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A QUANTITATIVE ANALYSIS OF THE PHYTOPLANKTON OF THE GULF OF PANAMA

I. RESULTS OF THE REGIONAL PHYTOPLANKTON SURVEYS DURING JULY AND NOVEMBER, 1957 AND MARCH, 1958

by — por

Theodore J. Smayda

(Con Resumen en Español)

La Jolla, California

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I. RESULTS OF THE REGIONAL PHYTOPLANKTON SURVEYS DURING JULY AND NOVEMBER, 1957 AND MARCH, 1958

UN ANALISIS CUANTITATIVO DEL FITOPLANCTON EN EL GOLFO DE PANAMA[1]

I. LOS RESULTADOS DE LAS INVESTIGACIONES REGIONALES DEL FITOPLANCTON DURANTE JULIO Y NOVIEMBRE DE 1957, Y MARZO DE 1958

by — por

Theodore J. Smayda[2]

RESUMEN

1. La Comisión Interamericana del Atún Tropical recolectó en el Golfo de Panama muestras cuantitativas de fitoplancton en la superficie y a los diez metros, como sigue:

a) Del 18 al 21 de marzo de 1958 (31 estaciones)—durante el máximum de la estación de afloramiento.

b) Del 10 al 12 de julio de 1957 (10 estaciones)—durante la epóca de transición a la estación lluviosa cuando reaparecen los vientos ligeros que causan el afloramiento.

c) Del 7 al 8 de noviembre de 1957 (15 estaciones)—durante el máximum de la estación lluviosa.

2. Las poblaciones máximas de fitoplancton aparecieron durante la estación de afloramiento, seguido por una considerable disminución durante el mes de julio y una calma durante noviembre.

3. Durante la investigación se observó una remarcable uniformidad regional en la composición de las especies a pesar de las diferencias regionales en las condiciones de crecimiento. Las diatomeas predominaban en gran número en las comunidades.

4. Durante todas las investigaciones, las regiones más cerca de la costa, generalmente al norte de los 8°30′N, eran las más productivas. Las áreas menos productivas fueron las mar afuera de las Bahias de San Miguel y Parita, lo que sugiere que el aumento en las sales nutritivas causado por las escorrentías es inadecuado para sostener poblaciones grandes de plantas autotróficas en estas regiones.

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1. Contribution No. 58 from the Narragansett Marine Laboratory, University of Rhode Island, Kingston, R. I.

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5. Durante todas las investigaciones, el crecimiento del fitoplancton pareció estar limitado por la disponibilidad de las sales nutritivas.

6. Durante todas las investigaciones el crecimiento del fitoplancton pareció estar relacionado con la profundidad de la columna de agua.

7. Aunque las precipitación por debajo del promedio normal contribuyó a condiciones desusadamente favorables de crecimiento (estabilidad reducida, aumento de la transparencia y, presumiblemente, de la reserva de sales nutritivas) durante la investigación de noviembre en relación a noviembre de 1955 y de 1956 en los 8°45′N, 79°23′W, no se observó la alta reacción de fitoplancton que se esperaba.

8. Durante la investigación de noviembre, las reacciones locales de las diatomeas y sus fluctuaciones regionales pudieron relacionarse en forma satisfactoria con condiciones asociadas con la salinidad de la superficie. Sin embargo, esta correspondencia puede atribuirse sin duda a factores asociados con los niveles observados de salinidad, probablemente con las sales nutritivas, en lugar de directamente con la salinidad.

9. Condiciones calurosas no comunes ocurrieron durante la investigación de marzo, las que pueden atribuirse a que los vientos que ocasionan el afloramiento fueran más débiles que los normales, lo que contribuyó a que la cosecha estable fuera considerablemente más baja y a la demora de tres a cinco semanas en la suceción relativa a la que se observó durante 1955-1957 en los 8°45′N, 8°23′W, en el Golfo de Panamá.

10. Durante la investigación de marzo, existió una relación *inversa* bien definida entre la temperatura y la abundancia media de las diatomeas en los diez metros superiores, y entre la transparencia y la abundancia media de las diatomeas. Una relación *directa* ocurrió entre la salinidad de superficie y la abundancia media de las diatomeas en los diez metros superiores. Estas relaciones se interpretan como indicadoras de que la abundancia de diatomeas refleja primeramente las concentraciones de las sales nutritivas asociadas con una intensidad de afloramiento dada, en lugar de describir relaciones causales.

11. Los resultados de la investigación indican que la dinámica del fitoplancton observada en los 8°45′N, 79°23′W, desde noviembre de 1954 a mayo de 1957, es generalmente representativa del Golfo de Panamá.

12. Durante las investigaciones se observaron las siguientes formas nuevas, las que serán descritas en una publicación posterior:

Actinoptychus undulatus f. *catenata*	n.f.
Asterionella japonica f. *tropicum*	n.f.
Leptocylindrus maximus	n. sp.
Skeletonema costatum f. *tropicum*	n.f.

SUMMARY

1. Quantitative phytoplankton samples were collected by the Inter-American Tropical Tuna Commission at the surface and ten meters in the Gulf of Panama, as follows:

a) 18-21 March, 1958 (31 stations)—during the height of the upwelling season,

b) 10-12 July, 1957 (10 stations)—during the transition to the rainy season at a time when mild upwelling winds reappear,

c) 7-8 November, 1957 (15 stations)—during the height of the rainy season.

2. Maximum phytoplankton populations occurred during the upwelling season, followed by a considerable decline during July, and a further subsidence during November.

3. A remarkable regional uniformity in species composition was observed during the surveys despite regional differences in growth conditions. Diatoms overwhelmingly dominated the communities.

4. During all surveys, the innermost regions, generally north of 8°30′N, were the most productive. The least productive areas were in the offing of San Miguel Bay and Parita Bay, suggesting that nutrient accretion *via* runoff is inadequate to sustain sizeable autotrophic plant populations in those regions.

5. During all surveys, phytoplankton growth appeared to be limited by nutrient availability.

6. During all surveys, phytoplankton growth appeared to be related to depth of the water column.

7. Although below average rainfall contributed to unusually favorable growth conditions (reduced stability, increased transparency and, presumably, nutrient reserves) during the November survey relative to November 1955 and 1956 at 8°45′N, 79°23′W, the anticipated heightened phytoplankton response was not observed.

8. During the November survey, the local diatom responses and their regional fluctuations could be satisfactorily related to the accompanying surface salinity conditions. However, this correspondence is undoubtedly attributable to factors associated with the observed salinity levels, probably nutrients, rather than salinity directly.

9. Unusually warm conditions occurred during the March survey, attributable to considerably weaker upwelling winds than normally occurring then, which contributed to a considerably lower standing crop and a

retardation in succession of three to five weeks relative to that observed during 1955-1957 at 8°45′N, 79°23′W in the Gulf of Panama.

10. During the March survey, a well defined *inverse* relationship existed between mean temperature and mean diatom abundance in the upper ten meters, and between transparency and mean diatom abundance. A *direct* relationship occurred between surface salinity and mean diatom abundance in the upper ten meters. These relationships are interpreted to indicate that diatom abundance primarily reflected the nutrient concentrations associated with a given upwelling intensity, rather than describing casual relationships.

11. The survey results indicate that the phytoplankton dynamics observed at 8°45′N, 79°23′W from November, 1954 through May, 1957 are generally representative of the Gulf of Panama.

12. The following new forms, to be described in a later publication, were observed during the surveys:

Actinoptychus undulatus f. *catenata*	n.f.
Asterionella japonica f. *tropicum*	n.f.
Leptocylindrus maximus	n. sp.
Skeletonema costatum f. *tropicum*	n.f.

INTRODUCTION

The Inter-American Tropical Tuna Commission has maintained a hydro-biological station[1] in the Gulf of Panama located at 8°45′N, 79°23′W where the depth is approximately 42 meters at mean low water (Schaefer, Bishop and Howard, 1958). Routine hydrographic and biological observations have been made, including the collection of quantitative phytoplankton samples at bi-weekly intervals from November, 1954 through May, 1957 (Smayda, 1959; in prep.). In order to evaluate to what extent the phytoplankton response at this station might be representative of the Gulf of Panama, additional phytoplankton samples were collected at the author's request during three bathythermograph cruises to various regions of the Gulf. The results of these phytoplankton surveys are presented in this paper.

The quantitative phytoplankton material consisted of 112 water bottle samples (only 104 enumerable) collected from the surface and 10 meters at 56 stations as follows:

10-12 July, 1957	10 stations
7-8 November, 1957	15 stations
18-21 March, 1958	31 stations

The phytoplankton samples were dispensed into 400 ml. citrate bottles, preserved with neutralized formalin and shipped to the Institute for Marine Biology, Sect. B, Oslo, Norway. The phytoplankton enumeration was then carried out on 2 ml. and 50 ml. sedimented sub-samples employing an inverted microscope (Utermöhl, 1931).

The author is indebted to Dr. Milner Schaefer, Mr. Izadore Barrett, Mr. Antonio Landa and Mr. Gerald Howard of the Inter-American Tropical Tuna Commission for their assistance in the collection and forwarding of the samples and in providing hydrographic data. He is also deeply indebted to Professor Trygve Braarud for providing facilities at his institute as well as the numerous tangible and intangible benefits gained during his association with him and his distinguished staff from 1955-1959. Mr. Joel O'Connor kindly advised on and assisted with the statistical analyses. An IBM 1620 computer was employed using the regression program developed by Mr. Richard Cooper of the Narragansett Marine Laboratory. The author is also indebted to his wife, Norma, for her assistance in processing the results of the phytoplankton enumeration.

This study was conducted in part during the tenure of a Woods Hole Oceanographic Associates' Fellowship.

[1]Henceforth will be referred to as the permanent station.

ECOLOGICAL CONDITIONS IN THE GULF OF PANAMA

The following synopsis of the major environmental features of the Gulf of Panama has been abstracted from a considerably more detailed analysis to be presented elsewhere (Smayda, in prep.).

The Gulf of Panama, which approximates a circular embayment, occupies 28,850 km.^{2} and extends 175 km. inland from its entrance to the south where the distance from Cape Mala to the opposite (eastern) shore is 205 km. (Figure 1). San Miguel Bay and Parita Bay, two important drainage loci, and the Pearl Islands complex (Archipielago de las Perlas) are well-defined features within the Gulf of Panama.

The Gulf of Panama is relatively shallow throughout most of its expanse, 91.4 per cent of its total area being shallower than 200 meters.

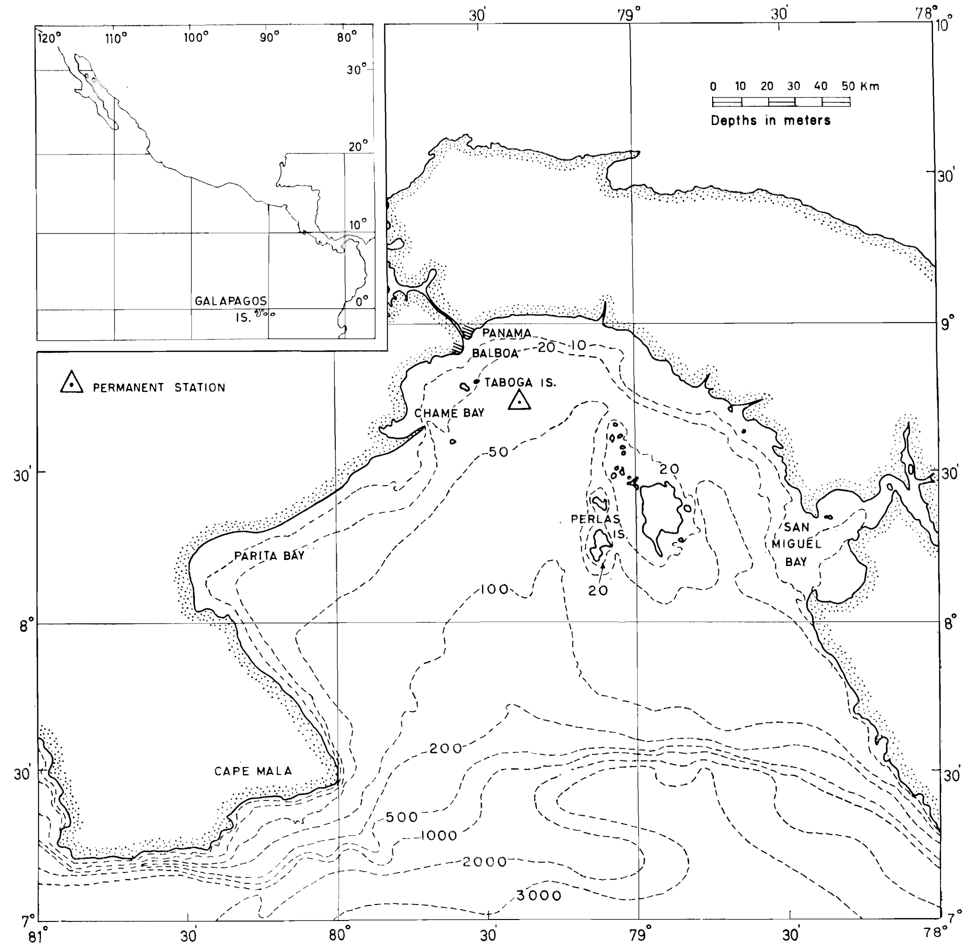

FIGURE 1. Principal features of the Gulf of Panama, and location of the permanent hydrobiological station maintained by the Inter-American Tropical Tuna Commission.

The mean depth within this isobath is approximately 60 meters. Near its entrance, however, the Gulf deepens precipitously, as along the 79°W meridian where the depth increases from 200 meters to 3,000 meters in 10 km. (Figure 1). The presence of a submarine valley is a significant topographical feature of the Gulf of Panama floor. Beginning north of the Pearl Islands, as indicated by the northeast protrusion of the 50 meter isobath, this arcuate valley continues southwards in the region west of the archipelago to the Gulf entrance where it remains detectable at the 200 meter isobath (Figure 1). This valley is important in guiding the incursion of offshore waters during upwelling (Smayda, in prep.).

Climatologically, the Isthmus of Panama is located within the path of the north-south seasonal movement of the Tradewind—Calm Belt (Doldrums) system (Chapel, 1927; Wooster, 1959). The Gulf of Panama, consequently, is successively influenced by the Northeast Trade Winds of the Atlantic, the Equatorial Calm Belt (Doldrums), and the Southeast Trade Winds of the Pacific during a calendar year. Important and specific hydrographic events accompany the different meteorological conditions.

From January through April, but occasionally including periods in December and May, the Gulf of Panama is predominantly influenced by the Northeast Trade Winds. These dry, northerly winds displace the watermass in the upper 40 to 75 meters offshore (Fleming, 1940; Schaefer, Bishop and Howard, 1958) causing an upwelling of 1) *colder*, 2) more *saline* and 3) *nutrient rich* water to the surface (Figure 2, Table 1). Although the relative upwelling intensity varies with wind strength, a continual influx of cold, enriched water is generally characteristic of this period, with upwelling usually attaining its maximum intensity during March.

TABLE 1. Monthly Winds and Mean Precipitation at Balboa during 1956 Compared to Mean Temperature, Salinity and Phosphate Conditions at 8°45′N, 79°23′W.

	WINDS (km.)		RAIN[1]	°C	SALINITY	$P\text{-}PO_4$[2]
MONTH	NORTH	SOUTH	(mm.)	(Mean, upper 20 meters)		(mg.at./m²)
JAN	7918	160	28	21.46	31.99	58.50
FEB	8229	142	14	25.68	31.91	41.58
MAR	10896	166	18	21.13	33.82	77.07
APR	8184	590	74	23.88	33.72	43.56
MAY	5035	1056	199	27.14	33.03	36.00
JUNE	3568	1541	202	27.86	28.90	34.69
JULY	5584	485	187	27.77	30.22	43.10
AUG	4888	570	194	27.64	30.13	37.00
SEPT	3237	1496	191	28.22	29.57	29.45
OCT	2202	3602	254	27.77	28.72	25.04
NOV	4656	805	250	27.15	27.38	30.27
DEC	5290	163	138	26.05	29.12	37.61

[1]Anonymous, 1957. [2]Calculated from stations 17-102, July 1955 to December 1958.

