen throughout the study period. Spot (*Leiostomus xanthurus*), coastal shiners (Notropis petersoni) and Atlantic croaker (Micropogon undulatus) were common also. There did not appear to be any decrease in the abundance of these animals during or after dredging of the channel.

DISCUSSION

In general, channel dredging in D'Olive Bay has not had significant effects on circulation patterns, water temperature, dissolved oxygen, salinity or turbidity. There are exceptions to this, notably stations 8 and 9, where the accidental mud flow has created an unstable bottom condition. Frequent winds in the area cause resuspension of silt and clay sediments, and generate abnormally high turbidities at those stations. According to Krone (1966), decreased transparency due to sediment load has an inhibitory influence of the photosynthetic activity of pelagic and benthonic flora. His conclusion is supported by this study: phytoplankton primary productivity was decreased at station 9 after dredging was completed. In addition, sub-aquatic grass and algal standing crop was eliminated by the dredge-related mud flow. Taylor and Saloman (1968) reported that production and standing crop of sea grasses was reduced by hydraulic dredging in Boca Ciega Bay, Florida.

Generally, primary production is much higher in undisturbed areas than in turbid waters where benthic floral populations have been reduced or eliminated (Pomeroy, 1959). Phytoplankton productivity estimates in D'Olive Bay ranged from 0.37 gC/m^2/day in October to 5.02 gC/m^2/day in July. The latter figure is very high, compared to Taylor and Saloman's (1968) estimated mean for Florida and Texas estuaries (about 2.5 gC/m^2/day). Total primary production in D'Olive Bay during the early summer was considerably higher than pelagic productivity as a result of sub-aquatic grass blooms.

There were only temporary localized turbidity increases around the dredge operation itself. A silt plume extended 300 feet from the cutter head of the dredge, while no plume was observed at the weir discharge site. In a study of channel dredging in Bon Secour Bay, Alabama, the U. S. Army Corps of Engineers (1968) found that wind and tidal currents carried silt over 1200 feet from the open-water discharge point. In neither the present study or others (Ingle, 1952; Flemer, et al., 1967) did finfish appear to be harmed by increased suspended sediment loads caused by climatic conditions or dredging. These animals avoid turbidity increases. Ingle, et al. (1955) found, however, that if finfish were confined to high concentrations of suspended solids, they were killed. A small fish kill occurred in D'Olive

Bay August 12-13. Catfish (_Ictalurus_ sp.) mortality may have been caused by the sudden increase in dredging rate and sediment disturbance August 11.

Sediment load increases from other sources also affected turbidity levels in D'Olive Bay. Highway construction along D'Olive Creek caused heavy siltation in the upper bay area, especially at station 14, where over 12 inches of red clay accumulated during the study period. Construction of a gas station above that station also increased siltation. On July 23, a drag-line was used there to scoop mud from the edge of the bay. This operation was stopped the following day. Wind had a widespread influence on water conditions throughout D'Olive Bay. The destruction of most of the grass beds, increased turbidity, and depressed dissolved oxygen associated with a two-day west wind indicated that this natural climatological agent had at least as great an impact on the bay environment as did channel dredging.

The water quality effects of wind- or dredge-induced turbidity relate to oxygen consumption, as well as inhibition of productivity. Seattle University (1970) reported that sediment resuspension causes an initial high chemical oxygen demand (COD), followed by micro-organism proliferation and high biochemical oxygen demand (BOD). While neither COD nor BOD were measured in this study, it was obvious that the presence of rich organic sediments in D'Olive Bay resulted in depressed dissolved oxygen (DO) levels. This was most apparent during Phase II, when night-time DO approached 0.5 ppm. Also, daytime levels were very low (about 1.2 ppm) in grass beds affected by the August 2-3 west wind. Although many estuarine benthic animals are tolerant of low DO levels, the benthos associated with rich organic sediments and prolonged oxygen depletion is likely to be impoverished (McNulty, et al., 1962; Reish, 1959).

The most serious ecological consequence of channel dredging in D'Olive Bay was related to mechanical disruption of benthic communities. Areas in the channel and in the path of the mud flow supported few animals 40 days after dredging was completed. Similar results have been reported by Taylor and Saloman (1968) for deeply-dredged canals in Boca Ciega Bay. Moreover, they reported that "in 10 years, recolonization of canal sediments has been negligible." Observations by this investigator in the Bayou La Batre, Alabama ship channel indicate that dredging removes nearly all benthic animals from channel sites, and few return within 2 months.

In D'Olive Bay, benthic species biomass ranged from 0.07 to 152.17 g/m^2, and averaged 13.29 g/m^2, prior to completion of the channel. After dredging, mean biomass was only 0.23, including stations not directly affected by channel construction. This represents a decrease of about 13 g/m^2. Taylor and Saloman (1968) estimated benthic invertebrate biomass in luxuriant grass beds in Boca Ciega Bay at 137 g/m^2. This standing crop was exceeded at stations in D'Olive Bay where the marsh clam Rangia cuneata was abundant. The loss of several acres will have a significant effect on the annual productivity of D'Olive Bay. Sanders (1956) has estimated infaunal production at two to five times the standing crop; Taylor and Saloman used four as a multiplier. Using the same factor here, the decrease in benthic productivity during this study amounted to 52 g/m^2.

There are no comparative data on diversity estimates in dredged areas, but Taylor and Saloman (1968) have reported that the variety of infauna is very low in canals, while pelagic fish diversity is higher than elsewhere in Boca Ciega Bay. D'Olive Bay pelagic finfish populations did not appear to be affected by disruption of several acres of bottom. Demersal fish and shellfish dependent on benthic fauna were doubtless affected, however.

Wildlife in the bay area did not appear to be seriously affected by the dredging operation. Noise from the dredges probably drove some animals away, but species of waterfowl, fish and mammals were observed in the area after dredging was completed.

CONCLUSIONS

The results of this investigation can be summarized as follows:

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

(2) Over-stressing and breakage of the spoil area dike caused a 7-acre mud flow which significantly reduced primary productivity and submergent vegetation standing crop, and destroyed most benthic infauna.

(3) Most benthic organisms in the channel site were removed and destroyed; repopulation of this area was negligible within 40 days 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 impact was greater than that caused by normal dredge effluents.

(5) Rainfall runoff from construction unrelated to dredging had a significant effect on siltation and turbidity levels in the upper bay.

(6) Channel dredging had no effect on vertebrate wildlife populations in D'Olive Bay, except in the spoil disposal area itself.

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