

COMPARISON OF PHYTOPLANKTON PRODUCTION BETWEEN NATURAL AND ALTERED AREAS IN WEST BAY, TEXAS¹

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ABSTRACT

Phytoplankton production was compared between an undredged marsh area, a bay area, and an adjacent marsh area altered by channelization, bulkheading, and filling. Average gross production (mg carbon/liter/day) in the altered area (canals) was 8% higher than in the marsh and 48% higher than in the bay during June, July, and August 1969. Gross and net production were significantly higher in the canals and marsh than in the bay; differences between the canals and marsh were not significant.

Large areas of shallow bays and marshes are being dredged, bulkheaded, and filled for waterfront housing sites along the Gulf of Mexico coast. When these sites are developed, shallow marsh and bay areas are deepened or filled with spoil, thus changing the environment for marine organisms. Major changes to the bayshore environment as a result of these alterations include: (1) reduction in acreage of natural shore zone and marsh vegetation; (2) changes in marsh drainage patterns and nutrient inputs; and (3) changes in water depth and substrates. The effects of these environmental changes on the productivity of estuarine organisms are poorly understood.

Basic production in estuaries results from four types of plant life: phytoplankton, attached algae, sea grasses, and emergent vegetation. Production of sea grasses and emergent vegetation is reduced or lost when natural marsh areas are dredged and filled for housing sites. Whether or not this reduction in primary production by sea grasses and emergent vegetation is compensated for by an increase in production by phytoplankton and attached algae is not clear. The objective of this study was to compare phytoplankton production between housing development canals, natural marsh areas, and the open bay in a shallow Texas estuary.

STUDY AREA AND METHODS

The study area in West Bay, Texas, included a natural marsh, an open bay area, and the canals of a waterfront housing development (Figure 1). The developed area, which included about 45 hectares of emergent marsh vegetation, intertidal mud flats, and subtidal water area prior to alteration, was reduced to about 32 hectares of subtidal water by dredging and filling. The water volume (mean low tide level) was increased from about 184,000 to about 394,000 kliter.

Sampling stations were established in dead-end canals in a housing development, natural marsh areas, and an open bay area (Figure 1). Water depths at mean low tide at stations 1 through 5 were 1.6, 2.6, 0.5, 0.2, and 1.0 m respectively.

Primary production was measured on six occasions at each station between June 18 and August 14, 1969. Measurements were made using the light- and dark-bottle technique designed by Gaarder and Gran (1927). Water samples were taken 15 cm below the surface at all stations. A 4-liter bottle having a vent at the bottom with a 30-cm rubber tube attached was used to take the subsurface samples. Number 10 netting (0.060-mm mesh) was placed over the mouth of the bottle and the bottle was submerged, mouth down, until the container filled. The netting was used to eliminate most of the zooplankton from the samples.

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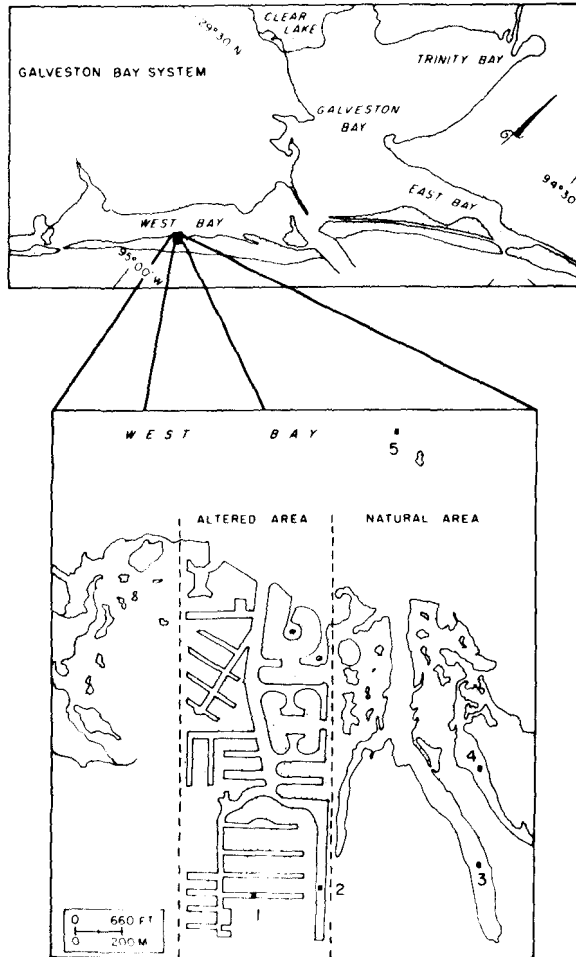