The North East Trade Winds usually weaken in May attendant with the northward movement of the wind system resulting in an abrupt cessation of upwelling (Figure 2, Table 1). A marked increase in temperature and reduction in phosphate reserves occur throughout the water column at this time. The Gulf of Panama then becomes increasingly influenced by the Doldrums, followed by the rain-bearing southwest winds of the South East Trade Winds which usually persist until mid-December. Although there is usually a slight resurgence of northerly winds during July and/or August sufficient to induce mixing or even cause a slight upwelling, the ecological conditions associated with the rainy season are generally detrimental to phytoplankton production (Figure 2, Table 1).

Considerable runoff occurs during the rainy season causing a marked dilution and, hence, increased stability of the watermass (Table 1). Dur-

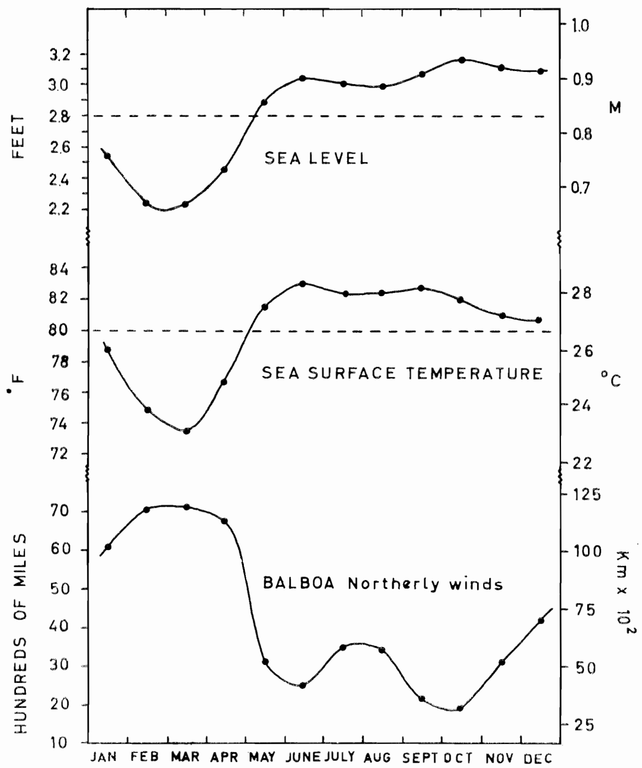

FIGURE 2. **Long-term monthly averages of sea-level, sea-surface temperature (1908-1953) and northerly winds (1915-1956) at Balboa. (Modified from Schaefer, Bishop and Howard, 1958). The number of miles of northerly winds per month (weighted to a 31-day basis) was calculated by weighting the mean velocity of the north, northwest and northeast winds during a given month by the mean number of hours blowing. Measurements of the wind direction, velocity and duration of blowing were obtained for the years 1915-1956 from continuously recording anemometers located at Balboa.**

ing 1955 at the permanent station, the surface salinity decreased from an upwelling maximum of 34.61 ‰ to 21.68 ‰ during mid-November. The silt-laden runoff also progressively increases the turbidity of the watermass which, combined with a reduced incident radiation accompanying the high cloud cover, raises the compensation depth. For example, the mean depth of the one per cent isolume during the 1956 rainy season was at approximately 30 meters, whereas during dryer 1957 it was at 50 meters. Phosphate accretion *via* runoff from the well-leached lateritic soils appears to be minimal (Table 1). Indeed, the evidence from the permanent station suggests that the runoff actually dilutes the inorganic phosphate reserves in the euphotic zone. The observations of Schaefer and Bishop (1958) in the Gulf of Panama suggesting that quantitative amounts of iron accretion accompany runoff are not contradictory, however, considering the widespread occurrence of iron in tropical lateritic soils (Mohr and Van Baren, 1954). Finally, the prevailing southerly winds during the rainy season tend to hold in place the warm, diluted and nutrient impoverished superficial waters of the Gulf of Panama hindering flushing and admixture with more fertile waters (Figure 2).

The average diatom biomass in the upper 20 meters during the upwelling season at the permanent station from 1955-1957 was ten-fold

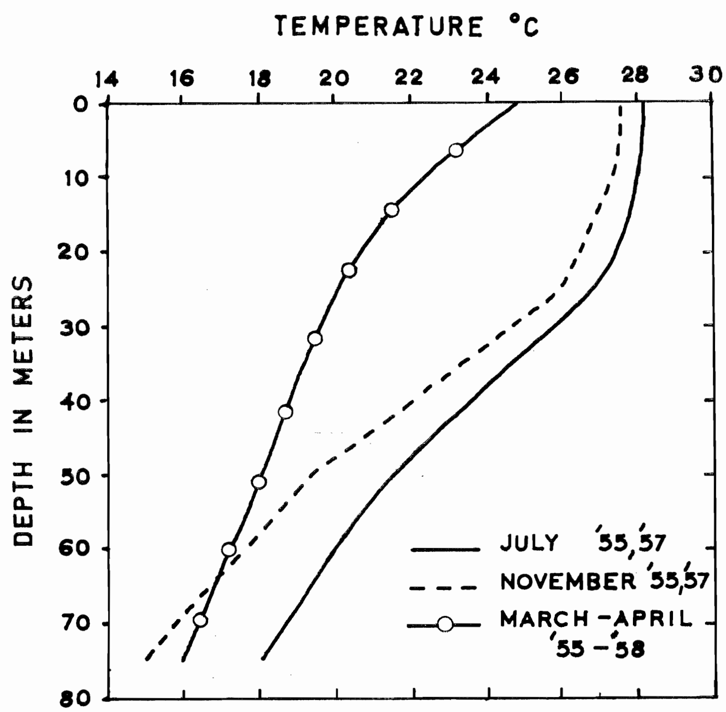

FIGURE 3. **Mean thermal conditions in the upper 75 meters of the Gulf of Panama during certain months as calculated from bathythermograph observations.**

greater than that observed during the rainy season (Smayda, 1959). Thus, the environmental conditions and ensuing biological response at 8°45′N, 79°23′W are very wind-dependent, permitting a natural classification of the annual phytoplankton cycle into a fertile upwelling period during the northern winter and a relatively unproductive rainy season during the remainder of the year. The average thermal conditions in the upper 75 meters during various times of the year suggest that a similar condition exists throughout the Gulf of Panama (Figure 3). However, the associated regional phytoplankton distribution must also be examined now.

PHYTOPLANKTON OBSERVATIONS DURING THE SURVEY OF 10-12 JULY, 1957

Phytoplankton samples were collected from the surface and 10 meters at ten stations, Stations 1-10 (Figure 4), during a bathythermograph survey from 10-12 July, 1957 comprising 46 stations. The Gulf of Panama

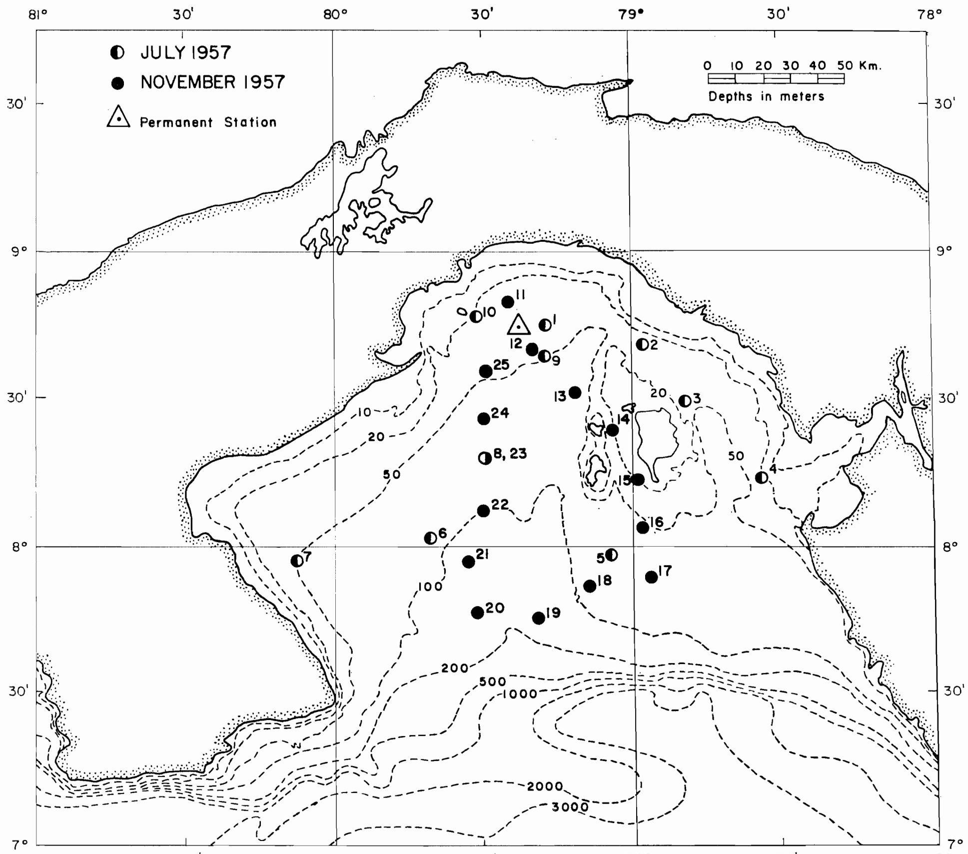

FIGURE 4. Phytoplankton stations during the surveys of 10-12 July and 7-8 November, 1957.

was characterized by uniformly high temperatures in the superficial layers associated with a well-developed thermocline below 25 meters at that time (Table 2).

TABLE 2. Mean Vertical Temperature Conditions During 10-12 July, 1957 (Bathythermograph Survey No. 8)

Depth (meters):	0	5	10	25	50	75
Temperature (°C):	28.59	28.56	28.54	27.63	22.86	18.74
Observations:	46	46	46	42	25	10

At the ten phytoplankton stations, the temperature ranged from 28.06° to 29.44°C in the upper 10 meters. Wind direction and force were the only ancillary observations made during this survey (Figure 5A).

Diatoms were the most active phytoplankton component throughout the Gulf of Panama during the July survey (Tables 3, 4). Their average population density of 51,900 cells/liter[1] was significantly greater than that observed for the other groups (Table 4). The coccolithophores (dominated by *Gephyrocapsa oceanica*) were recorded only at stations 3, 5 and 7, whereas the more ubiquitous and abundant brown dinoflagellates were dominated by *Exuviaella baltica.* The diatoms, autotrophic dinoflagellates and monads attained their maximum concentrations at station 2, the coccolithophores at station 3, and the Gymnodiniaceae at station 4 (Table 4, Appendix Table 1).

The diatoms exhibited a conspicuous regional variation in abundance permitting the division of the Gulf of Panama into a northern and a southern floral region during this survey (Table 4, Figure 5). Stations 1, 2, 3, 9, 10 comprised the northern, inner region where the mean diatom abundance in the upper 10 meters of 89,455 c/l was six-fold greater than the 14,345 c/l characteristic of the outermost stations: 4, 5, 6, 7, 8. Although the average overall contribution of the various flagellate components was relatively insignificant, they also tended to be more abundant in the northern region (Table 4).

The regional variation in diatom abundance could be further related to depth of the water column. All stations in the phytoplankton "rich" northern region were located in 30 to 50 meters of water, whereas the average diatom density was considerably less at those stations located at other depths:

Depth (m)	Stations	Mean Diatoms (c/l)
20-30	4, 7	15,090
30-50	1, 2, 3, 9, 10	89,455
70-80	5, 6, 8	13,748

1. c/l will be used hereafter.

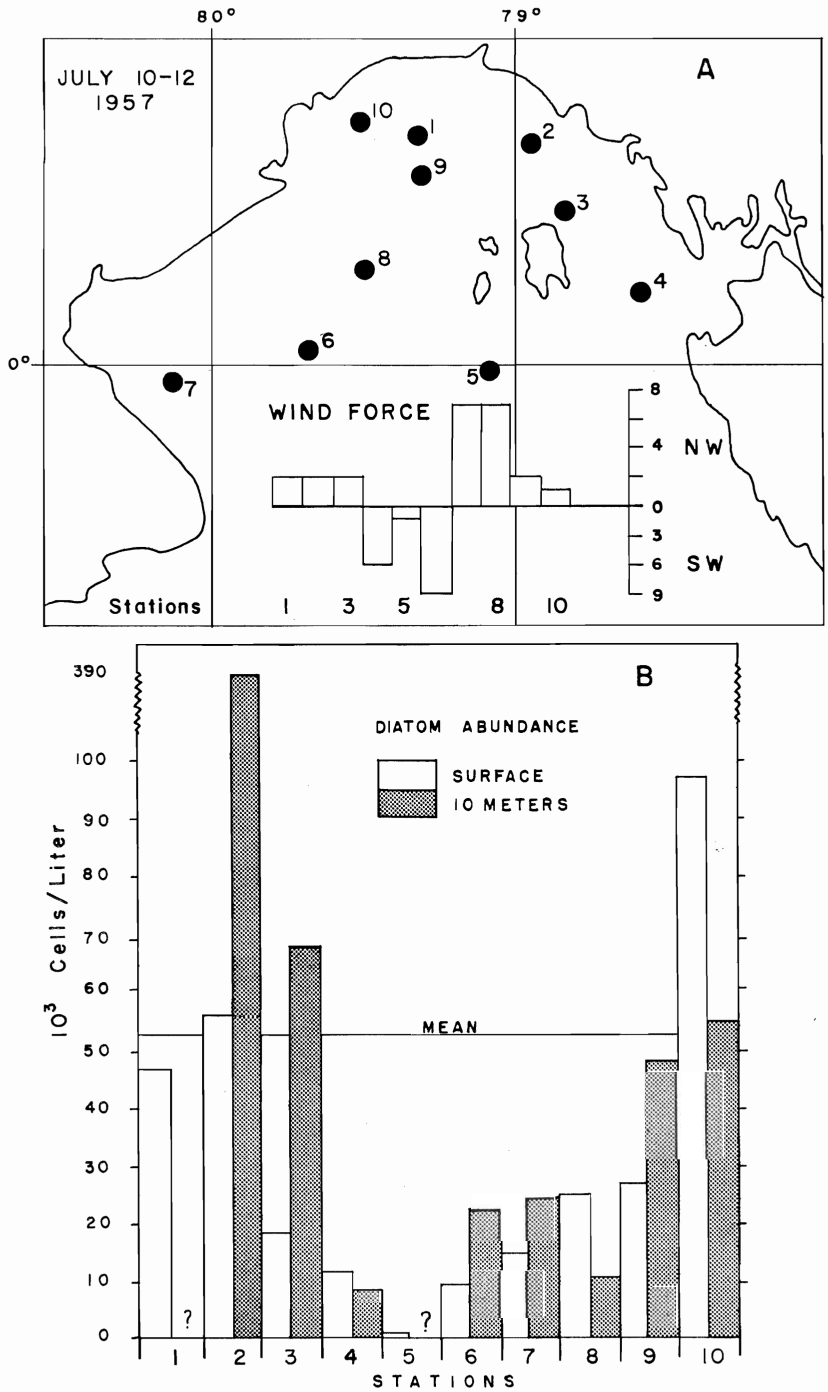

FIGURE 5. **A. Phytoplankton stations, and local wind direction and force during July survey. B. Regional variation in diatom abundance during July survey.**

TABLE 3. Maximum Abundance of Major Diatoms at July 1957 Stations, cells/10 ml.; + less than 5 cells/10 ml.