FIGURE 1.—Study area and sampling locations in the Jamaica Beach area of West Bay, Tex.

For each station, six biological oxygen demand (BOD) bottles (300 ml)—two wrapped with black rubber tape and four unwrapped—were filled (gravity flow) from the 4-liter water sample by inserting the rubber tube down to the bottom of each bottle. About 300 ml of water was permitted to overflow after the bottle was full. Two of the unwrapped bottle samples were fixed immediately for oxygen determination. The remaining bottles were stoppered and suspended 15 cm below the surface. The time of sampling was recorded for each station and the bottles were recovered 24 hr later and fixed for oxygen determination.

Water temperature ($^{\circ}$ C) and turbidity in Jackson turbidity unit—JTU (American Public Health Association, 1962)—observations were made just before the water samples for plankton were taken (Table 1); insolation was measured with a recording pyrhelimeter located at station 1.

TABLE 1.—Water temperatures and turbidities observed just before each incubation period.

Date	Station					Average
	1	2	3	4	5	
$^{\circ}$ C						
Temperature						
June 18	29.0	29.0	29.0	29.0	29.0	29.0
June 25	31.5	31.0	30.5	30.5	31.0	30.9
July 9	31.5	31.5	31.0	31.0	31.5	31.3
July 24	30.5	29.5	30.0	29.5	29.0	29.7
July 30	32.0	31.0	31.5	31.5	31.0	31.4
Aug. 13	31.5	31.0	30.5	30.5	32.0	31.1
Average	31.0	30.5	30.4	30.0	30.6	30.6
Jackson turbidity units						
Turbidity						
June 18	9.0	8.0	16.0	16.0	12.0	12.2
June 25	11.5	13.0	29.0	24.5	53.0	26.2
July 9	9.5	8.0	18.0	24.0	14.0	14.7
July 24	12.5	10.0	29.5	24.5	27.0	20.7
July 30	9.0	8.5	21.0	18.5	17.0	14.8
Aug. 13	9.5	6.5	19.0	12.0	18.5	13.1
Average	10.2	9.0	22.1	19.9	23.6	16.9

Dissolved oxygen was measured using a modified Winkler method (Carritt and Carpenter, 1966). Oxygen determinations were made within 3 hr after fixing the water samples. Changes in dissolved oxygen were converted to changes in organic carbon using the relation formulated by Ryther (1956): 1.0 mg oxygen is equivalent to 0.30 mg carbon.

Net production (NP), respiration (R), and gross production (GP) were determined using the carbon values from the initial (I), light (L), and dark (D) bottle values as follows:

$$NP = L - I, R = I - D, \text{ and } GP = NP + R.$$

ENVIRONMENTAL AND HYDROLOGICAL DATA

Surface water temperature varied no more than 1.5° C between stations on any sampling date and no more than 3° C between dates at

any station (Table 1). Surface water temperatures were slightly higher in the canals and bay than in the marsh.

Turbidity values of surface water samples varied as much as 41.5 JTU between stations on June 25 and as much as 41 JTU between dates at station 5 (Table 1). Average turbidity values from the marsh and bay stations were about double those from the canal stations. On June 25, however, turbidities in the bay were about twice those in the marsh and about four times those in the canals.