SPECIES	STATIONS 1	2	3	4	5	6	7	8	9	10
Bact. elegans	7	370	110	65	—	+	27	+	36	60
hyalinum var. princeps	17	110	20	—	—	+	17	+	15	20
Ch. compressus	13	225	9	—	—	100	35	+	36	60
curvisetus	12	450	50	+	—	15	—	+	30	135
didymus	+	150	13	+	—	+	9	+	25	110
lorenzianus	20	190	55	+	—	5	30	14	42	69
Nitz. delicatissima	130	115	45	+	—	—	40	65	5	65
pacifica + pungens	45	115	40	25	—	10	+	+	—	25
Rh. delicatula	80	625	70	45	—	9	10	16	165	210
Skel. costatum f. tropicum	13	405	105	—	—	15	5	+	19	70

TABLE 4. Population Densities at Stations 1-10; 10-12 July, 1957. (cells/liter; n.d. = no data).

STATION AND DEPTH (m)	DIATOMS	GYMNO-DINIACEAE	DINO-FLAGELLATES	COCCO-LITHOPHORES	MONADS
1— 0	47,100	—	40	—	8,500
—10	n. d.	n. d.	n. d.	n. d.	n. d.
2— 0	56,700	—	1,300	—	3,000
—10	387,360	3,500	3,500	—	14,000
3— 0	18,320	4,500	1,260	—	2,500
—10	68,020	3,500	780	3,720	5,500
4— 0	12,160	5,000	1,280	—	3,500
—10	9,200	6,000	1,000	—	2,000
5— 0	60	20	100	1,040	—
—10	n. d.	n. d.	n. d.	n. d.	n. d.
6— 0	9,520	5,000	1,200	—	10,500
—10	23,320	—	500	—	—
7— 0	15,220	1,000	540	500	3,500
—10	23,780	1,000	720	520	7,000
8— 0	25,100	—	540	—	4,000
—10	10,740	—	100	—	3,000
9— 0	27,100	1,500	1,160	—	6,500
—10	47,860	1,000	1,240	—	2,500
10— 0	97,480	1,500	1,440	—	5,500
—10	55,160	5,500	1,020	—	7,000
STATION MEANS:					
St. 1-10	51,900	2,115	930	320	4,915
St. 1, 2, 3, 9, 10	89,455	2,335	1,195	413	6,110
St. 4-8	14,345	2,005	665	229	3,725

As with depth, there is an interesting correlation between diatom density and wind behavior observed at the collection site. The lowest diatom densities were encountered at stations 4, 5, 6 where southwest winds prevailed, and at stations 7 and 8 where northerly winds with a wind force of 7 to 8 were observed (Figure 5). The "fertile" stations, however, were located in areas where northerly winds with a force of 1 to 2 prevailed. It was demonstrated earlier that mild northerly winds usually reappearing during July may induce moderate upwelling (Figure 2, Table 1). Furthermore, upwelling appears to be especially intense in the northern regions within the 50 meter isobath (Smayda, in prep.). The relationships observed between plankton density, depth and wind during the July survey suggest, then, that the observed regional differences in phytoplankton abundance might be related to differences in upwelling intensity. However, the temperature data clearly indicate that sub-surface upwelling was not occurring at this time (Table 2, Appendix Table 1). An alternate possibility of wind-induced mixing with the deeper, enriched layers cannot be excluded, although the temperature data suggest that this process, if occurring, could not have been very vigorous.

The paucity of phytoplankton at station 4 located in the offing of San Miguel Bay, through which 45 per cent of the total annual runoff volume enters the Gulf (Smayda, in prep.), is notable (Figure 5, Table 4). This suggests that a limited accretion of inorganic nutrients with runoff occurs in this area, the presence of which is clearly signaled by the occurrence of *Peridinium inconspicuum*, a brackish dinoflagellate (Appendix Table 1). The heterotrophic Gymnodiniaceae, however, attained their maximum abundance at station 4 (Table 4).

A comparison of the average July phytoplankton densities in the upper 10 meters at the permanent station (8 observations) with those observed during the July, 1957 survey is presented in Table 5.

TABLE 5. A Comparison of the Average July Phytoplankton Densities in the Upper 10 Meters at 8°45′N, 79°23′W with Those Observed During the Gulf Survey of 10-12 July, 1957 (in cells/liter).

Stations:	1955, 1956 Permanent	1957 1-10	1957 1, 2, 3, 9, 10	1957 4-8
Diatoms	67,147	51,900	89,455	14,345
Dinoflagellates	1,747	930	1,195	665
Gymnodiniaceae	3,125	2,115	2,335	2,005
Coccolithophores	8,517	320	413	229
Monads	27,000	4,915	6,110	3,725

It is observed that the overall survey results are lower than the mean standing crop observed at the permanent station during July. However, the average phytoplankton densities, excepting the coccolithophores and monads, characteristic of the northern region (Stations 1, 2, 3, 9, 10) during the July survey compare very favorably with those at the similarly located permanent station (Figure 4).

The community present during the July survey was similar to that found at the permanent station (Table 3, Appendix Table 1).

PHYTOPLANKTON OBSERVATIONS DURING THE SURVEY OF 7-8 NOVEMBER, 1957

Environmental Conditions

Phytoplankton samples were collected from the surface and 10 meters at 15 stations, Stations 11-25 (Figure 4), during the bathythermograph survey from 7-8 November, 1957 comprising 32 stations. Although a slight cooling of the watermass occurred by November in the upper 25 meters, the surface temperatures remained high, ranging from 27.5° to 29.2°C (Table 6).

TABLE 6. Mean Vertical Temperature Conditions During 7-8 November, 1957 (Bathythermograph Survey No. 9)

Depth (Meters):	0	5	10	25	50	75
Temperature (°C):	28.17	27.92	27.81	26.13	19.02	15.31
Observations:	32	32	32	30	20	14

A well-developed thermocline persisted below 25 meters, the watermass below this depth having cooled approximately 3.5°C since July (Tables 2, 6).

Surface salinity determinations made at 16 stations, located near the phytoplankton stations, ranged from 28.66 to 29.87 ‰, with a mean of 29.36 ‰ (Figure 6). These abnormally high salinities during the height of the rainy season (Table 1) undoubtedly reflect the below average rainfall recorded during 1957, distinguishing it as a "dry year" (Anonymous, 1957). The extent of this deviation, and associated ecological conditions, can be estimated from a comparison of conditions during early November at the permanent station during 1955-1957 (Table 7).

TABLE 7. A Comparison of the Surface Salinity, Surface Oxygen Saturation, Phosphate Concentration and Transparency During Early November 1955-1957 at 8°45′N, 79°23′W.

Date	Surface ‰	Surface O_2 (% Sat.)	Phosphate (mg.-at./m^2)	Secchi Disc (meters)
15 XI 1955	21.68	109.3	18.32	no data
8 XI 1956	24.88	97.7	13.62	6.5
5 XI 1957	28.62	96.1	51.84	11.0

It is seen that the surface waters were approximately 4.00 to 7.00 ‰ more saline in November 1957 than during the previous two years; that is, 13 to 24% *less dilute*. This was accompanied by a considerably greater phosphate concentration and increased transparency during 1957, two parameters significantly influenced by freshwater runoff, as discussed on page 201. (The high oxygen saturation value during 1955 suggests that considerably higher phosphate reserves, since utilized, were actually associated with the observed salinity. However, oxygen saturation was repeatedly found

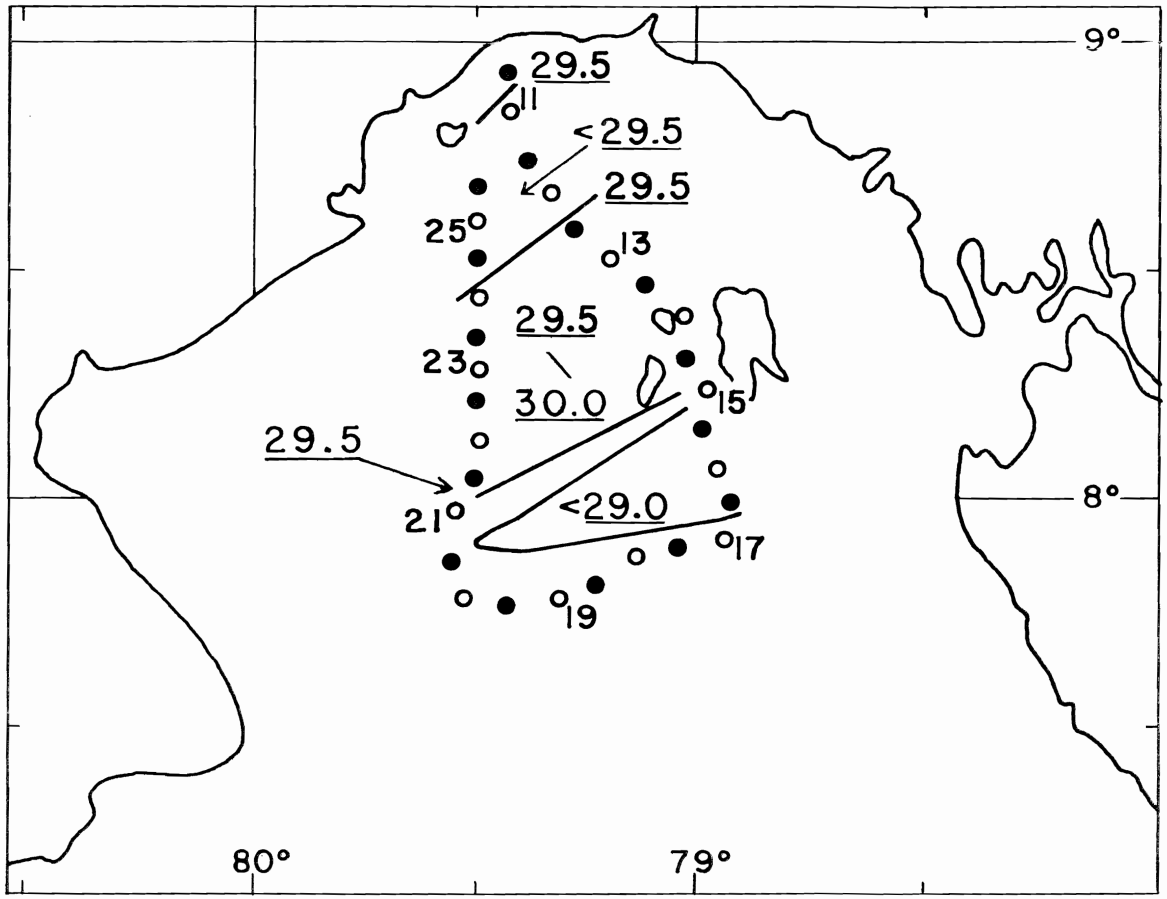

FIGURE 6. Surface salinity distribution during November survey. Filled circles represent stations where salinity determinations were made, and open circles phytoplankton stations.

to be an inadequate index of phytoplankton activity in the Gulf of Panama, unlike in certain non-tropical areas (Braarud and Bursa, 1939, for example).)

Secchi Disc measurements made during the November, 1957 survey at seven stations ranged from 6.0 to 12.5 meters, with a mean of 9.7 meters, revealing a transparency consistent with that expected from the salinity levels.

Thus, it appears reasonable to conclude that *unusually favorable growth conditions, relative to 1955 and 1956, characterized the superficial waters during the survey of 7-8 November, 1957.*

Despite the narrow salinity range, three surface watermasses can be distinguished (Figure 6). A central watermass of high salinity, 29.5 to 30.0 ‰, occurred between the slightly more dilute waters, less than 29.5 ‰, present in the inner and outer regions. The tongue of dilute water, less than 29.0 ‰, extending to the southwest from San Miguel Bay is especially well-defined (Figure 6). The surface salinity pattern, perhaps fortuitously, suggests the counter-clockwise circulation described for the Gulf of Panama (Wooster, 1959).

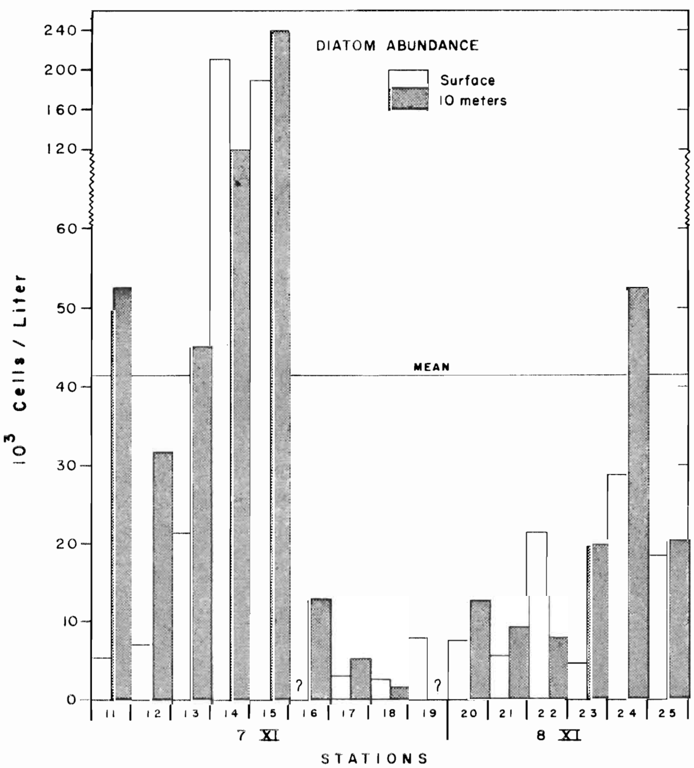

FIGURE 7. Diatom abundance at the surface and 10 meters during November survey.

Analysis of Phytoplankton Growth During November

Regional variations in the phytoplankton standing crop occurred, the northern reaches of the Gulf tending to be richer than the outer regions, as during July (Figures 6, 7, Table 8). A progressive increase in diatom abundance occurred on the track from station 11 to 15, except at station 12 where the coccolithophores exhibited their greatest abundance during the survey (Figures 6, 7, Table 8.) The densest populations of the survey occurred at stations 14-15 located in the passage between the Pearl Islands. Continuing southwards, a precipitous decrease in all components occurred at station 16, a condition which persisted in the southernmost region through station 21. On the inbound track, the diatom population then increased two-fold at station 22, and progressively thereafter through station 24, whereupon the population declined at station 25 (Figures 6, 7, Table 8).

TABLE 8. Population Densities at Stations 11-25; 7-8 November, 1957. (cells/liter; n.d. = no data).

STATION AND DEPTH (m)	DIATOMS	GYMNO-DINIACEAE	DINO-FLAGELLATES	COCCO-LITHOPHORES	MONADS
11— 0	5,120	—	220	8,000	2,500
—10	52,980	3,540	180	4,520	4,500
12— 0	6,680	1,000	780	6,040	2,500
—10	31,700	6,500	700	9,040	3,500
13— 0	21,280	500	40	3,000	1,500
—10	44,480	7,000	680	9,000	2,500
14— 0	209,600	3,500	200	7,000	2,000
—10	119,440	6,000	—	6,000	2,000
15— 0	190,740	8,300	1,560	7,500	3,500
—10	239,550	500	80	13,540	500
16— 0	n. d.	n. d.	n. d.	n. d.	n. d.
—10	12,100	4,000	40	1,540	—
17— 0	3,380	500	20	1,500	1,000
—10	4,980	—	1,060	1,040	—
18— 0	2,240	500	—	—	—
—10	1,500	—	—	—	—
19— 0	8,000	500	160	1,500	—
—10	n. d.	n. d.	n. d.	n. d.	n. d.
20— 0	7,480	—	200	2,000	—
—10	11,960	500	80	3,000	2,500
21— 0	5,620	500	500	2,000	1,000
—10	8,620	—	—	500	500
22— 0	21,200	80	80	1,500	4,040
—10	7,700	—	1,160	7,500	3,500
23— 0	4,380	—	—	1,000	1,000
—10	19,500	40	660	1,540	1,000
24— 0	28,810	—	820	3,500	4,000
—10	52,360	40	780	6,000	1,500
25— 0	18,280	2,000	200	2,040	1,500
—10	20,740	5,580	2,160	3,660	4,500
MEAN:	41,443	1,824	441	4,052	1,822

This regional variation in abundance was clearly associated with the observed pattern of surface salinity distribution (Figures 6, 7). The greatest diatom populations generally occurred within the central core of dense water, as at stations 13-15, 22-24 (Figures 6, 7, Table 8). Sparse populations accompanied the increased dilution, 28.66 to 29.50 ‰, characteristic of the southernmost stations 16-21. Similarly, the transition from the central watermass to the fresher northern region, delineated by the 29.5 ‰ isohaline, was likewise accompanied by a population decrease—compare stations 12 and 13, 24 and 25 (Figures 6, 7, Table 8).

Although surface salinity determinations were not made at the phytoplankton stations, the mean diatom populations in the upper 10 meters are compared to the average of the *two* surface salinity determinations nearest the phytoplankton stations (Figures 6, 8). Notwithstanding the inherent shortcomings of this procedure, a remarkably good direct correlation is apparent (Figure 8). Two relationships could be distinguished. The diatom-salinity relationship at those stations located in 80-90 meters

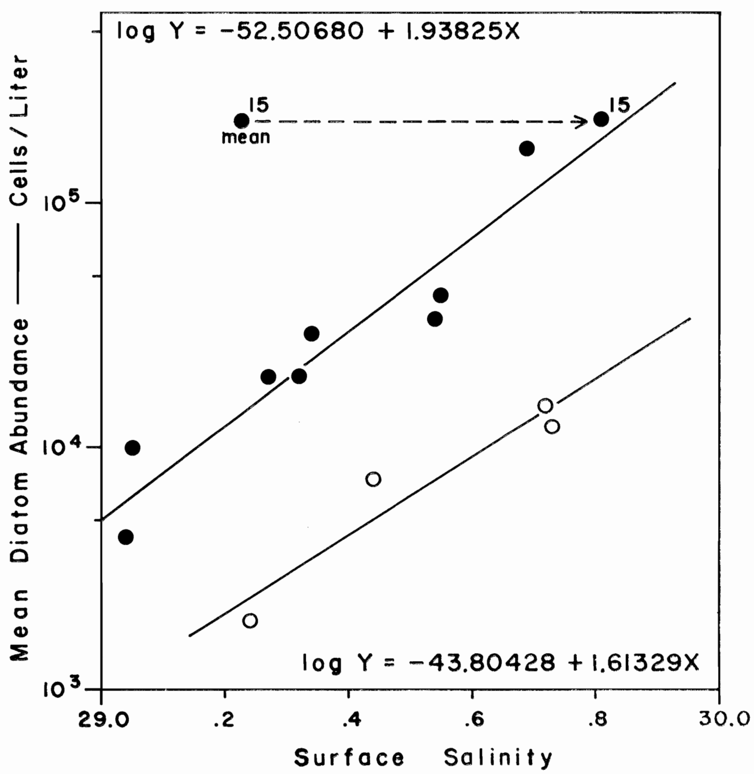

FIGURE 8. **The relationship between mean diatom abundance in the upper 10 meters and mean surface salinity near phytoplankton stations during the November survey. Open circles represent stations located where water column 80-90 meters deep, and filled circles stations at other depths. The two plots for station 15 and regressions are explained in the text.**

of water (open circles) differs from that at other depths, including greater ones (Figure 8). This confirms the July observations that phytoplankton growth is influenced by the depth of the water column as well. (Two plots are recorded for station 15 which lies in the central, saline watermass near its transition into the dilute southern one (Figures 6, 8). The nearest salinity observation within its own watermass appears to be a more appropriate datum to use in the correlation than a mean value, which includes an observation in the dilute watermass, in this instance.)

Calculation of semi-logarithmic linear regressions using the least square method reveals that 91 per cent of the variation can be explained by each regression. The standard error of the estimate is 0.073 for the 80-90 meter regression (open circles) and 0.055 for the other regression. Application of the *t*-test indicates that the regressions are significant to the 0.05 and 0.001 probability level, respectively.

Thus, the local diatom responses and their regional fluctuations during the November survey can be satisfactorily related to the accompanying surface salinity conditions. However, these responses are undoubtedly attributable to factors associated with the observed salinity levels, rather than salinity directly. (Note that the diatom responses could be related to the mean salinity values whose range was *less* than 1.0 ‰, 29.0 to 29.8 ‰ (Figure 8).) The uniformly high temperatures in the upper 10 meters at all phytoplankton stations, range of 27.8° to 28.9°C, cannot adequately account for the observed regional variation in diatom growth.

Light transmission and phosphate concentration were demonstrated previously to vary with salinity during the rainy season (Tables 1, 7). The average daily incident radiation recorded at Curundu near Balboa (Figure 1) was 615 gm.cal. per cm.^{2} during the week previous to the November survey. The average of seven scattered Secchi Disc observations made during the survey was approximately 10 meters. Using the Poole and Atkins (1929) formula to calculate the average extinction coefficient (k) per meter,

$$k = \frac{1.7}{D} \quad (1)$$

where D equals the Secchi Disc depth in meters, and then using the extinction coefficient together with the incident radiation datum in the formula,

$$\frac{I}{I_0} = e^{-kL} \quad (2)$$

where I_0 represents the incident intensity and I the intensity at depth L in meters, it can be calculated that the average energy flux was 307 gm.cal. per cm.^{2} at the mean depth, 4.1 meters, of the 50 per cent isolume during the November survey. This intensity is similar to that occurring during the upwelling season when intense phytoplankton growth occurs (Smayda, 1959). These observations suggest that it is unlikely that light either limited phytoplankton growth in the superficial waters during the November survey, or accounted for the regional variations in diatom response. Consequently, it seems likely that variable nutrient conditions associated, and known to fluctuate, with salinity best account for the relationship (Figure 8) observed between diatom abundance and salinity during the November survey.

The direct correlation between diatom abundance and salinity level is especially informative about nutrient accretion during the rainy season. Since the observed dilution is related to freshwater runoff (Table 1), any significant leaching of nutrients accompanying drainage would probably be reflected in an increased phytoplankton response. Accordingly, the November salinity—plankton relationship might be inverted; that is, maximum phytoplankton growth would occur at the lowest salinities. That this did not occur further supports the conclusion that nutrient accretion during the rainy season is inadequate to sustain large populations (Smayda, in prep.).

TABLE 9. Maximum Abundance of Major Diatoms and Coccolithophores at November 1957 Stations.
(cells/10 ml.; + less than 5 cells/10 ml.)

	STATIONS														
SPECIES	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Bact. elegans	29	25	45	240	305	8	6	8	5	13	+	12	15	70	60
hyalinum var. princeps	+	+	+	5	55	+	+	+	+	—	—	—	—	—	—
Ch. affinis	+	24	+	80	535	+	+	—	+	+	5	12	7	15	18
brevis	+	+	+	55	140	+	—	—	—	—	—	—	—	+	+
compressus	355	55	6	315	755	+	+	—	+	+	50	10	75	10	17
didymus	5	28	7	100	35	17	8	8	7	15	30	12	12	60	15
laciniosus	+	19	+	110	120	15	7	—	7	6	5	+	+	15	20
laevis	+	+	25	40	30	+	+	15	+	+	—	—	+	20	+
lorenzianus	6	9	30	65	75	+	+	—	+	6	—	+	+	+	+
Nitz. closterium	5	15	5	25	45	—	—	—	+	10	—	—	10	+	+
delicatissima	10	—	25	80	55	5	+	—	30	30	—	5	—	—	—
pacifica + pungens	11	7	15	130	145	+	5	5	+	15	10	14	6	170	50
Rh. delicatula	+	50	25	285	190	25	20	—	+	+	+	+	5	+	+
stolterfothii	+	+	35	95	16	+	+	—	+	—	+	+	+	10	5
Skel. costatum f. tropicum	45	16	340	395	290	6	+	—	+	15	20	12	20	165	15
Calciosolenia sinuosa	10	5	35	35	5	5	—	—	—	—	5	—	—	5	—
Coccolithus huxleyi	10	15	15	10	40	5	5	—	5	15	—	—	—	15	—
Gephyrocapsa oceanica	65	60	35	30	100	5	10	—	10	15	15	70	15	40	35
Halopappus adriaticus	+	15	5	10	5	+	—	—	—	—	—	5	+	—	5

Community Structure and Comparison of Standing Crops

The major diatom species observed during the November survey included those present during July (Tables 3, 9, Appendix Tables I, II). As during the latter survey, the same diatom community predominated throughout the Gulf. *Chaetoceros affinis* and *Ch. brevis* increased in abundance since July to warrant their inclusion as major species, whereas *Lepto-*

cylindrus minimus, Ch. constrictus, curvisetus and *socialis* decreased by November. Except for the *Nitzschia pacifica* + *pungens* complex, each of the major diatom species attained their maximum abundance during the November survey at stations 14-15 (Table 9). *Ch. compressus* and/or *Skeletonema costatum* f. *tropicum* clearly dominated at those stations where the mean diatom density exceeded 25,000 c/l—stations 11, 13-15 and 24 (Table 9). The communities at the other stations were characterized by the absence of certain species (Table 9; Appendix Table II), and a modest dominance of different species: *Rhizosolenia delicatula* (stations 16, 17), *Ch. laevis* (18), *Nitz. delicatissima* (19, 20), *Ch. compressus* (21, 23) and *Bacteriastrum elegens* (25). Several species co-dominated at station 22 (Table 9). Most of the major diatoms were ubiquitous, although *Bact. hyalinum* var. *princeps* was conspicuously absent at stations 20-25, and *Ch. brevis* at stations 17-23 (Table 9).

Among the coccolithophores, *Gephyrocapsa oceanica* was ubiquitous, whereas *Calciosolenia sinuosa, Coccolithus huxleyi* and *Halopappus adriaticus* were irregularly distributed at stations 17-25 (Table 9). No consistent regional pattern was apparent in the distribution of any of the autotrophic dinoflagellate species (Appendix Table II).

A comparison of the average November phytoplankton standing crops in the upper 10 meters at the permanent station with those observed during the November, 1957 survey is presented in Table 10.

TABLE 10. A Comparison of the Average November Phytoplankton Densities in the Upper 10 Meters at 8°45′N, 79°23′W with Those Observed During the Gulf Survey of 7-8 November, 1957 (in cells/liter).

Stations:	1954, 1956 Permanent	1957 11 - 25	Excluding 14-15
Diatoms	15,740	41,443	16,771
Dinoflagellates	1,710	441	438
Gymnodiniaceae	1,500	1,824	1,366
Coccolithophores	3,650	4,052	3,310
Monads	4,500	1,822	1,800

If the densely populated survey stations 14-15 are omitted in the comparison, the mean diatom abundance at the 13 other stations approximates that at the permanent station. The mean densities of the autotrophic dinoflagellates and monads were somewhat greater at the permanent station, whereas no appreciable differences were observed for the coccolithophores and Gymnodiniaceae.

The November survey data confirm the July observations that the brown dinoflagellates were more important at the permanent station during these months than elsewhere in the Gulf (Tables 5, 10). Furthermore, the November data, together with that of the July survey, indicate that the absence of a succession from a diatom to a dinoflagellate community during the rainy season noted at the permanent station (Smayda, in prep.) is also characteristic of a large part of the Gulf.

The decline in diatoms, Gymnodiniaceae and monads which occurred between July and November at the permanent station (Smayda, in prep.) likewise was observed between the July and November surveys (Tables 5, 10). Unlike at the permanent station, however, the regional coccolithophore importance during the November survey was significantly greater than that during July. The data provide no clue for this behavior.

The surprising fact brought out in the comparison is the failure of the phytoplankton to respond to the seemingly more beneficial growth conditions extant during the November survey than normally encountered at the permanent station at this time of year (Tables 1, 8, 10). Only stations 14-15, characterized by the highest salinities (Figure 8), exhibited exceptional growth. The role of local influences on phytoplankton abun-

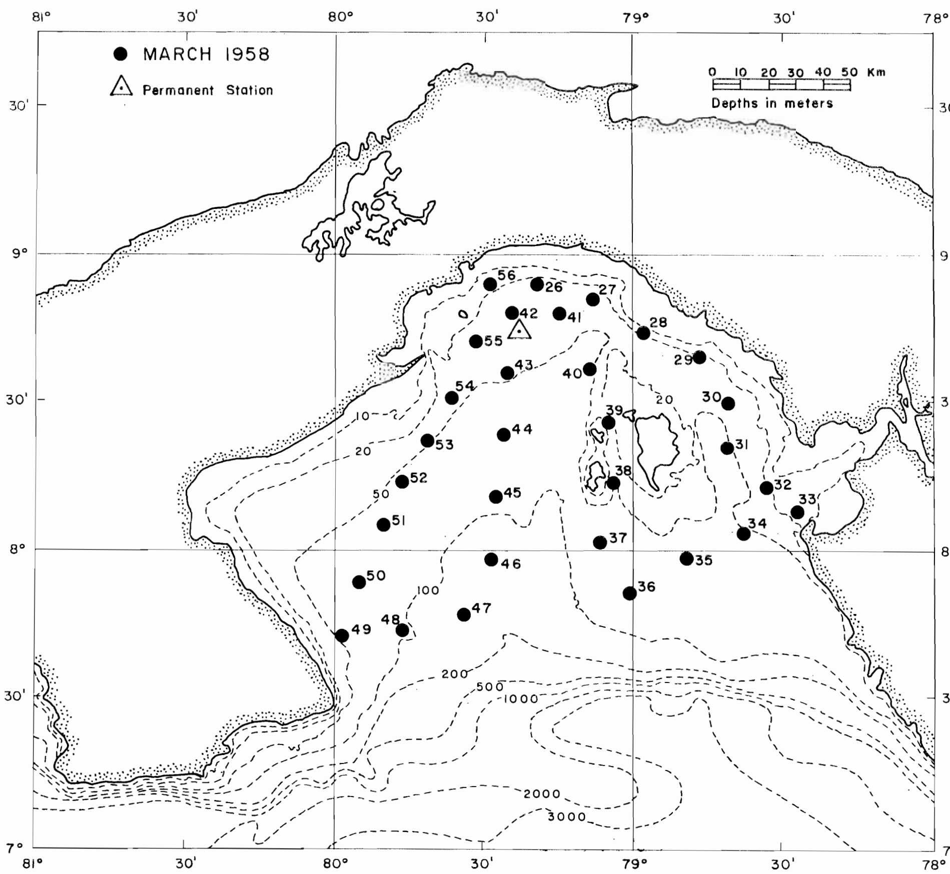

FIGURE 9. Phytoplankton stations during the survey of 18-21 March, 1958.

dance at these two stations, located in the main passage of the Pearl Island archipelago, cannot be assessed from the data at hand.

PHYTOPLANKTON OBSERVATIONS DURING THE SURVEY OF 18-21 MARCH, 1958

Environmental Conditions

Phytoplankton samples were collected from the surface and 10 meters at 31 stations, Stations 26-56 (Figure 9), during a bathythermograph survey from 18-21 March, 1958 comprising 62 stations. Surface-to-bottom temperatures were recorded at all stations (Figures 11-16, Table 11), while surface salinity determinations were made at 31 locations situated near the phytoplankton stations (Figure 10).