Insolation was similar on all sampling dates. The daily averages ranged from 0.82 to 0.85 cal/cm²/day.

Overproduction of phytoplankton, in terms of oxygen balance, occurred in some canals of the development. Plankton blooms that reduced oxygen to zero at night, and caused fish kills at station 1, occurred at least three times during the study period. These blooms were observed on July 4, July 18, and August 7.

PRODUCTION AND RESPIRATION

Average gross production ranged from 1.17 at station 5 to 2.25 mg carbon/liter/day at station 1 during the study (Table 2 and Figure 2). Average values at the two canal stations were almost identical. Likewise, there was almost no difference between average values at the two marsh stations. Average production in the canals was slightly higher (8%) than in the marsh and much higher (48%) than in the bay. In similar studies in Boca Ciega Bay, Fla., Taylor and Saloman (1968) reported that primary production of phytoplankton did not differ consistently between development canals and open bay areas.

Average net production ranged from 0.84 at station 5 to 1.74 mg carbon/liter/day at station 1. Like gross production, the values were about the same among canal stations and among marsh stations. Average net production in the canals was 13% higher than in the marsh and 51% higher than in the Bay.

Respiration averaged 0.51 mg carbon/liter/day, or 27.7% of gross production and ranged from 23.4 to 34.4% between stations (Table 2).

TABLE 2.—Net production (*NP*), respiration (*R*), gross production (*GP*), and percent respiration (*%R*) by station and date in West Bay, Tex.

Date	Variable	Station					Average
		1	2	3	4	5	
		mg carbon/liter/day					
June 18	<i>NP</i>	2.01	0.91	0.70	1.08	0.54	1.05
	<i>R</i>	0.23	0.69	0.58	0.31	0.34	0.43
	<i>GP</i>	2.24	1.60	1.28	1.39	0.88	1.48
	<i>%R</i>	10.3	43.1	45.3	22.3	38.6	31.9
June 25	<i>NP</i>	1.33	1.75	0.87	1.04	0.74	1.15
	<i>R</i>	0.39	1.07	0.63	0.52	0.37	0.60
	<i>GP</i>	1.72	2.82	1.50	1.56	1.11	1.74
	<i>%R</i>	22.7	37.9	42.0	33.3	33.3	33.8
July 9	<i>NP</i>	1.80	1.08	1.61	1.34	0.84	1.33
	<i>R</i>	0.37	0.56	0.53	0.43	0.31	0.44
	<i>GP</i>	2.17	1.64	2.14	1.77	1.15	1.77
	<i>%R</i>	17.0	34.1	24.8	24.3	26.9	25.4
July 24	<i>NP</i>	2.57	3.04	1.77	2.40	0.94	2.14
	<i>R</i>	0.43	0.38	0.44	0.70	0.32	0.45
	<i>GP</i>	3.00	3.42	2.21	3.10	1.26	2.60
	<i>%R</i>	14.3	11.1	19.9	22.6	25.4	18.7
July 30	<i>NP</i>	0.81	1.30	1.82	2.12	0.74	1.36
	<i>R</i>	0.74	0.46	1.19	0.40	0.32	0.62
	<i>GP</i>	1.55	1.76	3.01	2.52	1.06	1.98
	<i>%R</i>	47.7	26.1	39.5	15.9	30.2	31.9
Aug. 13	<i>NP</i>	1.94	1.90	1.43	1.57	1.26	1.62
	<i>R</i>	0.87	0.33	0.77	0.44	0.31	0.54
	<i>GP</i>	2.81	2.23	2.20	2.01	1.57	2.16
	<i>%R</i>	30.9	14.8	35.0	21.9	19.7	24.5
Average	<i>NP</i>	1.74	1.66	1.37	1.59	0.84	1.44
	<i>R</i>	0.50	0.58	0.69	0.47	0.33	0.51
	<i>GP</i>	2.25	2.24	2.06	2.06	1.17	1.95
	<i>%R</i>	23.8	27.8	34.4	23.4	29.0	27.7

Distinct differences in the percents of gross production attributable to respiration between canal, marsh, and bay areas were not apparent.