TABLE 11. Mean Vertical Temperature Conditions During 18-21 March, 1958 (Bathythermograph Survey No. 10)

Depth (meters):	0	5	10	25	50	75
Temperature (°C):	26.71	26.02	24.62	22.48	19.61	16.58
Observations:	62	62	62	56	35	10
°C Change since November	−1.46	−1.97	−3.19	−3.65	+0.59	+1.27

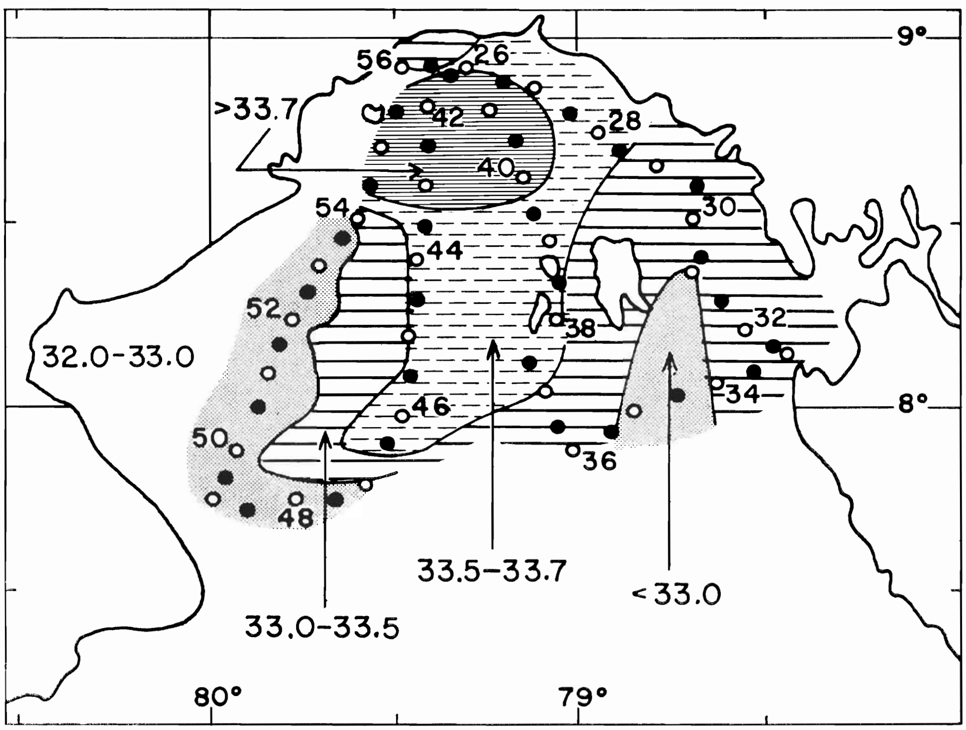

FIGURE 10. Surface salinity distribution during March survey. Filled circles represent stations where salinity determinations were made, and open circles phytoplankton stations.

Upwelling regularly occurs during March (Table 1). This condition is reflected in the approximately 4.0 ‰ rise in mean surface salinity since November to 33.31 ‰ during the March survey, when it ranged from 32.59 to 33.96 ‰ (Figures 6, 10). Similarly, the mean temperatures *declined* since November from approximately 1.5° at the surface to 3.7°C at 25 meters, while the deeper waters became slightly warmed (Table 11). However, the mean temperatures at the surface, 26.71°C, and at 25 meters, 22.48°C, during the March survey were approximately 3° to 5°C higher than during similar bathythermograph surveys in 1955 and 1957. The high surface temperatures also contrast to the 19.4°C observed at the permanent station during mid-March, 1955. Accordingly, *the temperature data suggest that upwelling was not as intense during the March, 1958 survey as that observed previously during this period.*

Secchi Disc measurements made at 23 phytoplankton stations ranged from 5 to 18 meters, with a mean of 9.3 meters. This average transparency is comparable to that present during the November survey.

The temperature distribution at 10 meters exhibits well-defined regional variations which are undoubtedly attributable to differences in upwelling intensity (Figure 11). The surface salinity distribution generally corroborates the upwelling pattern suggested by the thermal conditions (Figure 10). (Since these figures are based on observations made over a span of four days during a hydrographically dynamic period, much significance cannot be attributed to the relative position of a given isotherm or isohaline. The general regional differences in upwelling demonstrated by these figures, however, are undoubtedly real.) Thus, upwelling was most pronounced in the innermost regions, especially at depths shallower than 50 meters, where a relatively *cold*, less than 24°C, *saline*, greater than 33.7 ‰, watermass was generally present (Figures 10-16). Indeed, irrespective of the surface salinity distribution, the temperature data suggest that relatively intense upwelling characterized the entire inner region north of 8°30′N (Figure 11). To the south, a slightly warmer, more dilute watermass occurred in the region overlying the submarine canyon and within the Pearl Island straits (Figures 10, 11). This watermass, in turn, was wedged between the appreciably warmer, more dilute waters characteristic of Parita and San Miguel Bays (Figures 10, 11). The extensive occurrence of the stagnant, dilute watermass in the Parita Bay region west of the 26°C isotherm is especially notable (Figures 10, 11). An upwelling of cold water, less than 24°C, is detectable south of the Pearl Islands at stations 36 and 37 (Figure 11).

The March salinity distribution is similar in certain respects to that observed during the November survey except, excluding the rise in salinity, for the presence of the most saline waters in the innermost region of the Gulf (Figures 6, 10). The observed upwelling pattern suggested by the

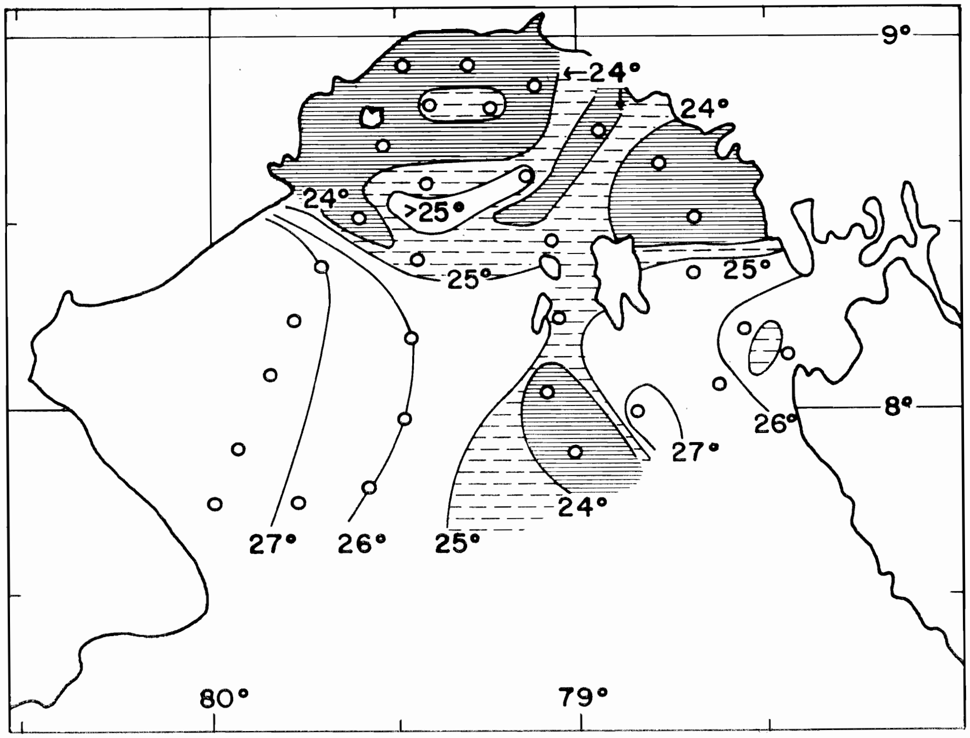

FIGURE 11. Temperature distribution at 10 meters during March survey. Open circles represent phytoplankton stations.

temperature-salinity distribution during the March, 1958 survey conforms, in general, to that predictable on theoretical grounds (Smayda, in prep.). Although nutrient determinations were not made during this survey, higher phosphate levels can be expected to accompany the colder, more saline waters than in those of less intense upwelling (Table 1; Smayda, in prep.).

Phytoplankton Distribution

The vertical oscillations of the 24° and 25°C isotherms in the upper 10 meters from station-to-station have been arbitrarily chosen as an index of relative upwelling intensity to facilitate description and analysis of the regional phytoplankton distribution. The temperature distribution on the track from stations 26-36 (Figure 9) indicates the occurrence of upwelling, of unequal intensity, through station 30 (Figures 9, 12), whereas a very warm, stagnant watermass (27°C) occurred at stations 31 to 35 (Figure 13). (Stations 31 and 32 are biologically transitional between these two watermasses despite their location within the stagnant watermass. Phytoplankton growth and composition at station 31 are related to that in the upwelling zone whereas that at station 32 is representative of the 27°C watermass. Both stations will be referred to as transitional in the text to follow.) This variation in upwelling intensity was accompanied by differences in both phytoplankton abundance and community organization (Tables 12-15):

1. A sparse Pennate community consisting of *Nitzschia closterium, delicatissima, pacifica + pungens, Thalassionema nitzschioides,* and an unidentified Pennate species (either a small *Pleurosigma* or *Gyrosigma* species) characterized station 26 (Table 13). This community persisted at the other stations.

2. A *Chaetoceros* community consisting of *Ch. curvisetus* and cf. *vixvisibilis* predominated at stations 27 and 28 (Table 13).

3. An abundant *Skeletonema costatum* f. *tropicum* stand, and presence of an important *Rhizosolenia* community consisting of *Rh. delicatula, fragilissima, setigera* and *stolterfothii* characterized the intense growth at stations 29-31 (Table 14).

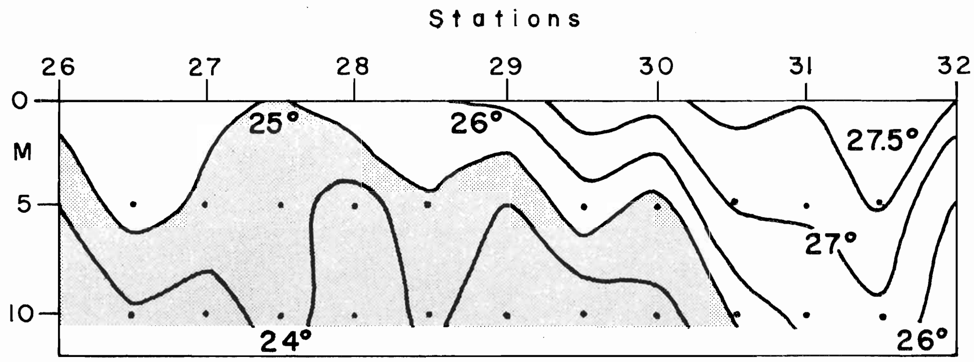

FIGURE 12. Thermal conditions in the upper 10 meters at March survey stations 26-32.

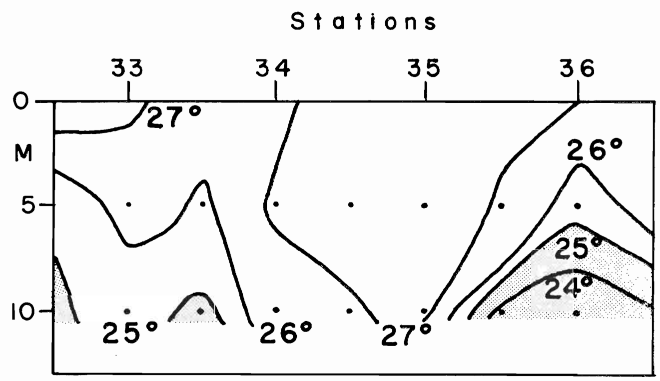

FIGURE 13. Thermal conditions in the upper 10 meters at March survey stations 33-36.

The sudden pre-eminence of the *Skeletonema* + *Rhizosolenia* association at station 29, which remained through station 31, provides biological evidence that the watermass at those stations differs somewhat from that at station 28. On theoretical grounds, it is expected that upwelling in the *region* of stations 29-31 results primarily from an influx *east* of the Pearl Islands within the San Miguel Bay area (Smayda, in prep.). The upwelled waters in the inner regions north of station 29, however, are derived from the watermass flowing northwards *west* of the Pearl Islands within the submarine canyon and, perhaps, through the Pearl Island straits (Figures 1, 9; Smayda, in prep.). Although the temperature differences are slight, the data indicate the presence of a watermass warmer by 1.3° to 1.5°C in the upper 10 meters between stations 28 and 29 (sampled the same day), suggesting the anticipated incursion of *two* watermasses in this region (Figures 11, 12).

The presence of the littoral diatom *Melosira moniliformis* in appreciable densities at stations 26-31, accompanied by an abundance of terrigenous material in the samples, suggests that a roiling of the bottom accompanied upwelling in this region (Appendix Table III). This stirring can be expected to augment the nutrient supplies through a release of inorganic phosphate from the sediments (Jayaraman and Seshappa, 1957).

TABLE 12. Population Densities at Stations 26-36; 18-19 March, 1958. (cells/liter; n.d. = no data).

STATION AND DEPTH (m)	DIATOMS	GYMNO-DINIACEAE	DINO-FLAGELLATES	COCCO-LITHOPHORES	MONADS
26— 0	72,500	—	20	2,020	13,500
—10	n. d.	n. d.	n. d.	n. d.	n. d.
27— 0	n. d.	n. d.	n. d.	n. d.	n. d.
—10	54,700	3,000	100	—	10,020
28— 0	130,940	500	280	500	3,000
—10	341,220	—	40	500	4,000
29— 0	832,500	—	40	3,500	7,500
—10	674,760	—	40	500	9,000
30— 0	576,500	30,000	3,820	10,000	55,000
—10	368,520	10,000	1,600	2,000	76,000
31— 0	275,000	5,500	1,280	15,000	7,500
—10	n. d.	n. d.	n. d.	n. d.	n. d.
32— 0	117,080	7,500	620	1,000	5,000
—10	81,400	1,000	1,560	3,000	6,000
33— 0	35,340	7,000	7,880	4,500	8,500
—10	34,140	1,000	1,040	1,040	5,500
34— 0	4,540	3,000	1,040	—	19,500
—10	9,840	4,500	520	4,020	3,500
35— 0	4,740	3,000	1,040	2,000	4,000
—10	6,140	4,000	620	3,040	13,500
36— 0	700	3,000	1,080	5,500	6,000
—10	1,200	10,500	120	4,040	21,500

TABLE 13.

Station	26[a)]	27[b)]	28	
Date		18 March 1958		
Depth (meters)	0	10	0	10
°C	25.8	25.1	25.8	23.1
DIATOMS (cells/liter)	72,500	54,700	130,940	341,220
DINOFLAGELLATES	20	3,100	780	40
COCCOLITHOPHORES	2,020	—	500	500
MONADS	13,500	10,020	3,000	4,000
TOTAL	88,040	67,820	135,220	345,760
CHAETOCEROS SPP.	+	43,040 78.8%	35,740 27.3%	157,740 46.2%
—cf. vixvisibilis	—	33,000	23,500	124,000
—curvisetus	+	10,040	12,000	33,500
PENNATE SPP.	68,600 94.6%	8,000 14.6%	60,300 46.1%	106,500 31.2%
Nitz. closterium	12,500	+	8,500	8,000
—delicatissima	2,500	2,000	—	21,000
—pacifica + pungens	19,000	2,500	8,000	16,000
Pennate sp.	33,000	2,500	9,500	20,000
Thal. nitzschioides	—	1,000	33,500	41,000
Skel. costatum f. tropicum	1,500 2.1%	1,620 3.0%	24,500 18.7%	61,500 18.0%

Data lacking from a). 10 meters, and b). surface; + = less than 500 cells/liter.

The transition into the stagnant 27°C watermass was accompanied by a pronounced decline in diatom abundance at stations 32-35 (Table 12), and renewed predominance of the Pennate facies, especially *Nitz. delicatissima,* which comprised from 70 to 95 per cent of the diatom population (Tables 15, 16). The *Chaetoceros* — *Skeletonema* — *Rhizosolenia* communities were either very sparse or absent within this watermass.

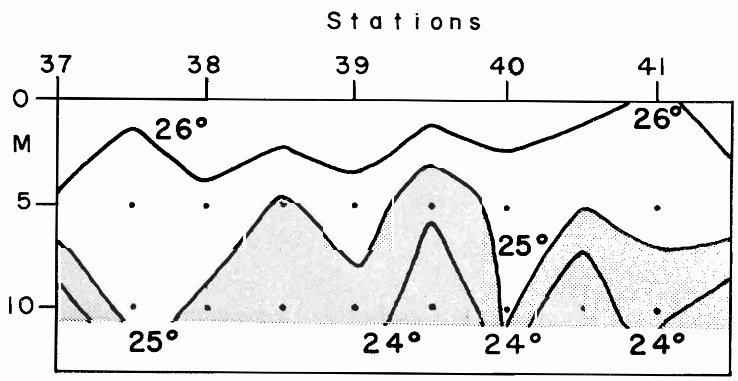

FIGURE 14. Thermal conditions in the upper 10 meters at March survey stations 37-41.

The anomalous occurrence of a meager, Pennate-dominated community, despite the presence of 24°C water, characterized station 36 (Figure 13, Table 12). The thermal conditions suggest that the phytoplankton-impoverished watermass at station 36 was primarily flowing northwards, rather than upwelling at this station, where it then upwelled at stations 37-41 (Figures 9, 13, 14). However, this does not adequately explain the lack of phytoplankton growth at station 36. A precipitous increase in

TABLE 14.

Station	29				30				31[a]	
Date			18 March 1958							
Depth (meters)	0		10		0		10		0	
°C	26.0		23.1		27.3		23.6		27.5	
DIATOMS (cells/liter)	832,500		674,600		576,500		368,520		275,000	
DINO-FLAGELLATES	40		40		33,820		11,600		6,780	
COCCO-LITHOPHORES	3,500		500		10,000		2,000		15,000	
MONADS	7,500		9,000		55,000		76,000		7,500	
TOTAL	843,540		684,140		675,320		458,120		304,280	
CHAETOCEROS	139,960	16.8%	154,740	23.0%	45,380	7.9%	49,000	13.4%	25,300	9.5%
—cf. vixvisibilis	56,000		123,000		—		2,000		—	
—curvisetus	71,000		30,500		8,500		23,500		1,000	
PENNATE	167,500	20.2%	198,000	28.1%	42,780	7.4%	61,080	16.6%	41,500	15.1%
Nitz. closterium	41,000		51,000		9,000		34,000		3,500	
—delicatissima	18,000		36,000		—		4,000		5,500	
—pacifica + pungens	58,000		46,000		16,000		17,000		11,500	
Thal. nitzschioides	20,500		41,000		13,500		5,000		21,000	
Pennate sp.	30,000		22,000		3,000		—		—	
RHIZOSOLENIA	161,000	19.3%	69,500	10.3%	279,860	48.5%	120,120	32.6%	141,560	51.4%
—delicatula	126,000		33,000		181,000		87,000		55,500	
—fragilissima	4,000		3,500		39,000		5,000		2,500	
—setigera	11,500		12,500		32,000		4,500		8,000	
—stolterfothii	19,500		20,500		27,000		23,500		75,000	
Skel. costatum f. tropicum	206,000	24.7%	152,000	22.5%	99,500	17.3%	85,000	23.1%	34,000	12.4%
Eucampia cornuta	43,000		47,500		13,500		9,500		7,000	
Cerataulina bergonii	37,000		11,500		58,000		4,500		18,000	
Lept. minimus	37,000		—		—		—		—	
Thal. aestivalis	32,000		31,000		—		—		—	

a). No data from 10 meters

TABLE 15.

Station	32				33			
Date			18 March 1958					
Depth (meters)	0		10		0		10	
°C	27.5		25.3		27.2		25.5	
DIATOMS (cells/liter)	117,080		81,400		35,340		34,140	
DINOFLAGELLATES	8,120		2,560		14,880		2,040	
COCCOLITHOPHORES	1,000		3,000		4,500		1,040	
MONADS	5,000		6,000		8,500		5,500	
TOTAL	131,200		92,960		63,220		42,720	
CHAETOCEROS SPP.	29,620	25.3%	3,280	4.0%	14,500	41.0%	7,200	20.5%
—cf. vixvisibilis	28,500		3,000		14,500		7,000	
PENNATE SPP.	68,000	58.1%	72,200	88.7%	18,580	52.6%	25,740	75.4%
Nitz. delicatissima	40,000		61,500		11,000		17,500	
Thal. nitzschioides	20,500		+		+		+	
RHIZOSOLENIA SPP.	2,060	1.8%	2,240	2.8%	1,500	4.2%	+	
Skel. costatum f. tropicum	14,000	12.0%	3,160	3.9%	+		+	

diatom abundance and change in community organization accompanied upwelling at station 37 which persisted through station 41 (Tables 12, 16-19). The *Skeletonema* + *Rhiz. delicatula* association generally dominated, although *Ch. decipiens* and the Pennate community were important at certain stations. A slight subsidence in upwelling at stations 40 and 41 was accompanied by a decline in diatom abundance (Figure 14, Tables 16, 19). The community at station 40, where *Ch.* cf. *vixvisibilis* and *Skel. costatum* f. *tropicum* predominated, is clearly related to that at stations 28-31 (Tables 13, 14, 19).

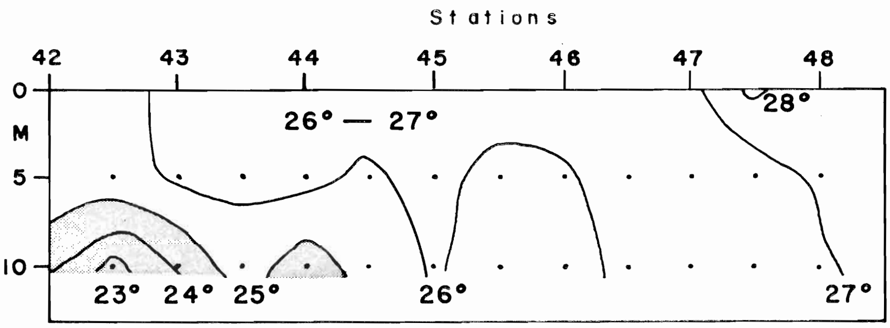

FIGURE 15. Thermal conditions in the upper 10 meters at March survey stations 42-48.

TABLE 16. Population Densities at Stations 37-47; 19-20 March, 1958. (cells/liter).

STATION AND DEPTH (m)	DIATOMS	GYMNO-DINIACEAE	DINO-FLAGELLATES	COCCO-LITHOPHORES	MONADS
37— 0	632,800	1,000	1,440	15,000	2,000
—10	886,840	6,000	3,360	8,000	21,000
38— 0	801,120	2,000	14,620	3,000	14,000
—10	1,409,320	1,000	120	2,000	40,000
39— 0	684,800	5,000	3,440	3,000	32,000
—10	1,162,760	3,000	1,640	7,000	16,000
40— 0	445,480	2,000	8,160	—	3,000
—10	765,520	2,000	680	8,000	13,000
41— 0	259,460	3,000	1,240	2,000	10,000
—10	480,680	3,000	1,240	5,000	8,000
42— 0	232,120	—	40	1,000	4,000
—10	293,800	2,000	1,480	10,000	13,000
43— 0	322,640	—	160	—	2,000
—10	141,360	3,000	1,000	5,000	20,000
44— 0	232,040	—	880	4,000	9,000
—10	266,360	1,000	1,320	5,000	7,000
45— 0	32,560	—	1,640	10,000	5,500
—10	211,900	—	1,240	10,000	15,000
46— 0	586,800	2,000	3,520	3,000	6,000
—10	670,320	—	1,440	7,000	6,000
47— 0	383,800	—	7,280	9,000	7,000
—10	527,080	—	400	8,000	5,000

The relative upwelling intensity observed at station 41 persisted at stations 42 and 43 (Figures 13, 14). However, the watermass in the region overlying the submarine canyon south to station 47 was appreciably warmer, indicating that upwelling was not as intense in the upper 10 meters, if occurring, as at stations 26-30 and 37-41 (Figures 12, 14, 15). Nonetheless, an abundant phytoplankton population dominated by ***Rhiz. delicatula*** occurred at stations 42-47 (Tables 20-22), generally exceeding that at stations 26-31 (Tables 12, 16). Growth was especially intense at stations 46 and 47 where ***Cerataulina bergonii*** and ***Eucampia cornuta*** comprised 10 to 20 per cent of the diatom population. The community at these stations was related to that at station 37 (Tables 17, 22, Appendix Tables III, IV). The temperature data provide no clue for the exceptional growth at stations 44-47.

A greatly reduced population accompanied the presence of 27°C water at stations 48-52 (Figures 9, 15, 16, Table 23). As at stations 32-35, the Pennate community predominated within this stagnant watermass.

TABLE 17.

Station	**37**			
Date	**19 March 1958**			
Depth (meters)	**0**		**10**	
°C	**26.7**		**23.5**	
DIATOMS (cells/liter)	632,800		886,840	
DINOFLAGELLATES	2,440		9,360	
COCCOLITHOPHORES	15,000		8,000	
MONADS	2,000		21,000	
TOTAL	652,240		925,200	
CHAETOCEROS SPP.	172,040	27.2%	226,080	25.5%
—affinis	55,000		8,000	
—brevis	5,500		39,000	
—costatus	28,000		61,000	
—constrictus	10,000		—	
—curvisetus	5,000		30,000	
—decipiens	24,500		60,000	
PENNATE SPP.	120,500	19.0%	157,000	17.3%
Nitz. closterium	23,000		64,000	
—delicatissima	44,000		64,000	
—pacifica + pungens	48,000		24,000	
Pennate sp.	4,000		15,000	
RHIZOSOLENIA SPP.	182,280	28.8%	322,640	36.4%
—delicatula	128,000		220,000	
—fragilissima	18,000		17,000	
—setigera	11,000		12,000	
—stolterfothii	25,000		73,000	
Skel. costatum f. tropicum	98,000	15.5%	114,000	12.9%

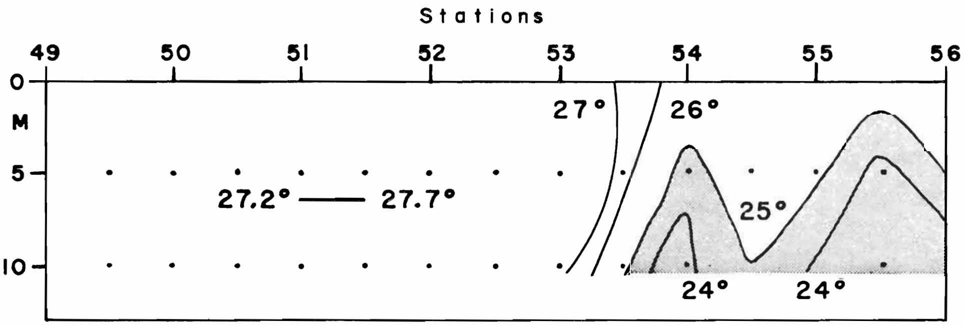

FIGURE 16. Thermal conditions in the upper 10 meters at March survey stations 49-56.

TABLE 18.

Station	**38**				**39**			
Date	**19 March 1958**							
Depth (meters)	**0**		**10**		**0**		**10**	
°C	**26.7**		**24.7**		**26.9**		**24.6**	
DIATOMS (cells/liter)	801,120		1,409,320		684,800		1,162,760	
DINOFLAGELLATES	16,620		1,120		8,440		4,640	
COCCOLITHOPHORES	3,000		2,000		3,000		7,000	
MONADS	14,000		40,000		32,000		16,000	
TOTAL	834,740		1,452,440		728,240		1,190,400	
CHAETOCEROS SPP.	355,680	44.4%	708,440	50.3%	150,160	21.9%	551,320	47.4%
—affinis	32,000		49,000		48,000		18,000	
—brevis	15,000		62,000		27,000		28,000	
—compressus	20,000		34,000		1,000		84,000	
—costatus	37,000		61,000		—		45,000	
—curvisetus	2,600		63,000		22,000		31,000	
—decipiens	190,000		227,000		21,000		135,000	
—didymus	7,000		61,000		3,000		53,000	
—laciniosus	7,000		31,000		—		20,000	
—lorenzianus	10,000		24,000		10,000		25,000	
—socialis	—		—		—		25,000	
—subsecundus	12,000		5,000		2,000		—	
PENNATE SPP.	286,000	35.7%	375,000	26.6%	203,000	29.7%	285,000	24.5%
Nitz. closterium	94,000		205,000		27,000		82,000	
—delicatissima	34,000		28,000		37,000		25,000	
—pacifica + pungens	114,000		88,000		65,000		80,000	
Pennate sp.	23,000		21,000		40,000		60,000	
Thal. nitzschioides	21,000		33,000		34,000		38,000	
RHIZOSOLENIA SPP.	127,120	15.9%	195,320	13.9%	200,200	29.2%	229,440	19.7%
—delicatula	77,000		130,000		145,000		134,000	
—fragilissima	12,000		1,000		1,000		—	
—setigera	9,000		9,000		18,000		22,000	
—stolterfothii	29,000		55,000		36,000		73,000	
Skel. costatum f. tropicum	1,640	.3%	25,000	1.8%	71,000	10.4%	80,000	6.9%
Cerataulina bergonii	6,000		57,000		21,000		3,000	
Eucampia cornuta	2,040		27,000		25,000		2,080	

TABLE 19.

Station	40				41			
Date	19 March 1958							
Depth (meters)	0		10		0		10	
°C	26.6		25.1		25.9		24.2	
DIATOMS (cells/liter)	445,480		765,520		259,460		480,680	
DINOFLAGELLATES	10,160		2,680		4,240		4,240	
COCCOLITHOPHORES	—		8,000		2,000		5,000	
MONADS	3,000		13,000		10,000		8,000	
TOTAL	458,640		789,200		275,700		497,920	
CHAETOCEROS SPP.	109,040	24.5%	310,160	40.5%	83,760	32.3%	133,440	27.8%
—affinis	14,000		6,000		+		10,000	
—brevis	22,000		15,000		+		17,000	
—compressus	1,000		20,000		16,000		15,000	
—constrictus	—		—		—		13,000	
—costatus	—		5,000		8,000		10,000	
—curvisetus	18,000		55,000		22,000		28,000	
—decipiens	15,000		+		+		6,000	
—laciniosus	—		22,000		6,000		—	
—lorenzianus	5,000		13,000		+		—	
—cf. vixvisibilis	—		137,000		5,000		22,000	
PENNATE SPP.	115,320	25.9%	138,080	18.0%	60,520	23.3%	137,000	28.5%
Nitz. closterium	6,000		13,000		5,000		10,000	
—delicatissima	36,000		61,000		25,000		46,000	
—pacifica + pungens	50,000		45,000		23,000		27,000	
Pennate sp.	14,000		7,000		7,000		7,000	
Thal. nitzschioides	2,320		5,080		+		47,000	
RHIZOSOLENIA SPP.	99,360	22.3%	121,400	15.9%	48,520	18.7%	131,720	27.4%
—delicatula	64,000		80,000		31,000		65,000	
—fragilissima	+		+		+		34,000	
—setigera	11,000		12,000		+		+	
—stolterfothii	23,000		28,000		16,000		32,000	
Skel. costatum f. tropicum	96,000	21.5%	155,000	20.2%	56,000	21.6%	70,000	14.6%

A notable increase in diatom abundance accompanied pronounced upwelling at stations 54-56 (Figure 16, Tables 23-25, Appendix Table V). ***Skeletonema*** dominated at stations 54 and 55, accompanied by rudimentary ***Chaetoceros, Rhizosolenia*** and Pennate communities (Table 24). The abundance of ***Biddulphia longicruris*** at the former station is noteworthy (Appendix Table V). An enormous development of ***Ch. curvisetus*** characterized station 56, unlike at stations 54 and 55 (Tables 24, 25). This indicates that, as with upwelling, biological differences occur between nearby stations (Figure 11, 14, 16).

TABLE 20.

Station	42				43			
Date	20 March 1958							
Depth (meters)	0		10		0		10	
°C	25.9		24.2		26.1		24.2	
DIATOMS (cells/liter)	232,120		293,800		322,640		141,360	
DINOFLAGELLATES	40		3,480		160		4,000	
COCCOLITHOPHORES	1,000		10,000		—		5,000	
MONADS	4,000		13,000		2,000		20,000	
TOTAL	237,160		320,280		324,800		170,360	
CHAETOCEROS SPP.	13,840	6.0%	42,280	14.4%	52,200	16.2%	12,760	9.0%
—affinis	+		+		17,000		2,440	
—brevis	—		—		11,000		+	
—curvisetus	9,000		10,400		14,000		2,560	
—cf. vixvisibilis	3,000		3,000		—		4,000	
PENNATE SPP.	33,200	14.3%	72,560	24.7%	45,000	14.0%	27,000	19.1%
Nitz. closterium	1,000		11,000		2,000		8,000	
—delicatissima	9,000		34,000		25,000		10,000	
—pacifica + pungens	19,000		10,000		18,000		9,000	
Pennate sp.	2,000		15,000		—		—	
Thal. nitzschioides	2,200		2,560		—		+	
RHIZOSOLENIA SPP.	87,800	37.8%	98,840	33.6%	189,200	58.6%	92,240	65.3%
—delicatula	68,000		78,000		109,000		63,000	
—fragilissima	8,000		6,000		6,000		2,200	
—stolterfothii	11,000		14,000		68,000		26,000	
Skel. costatum f. tropicum	94,000	40.5%	67,000	22.8%	36,000	11.2%	3,360	2.4%

TABLE 21.