Averages of gross and net production in the canals and marsh were significantly greater than in the bay; differences between the canals and marsh were not significant (Table 3).

The differences in production between stations were related to turbidity. The correlation coefficient (*r*) between average gross production and average turbidity at each station was -0.70 .

TABLE 3.—Comparisons of net productivity, respiration, and gross productivity between stations (one-way analysis of variance).

	Comparison between			
	Stations 1-5		Stations 1-4	
	df	F-value ¹	df	F-value
Net production	4,25	4.06*	3,20	0.72
Respiration	4,25	2.30	3,20	0.97
Gross production	4,25	5.05**	3,20	0.25

¹ Significance level:

* 5%

** 1%

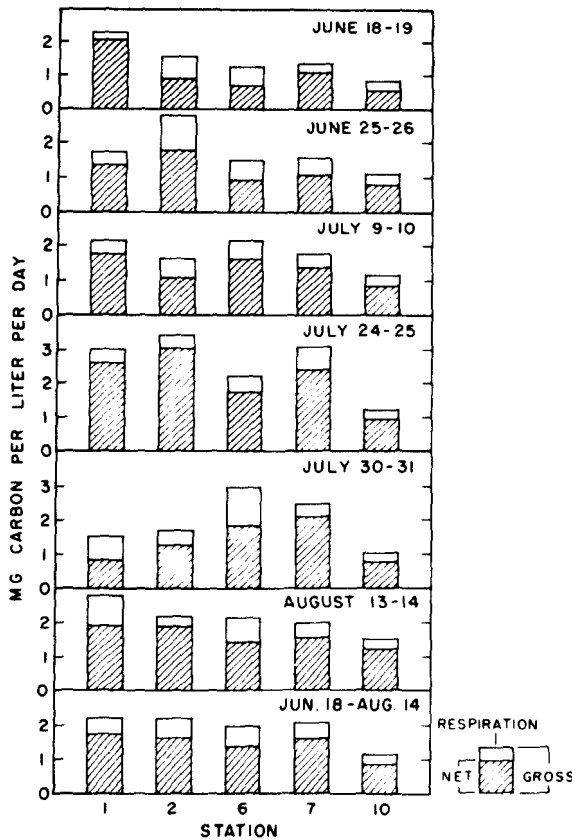


FIGURE 2.—Gross and net production and respiration by station and date, and average values for all sampling dates.

DISCUSSION

It is probable that eutrophic conditions will develop more frequently in housing development canals than in natural marsh areas because of differences in phytoplankton production, water circulation, water exchange, and high nutrient levels. In this study, gross production of phytoplankton in surface waters was higher in the canals than in the marsh or bay. We did not obtain information for computing production per unit area, but it is probable that production per unit area was significantly greater in the canals than in the other two areas, the reasons being the greater depths and lower turbidities in the

canals. Wind-driven circulation responsible for reaeration of the waters in the development is less than in the natural area because of houses blocking and diverting prevailing winds and because many of the canals are narrow and perpendicular to the direction of prevailing summer winds. Water depths at mean low tide in the development averaged about 1.5 m but were often much greater, sometimes over 3 m, whereas depths in the natural area averaged about 0.6 m but were always less than 1 m. With the average tide level change of 0.3 m, this means that only about one-fifth of the volume of water in the development exchanges with the bay during a normal tidal cycle, whereas about one-half exchanges per cycle in the natural area. Nutrient levels were about the same (nitrogen) or slightly higher (phosphates) in the canals than in the natural area (Moore and Trent, 1971). It is possible, however, that because of reduced water exchange, nutrient levels in parts of the development were too high to maintain a balanced ecological system.

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