Station	44				45			
Date	20 March 1958							
Depth (meters)	0		10		0		10	
°C	26.6		24.4		26.9		26.1	
DIATOMS (cells/liter)	232,040		266,360		32,560		211,900	
DINOFLAGELLATES	880		2,320		1,640		1,240	
COCCOLITHOPHORES	4,000		5,000		10,000		10,000	
MONADS	9,000		7,000		5,500		15,000	
TOTAL	245,920		280,680		49,700		238,140	
CHAETOCEROS SPP.	21,960	9.5%	11,320	4.2%	10,240	31.4%	70,340	33.2%
—curvisetus	12,560		6,560		5,360		56,000	
PENNATE SPP.	37,000	16.0%	46,000	17.3%	6,500	19.9%	37,000	17.5%
Nitz. closterium	9,000		8,000		2,000		23,000	
—delicatissima	6,000		14,000		1,500		12,000	
—pacifica + pungens	13,000		23,000		2,000		2,000	
Pennate sp.	9,000		1,000		1,000		—	
RHIZOSOLENIA SPP.	103,520	44.6%	168,200	63.1%	3,540	10.8%	81,440	38.4%
—delicatula	59,000		118,000		1,200		38,000	
—stolterfothii	38,000		38,000		1,600		40,000	
Skel. costatum f. tropicum	63,000	27.2%	36,000	13.5%	9,000	27.6%	14,000	6.6%

TABLE 22.

Station	46		47	
Date	20 March 1958			
Depth (meters)	0	10	0	10
°C	26.6	25.8	26.8	26.0
DIATOMS (cells/liter)	586,800	670,320	383,800	527,080
DINOFLAGELLATES	5,520	1,440	7,280	400
COCCOLITHOPHORES	3,000	7,000	9,000	8,000
MONADS	6,000	6,000	7,000	5,000
TOTAL	601,320	684,760	407,080	540,480
CHAETOCEROS SPP.	218,160 37.2%	243,440 36.3%	94,000 24.5%	146,000 27.7%
—affinis	64,000	24,000	21,000	24,000
—brevis	47,000	73,000	31,000	32,000
—compressus	25,000	27,000	—	—
—cf. constrictus	—	31,000	—	—
—costatus	—	27,000	4,000	2,000
—lorenzianus	26,000	13,000	14,000	19,000
—cf. vixvisibilis	—	24,000	5,000	51,000
PENNATE SPP.	91,000 15.5%	67,000 10.0%	46,000 12.0%	38,000 7.2%
Nitz. delicatissima	44,000	28,000	9,000	12,000
—pacifica + pungens	36,000	29,000	31,000	19,000
RHIZOSOLENIA SPP.	149,000 25.4%	222,280 33.2%	159,240 41.5%	209,160 39.7%
—delicatula	52,000	102,000	86,000	112,000
—fragilissima	48,000	46,000	44,000	56,000
—setigera	19,000	21,000	13,000	12,000
—stolterfothii	30,000	53,000	16,000	29,000
Skel. costatum f. tropicum	40,000 6.8%	25,000 3.7%	17,000 4.4%	15,000 2.8%
Cerataulina bergonii	39,000	41,000	23,000	38,000
Eucampia cornuta	33,000	29,000	22,000	70,000

TABLE 23. Population Densities at Stations 48-56; 20-21 March, 1958. (cells/liter; n.d. = no data).

STATION AND DEPTH (m)	DIATOMS	GYMNO-DINIACEAE	DINO-FLAGELLATES	COCCO-LITHOPHORES	MONADS
48— 0	4,120	500	80	2,000	2,000
—10	12,060	—	—	2,000	3,000
49— 0	n. d.	n. d.	n. d.	n. d.	n. d.
—10	2,300	—	520	3,500	2,500
50— 0	1,260	—	—	6,000	3,000
—10	1,680	—	520	3,000	12,500
51— 0	2,520	—	—	1,000	4,000
—10	2,140	—	—	2,500	6,000
52— 0	680	—	520	1,000	9,500
—10	1,100	—	540	1,000	6,000
53— 0	8,220	—	—	6,000	3,500
—10	63,880	500	2,500	4,500	9,500
54— 0	503,360	1,500	1,500	4,500	24,500
—10	1,321,800	1,500	—	7,500	14,000
55— 0	227,440	1,000	1,660	6,000	18,500
—10	221,980	2,000	280	9,000	10,500
56— 0	338,260	—	240	3,500	1,000
—10	1,602,100	1,000	480	5,000	70,000

TABLE 24.

Station	54				55			
Date	21 March 1958							
Depth (meters)	0		10		0		10	
°C	25.5		22.9		25.4		23.9	
DIATOMS (cells/liter)	503,360		1,321,800		227,400		221,980	
DINOFLAGELLATES	3,000		1,500		2,660		2,280	
COCCOLITHOPHORES	4,500		7,500		6,000		9,000	
MONADS	24,500		14,000		18,500		10,500	
TOTAL	535,360		1,344,800		254,560		243,760	
CHAETOCEROS SPP.	49,440	9.8%	109,500	8.3%	9,440	4.1%	48,900	22.0%
—costatus	—		15,500		+		+	
—curvisetus	30,000		46,500		3,840		45,000	
PENNATE SPP.	45,500	9.0%	52,500	4.0%	22,000	9.7%	16,580	7.5%
Nitz. closterium	12,000		23,500		5,000		8,500	
—delicatissima	7,000		7,500		6,500		5,500	
—pacifica + pungens	25,000		21,500		9,000		1,080	
RHIZOSOLENIA SPP.	36,000	7.2%	34,820	2.6%	87,080	38.3%	26,580	12.0%
—delicatula	23,000		20,500		62,000		10,500	
—stolterfothii	6,000		6,000		19,000		11,500	
Skel. costatum f. tropicum	327,000	65.0%	1,084,000	82.0%	103,000	45.3%	102,500	46.2%

TABLE 25.

Station	56			
Date	21 March 1958			
Depth (meters)	0		10	
°C	25.2		23.2	
DIATOMS (cells/liter)	338,260		1,602,100	
DINOFLAGELLATES	240		1,480	
COCCOLITHOPHORES	3,500		5,000	
MONADS	1,000		70,000	
TOTAL	343,000		1,678,580	
CHAETOCEROS SPP.	78,100	23.1%	1,117,960	69.8%
—curvisetus	72,000		1,055,000	
PENNATE SPP.	35,500	10.5%	63,000	3.9%
Nitz. closterium	12,000		25,000	
—pacifica + pungens	13,000		35,000	
RHIZOSOLENIA SPP.	128,500	38.1%	201,560	12.6%
—delicatula	97,000		75,000	
—setigera	6,500		21,000	
—stolterfothii	19,000		105,000	
Skel. costatum f. tropicum	91,000	26.9%	110,000	6.9%
Thal. subtilis	—		43,000	

TABLE 26.

Maximum Abundance of the Major Diatoms at March Stations.
(cells/10 ml.; + = less than 5 cells/10 ml.; * sample from one depth only)

SPECIES	STATIONS																													
	26*	27*	28	29	30	31*	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49*	50	51	52	53	54	55	56
Cer. bergonii	+	+	17	370	580	180	+	+	—	—	—	400	570	210	70	15	+	5	+	5	410	380	35	+	—	—	—	+	60	40	390
Ch. affinis	—	—	—	7	28	95	+	—	—	—	—	550	490	480	140	100	6	170	10	22	640	240	+	—	—	—	—	+	40	+	+
brevis	—	—	—	+	75	60	—	—	—	—	—	390	620	280	220	170	—	110	+	16	730	320	+	—	—	—	—	+	10	15	8
compressus	—	—	—	—	130	30	—	—	—	+	—	90	340	840	200	160	—	16	20	8	270	—	—	—	—	—	—	+	90	+	17
costatus	—	—	—	—	95	—	—	—	—	—	—	610	610	450	50	100	—	+	—	+	270	50	—	—	—	—	—	—	155	+	170
curvisetus	+	100	335	710	235	10	—	—	—	—	—	300	630	310	550	280	104	140	126	560	180	40	—	—	—	—	—	8	465	450	10550
decipiens	—	—	—	+	+	20	+	+	—	—	—	600	2270	1350	240	60	+	6	32	+	20	—	—	—	—	—	—	+	90	+	+
lorenzianus	—	—	+	+	28	25	—	—	—	—	—	75	240	250	130	+	6	6	17	17	260	190	—	+	+	—	—	+	65	7	+
cf. vixvisibilis	—	330	1240	1230	20	—	285	145	25	—	—	30	—	90	1370	220	300	40	—	60	240	510	—	—	—	—	—	—	—	30	—
Euc. cornuta	+	7	475	425	45	—	—	—	—	—	—	150	270	250	32	7	10	20	9	11	330	700	—	—	—	—	—	+	55	25	55
Nitz. closterium	125	+	85	510	340	35	80	65	20	20	+	640	2050	820	130	100	110	80	90	230	60	50	25	15	15	10	10	25	235	85	210
delicatissima	25	20	210	360	40	55	615	175	75	25	10	440	340	370	610	460	340	250	140	120	440	120	15	—	+	15	—	30	75	65	45
pacifica + pungens	190	25	160	580	170	115	20	65	+	15	+	650	1140	800	500	270	190	180	230	20	360	310	+	+	+	—	+	55	250	90	350
Pennate sp.	330	25	200	300	30	—	10	15	—	5	—	150	230	600	210	—	—	—	70	10	—	—	—	—	—	—	—	—	15	15	30
Rh. delicatula	+	+	10	1260	1810	555	20	15	—	—	—	2200	1300	1450	800	650	780	1090	1180	380	1020	1120	+	—	—	—	+	45	230	620	970
fragilissima	—	+	+	40	390	25	+	—	—	—	+	180	120	10	9	340	80	60	24	28	480	560	—	—	—	—	—	+	+	50	60
setigera	+	+	6	125	320	80	+	—	—	+	—	120	90	220	120	5	7	60	110	+	210	130	+	—	+	—	+	+	80	10	210
stolterfothii	+	+	90	205	270	750	+	+	—	—	—	730	550	730	280	320	140	680	380	400	530	290	—	+	+	—	+	+	60	190	1050
Skel. costatum f. tropicum	15	16	615	2060	995	340	140	+	—	+	+	1140	250	800	1550	660	880	360	630	190	400	150	+	—	—	—	—	270	10840	1030	1050
Thal. nitzschioides	16	10	410	410	135	210	205	+	+	+	—	40	330	380	50	470	26	5	13	+	90	—	+	—	—	—	—	+	175	200	45

Stage of Phytoplankton Succession

The striking dominance of the Pennate community at the impoverished stations 32-36 and 48-53 located in the 27°C watermass is demonstrated in the regional distribution of the major diatom species summarized in Table 26. Actually, the abundance of the Pennate species in this watermass is lower, in general, than that attained by them at the other stations. This suggests that their predominance in 27°C water is attributable to a greater tolerance to such adverse environmental conditions than that possessed by the sparse, or absent, *Chaetoceros* and *Skeletonema* + *Rhizosolenia* communities. The more heterogeneous and abundant diatom standing crops at stations 31 and 53 reflect their transitional location between the stagnant 27°C watermass and a more fertile, upwelled one (Figures 9, 12, 16). Otherwise, the regional uniformity in species composition, as during the July and November surveys, is remarkable (Tables 3, 9, 26, Appendix Tables I-V). Excluding the 27°C stations, *Rhiz. delicatula* was the primary or secondary dominant at 80 per cent of the stations, while *Skel. costatum* f. *tropicum* attained similar importance at 60 per cent of the stations (Table 26). Local influences upon growth, aside from upwelling, are probably manifested at stations 37-39 where *Ch. decipiens* and *Nitz. closterium* were important, and at station 56 where *Ch. curvisetus* dominated. The *Rhizosolenia* + *Skeletonema* association, however, persisted as secondary dominants at these stations as well.

The great importance of *Skeletonema* so late during the upwelling season contrasts with its behavior at the permanent station during 1955-1957 where it predominated during December and January along with *Ch. compressus* to characterize the Stage I upwelling community (Smayda, in prep.). A varied *Bacteriastrum* and *Chaetoceros* component comprised the subsidiary species during this stage which evolved into a Stage II community, dominated by *Rh. delicatula* and, occasionally, *Eucampia cornuta* during February. A Stage III community appeared during March dominated, in part, by *Nitz. closterium.*

The maximum March abundance recorded for *Skeletonema* at the permanent station was 3,500 c/l. The relative sparsity of *Ch. compressus* during the March 1958 survey, except for stations 38 and 39 where a modified Stage I community exists (Table 18), is notable. These observations, coupled with an insignificant *Bacteriastrum* component, an abundant *Rh. delicatula* stand, and a significant *Nitz. delicatissima* response, suggest that the general community organization during the March 1958 survey represented an early Stage II community, notwithstanding the abundance of *Skeletonema.* This suggests that *succession during the 1958 upwelling season was retarded from three to five weeks relative to that observed at the permanent station during 1955-1957.* The delayed succession might be attributable to the observation that upwelling winds were "considerably weaker" than usual during March, 1958 following an unusually warm February (Anonymous, 1958). These meteorological conditions would also explain the 3° to 5°C higher temperatures noted in the upper 25 meters during the March 1958 survey relative to previous years.

The considerable importance of *Cerataulina bergonii, Rhiz. fragilissima, setigera* and *Thalassionema nitzschioides* during March 1958 contrasts with their relative insignificance at the permanent station.

The foregoing discussion stressed the diatom dynamics observed during the March survey for, as during the July and November surveys, this group overwhelmingly dominated the phytoplankton (Tables 4, 8, 10, 12, 16, 23, 28). For this reason, the relative phytoplankton growth during the surveys has been primarily gauged from the diatom abundance and response to environmental factors. Of the other components, the coccolithophores, dominated by *Coccolithus huxleyi* and *Gephyrocapsa oceanica*, exhibited only minor regional variations in composition and abundance (Tables 12, 16, 23, Appendix Tables III-V). The Gymnodiniaceae, as during the July survey, attained maximum densities at stations 30-37 located in the proximity of San Miguel Bay (Figure 9, Tables 4, 12, 16). The autotrophic dinoflagellates, in general, attained slightly greater concentrations in the Pearl Island perimeter, being characterized otherwise by the relative unimportance of *Exuviaella baltica,* unlike at the permanent station or July survey (Tables 4, 12, 16, Appendix Tables I-V). Both dinoflagellate groups were conspicuously sparse in the stagnant 27°C watermass near Parita Bay (Table 23).

Analysis of Phytoplankton Growth During March

The station-to-station fluctuations in diatom abundance described earlier frequently paralleled changes in upwelling intensity. The general association between upwelling and diatom growth is clearly illustrated in their regional variations encountered during the March survey (Figure 17). Maximum diatom growth occurred in those regions where the lowest temperatures obtained, especially below 25°C. Comparison with the surface salinity distribution reveals that the regions of maximum diatom response were generally the most saline, i.e. above 33.5‰ (Figures 10, 17). The conspicuous paucity of plankton in the warm, dilute waters in the offing of Parita and San Miguel Bays is well-defined. Accordingly, the regional patterns in distribution of temperature, salinity and diatom abundance during March indicate that 1) the regional differences in diatom abundance can be attributed to variations in upwelling intensity, and 2) the inner reaches of the Gulf of Panama were the most productive during the March survey, as during the July and November surveys.

A more quantitative evaluation of upwelling has been facilitated by computing semi-logarithmic linear regressions by the least square method of mean diatom abundance in the upper 10 meters on temperature, salinity and Secchi Disc observations (Figures 18-21, Table 27). A well-defined

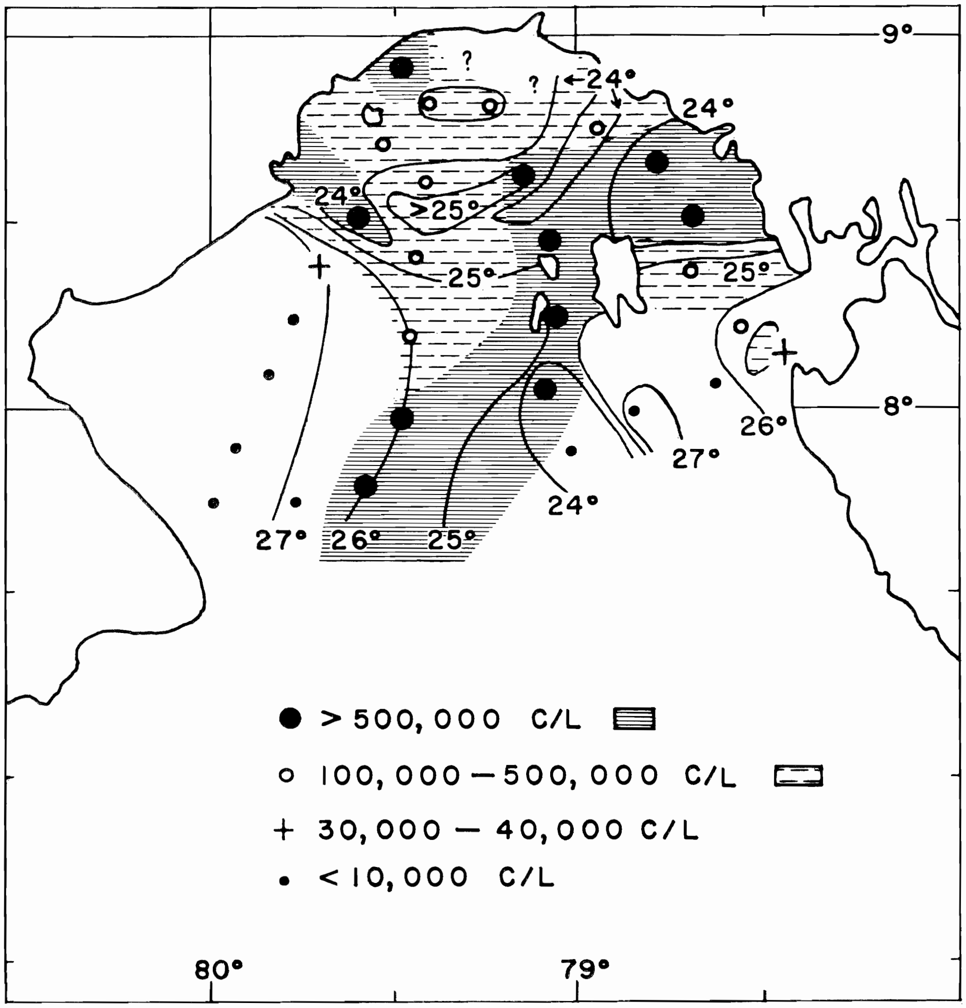

FIGURE 17. **The regional distribution of mean diatom abundance in the upper 10 meters, and thermal field at 10 meters during the March survey.**

inverse relation exists between the mean diatom abundance and temperatures in the upper 10 meters (Figures 18, 19). This relationship is especially pronounced at depths greater than 50 meters where 91 per cent of the variation can be explained by the regression (Figure 18). Stations 36 and 53, though plotted, were omitted in the regression since the diatom response at those stations appears to reflect growth conditions associated with their presence in transitional areas between poor and productive watermasses (Figures 10, 11, 17, 18). The temperature regression is not as good at those stations located at depths shallower than 50 meters where only 44 per cent of the variation can be explained by the regression (Figure 19, Table 27).

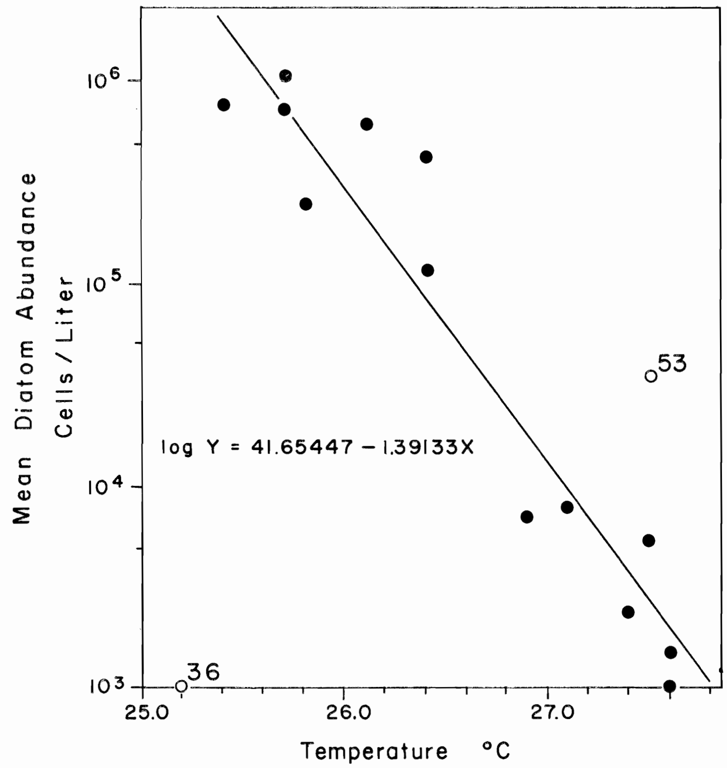

FIGURE 18. **The relationship between mean diatom abundance and mean temperature in the upper 10 meters at depths greater than 50 meters during March survey. Open circles are explained in text.**

As with the temperature-diatom data, the Secchi Disc observations could be partitioned into two natural sub-groups which were characterized by equally good regressions (Figure 20, Table 27). The lower regression in Figure 20 comprised stations 30, 32-36 and 48, stations characterized by 1) a mean salinity[1] of less than 33.20 $^0/_{00}$ and 2) their general occurrence in the warmer, stagnant regions of the Gulf (Figures 10-13, 15-20). The general environmental conditions characterizing this series are reflected in the means of 26.4°C and 33.01 $^0/_{00}$. No Secchi Disc observations were made at stations 49-54 where the hydrographic conditions through station 52 suggest an affinity with this regression. The upper regression in Figure 20 comprises those stations located primarily in colder, more saline waters as evidenced by their mean temperature and salinity values of 25.5°C and 33.62 $^0/_{00}$, respectively. Unlike the temperature regression, no influence of depth was apparent in the *inverse relation* between transparency and mean diatom abundance.

1. The mean surface salinity was obtained by averaging the two salinity observations nearest each phytoplankton station.

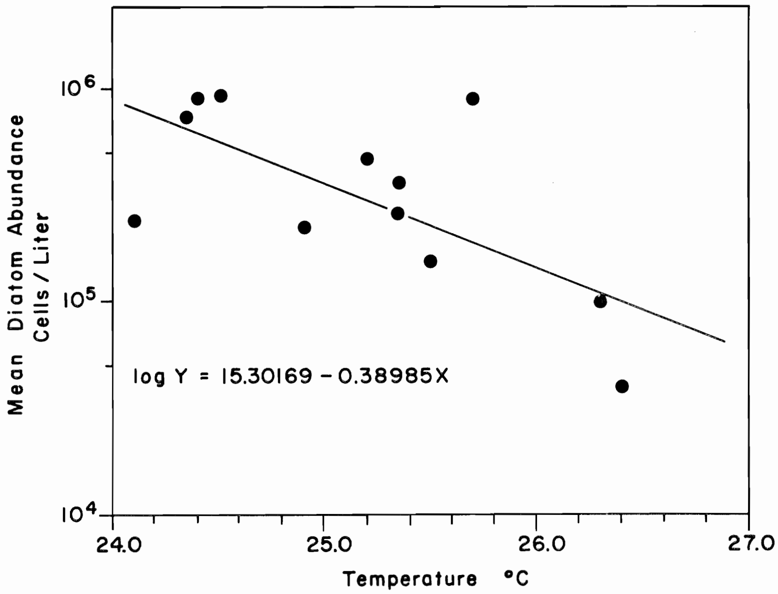

FIGURE 19. The relationship between mean diatom abundance and mean temperature in the upper 10 meters at depths shallower than 50 meters during March survey.

TABLE 27. Regression Equations for March Survey.
Y = mean diatom abundance, as cells/liter, in upper 10 meters.

X =	Regression Equation	% Variation Explained by Regression	Probability	Standard Error of Estimate	d.f.
Mean °C at Stations > 50 meters	log Y = 41.65447 — 1.39133X	91	.001	0.103	11
Mean °C at Stations < 50 meters	log Y = 15.30169 — 0.38985X	44	.02	0.100	10
Secchi Disc, in meters, at Stations 30, 32-36, 48	log Y = 6.16683 — 0.17043X	88	.005	0.129	5
Secchi Disc, in meters, at other stations	log Y = 6.47383 — 0.09573X	79	.001	0.043	11
Mean Surface Salinity	log Y = —60.59814 + 1.96568X	61	.001	0.129	24

Detailed explanation of X units provided in legends of Figures 18-21.

Maximum Secchi Disc readings were obtained in those areas where upwelling, and phytoplankton growth, were relatively insignificant. The low extinction coefficients at these stations, coupled with the annual occurrence of maximal incident light intensities during the upwelling season, suggest the unlikelihood that phytoplankton growth was light-limited in the superficial waters at these stations, or probably at any station during the March survey. Hence, the Secchi Disc regressions probably reflect the magnitude of the phytoplankton abundance at the stations, rather

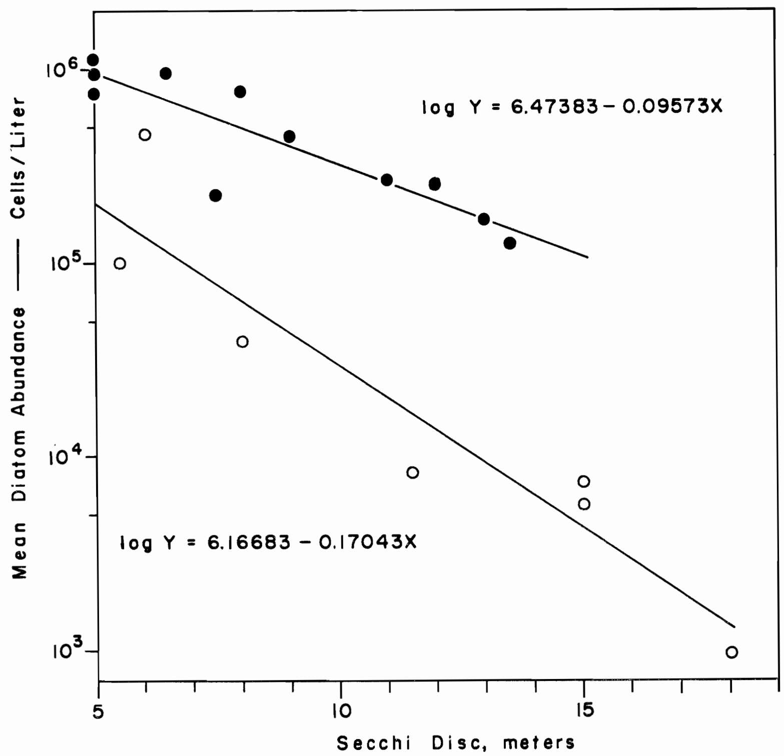

FIGURE 20. **The relationship between mean diatom abundance in the upper 10 meters and Secchi Disc observations during the March survey. The two regressions are explained in the text.**

than describe a causal relation between light intensity and phytoplankton growth.

The mean diatom abundance could be reasonably well related to the mean surface salinity conditions (Figure 21, Table 27). The salinity data suggest that a subgrouping of stations exists, as with the regressions on temperature and transparency during March, and salinity during November (Figures 8, 18-21). However, since no objective criteria could be applied to justify sub-grouping the stations, probably reflecting a lack of salinity data, a single salinity regression was derived (Figure 21, Table 27). The observation that 61 per cent of the variation is attributable to the regression is surprisingly good, bearing in mind the nature of the salinity data. The direct relation observed between salinity and mean diatom abundance, as during the November survey, however, can undoubtedly be ascribed to factors associated with salinity rather than salinity *per se.* For, in general, the highest salinity values accompanied the lowest temperatures which, in turn, were accompanied by the greatest diatom populations (Figures 17-19). The relatively greater upwelling intensities suggested by this association were undoubtedly accompanied by higher phos-

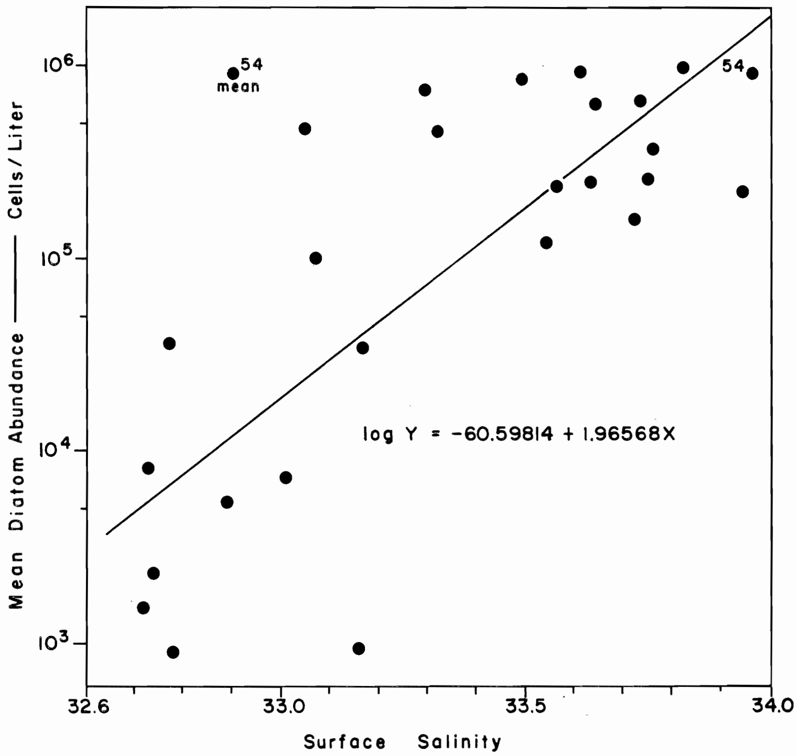

FIGURE 21. **The relationship between mean diatom abundance in the upper 10 meters and the mean surface salinity during the March survey.**

phate concentrations as well (Table 1). Consequently, the March temperature regressions, as with salinity, probably indicate the general influence of upwelling on phytoplankton growth, rather than describe a causal relationship. This suggests that the regional variations in diatom abundance observed during the March survey primarily reflect the nutrient concentrations associated with a given upwelling intensity and, secondarily, other factors.

Regressions of diatom abundance on temperature, salinity, or water transparency were often improved by grouping the data according to the depth of the water column at each station. However, an analysis of the notably weaker temperature regression derived for the March stations shallower than 50 meters (Table 27), and the data in general, suggests that the "depth effect" may represent several unknown factors. For example, the March temperature regression can be significantly improved if stations 28-30, 41-45, 53-56 are grouped. These stations are characterized by reasonably similar hydrographic conditions and, except for stations 44 and 45, their location within the inner regions of the Gulf of Panama. Other, somewhat more subjective groupings of the data can be made leading to improved regressions. Thus, there is some evidence that the regional differences in phytoplankton production encountered during the surveys, especially during March, are also attributable in part to the depth of the water column and unknown factors associated with depth.

The lack of nutrient and salinity data precludes a more refined statistical analysis of the phytoplankton growth during the March survey.

A comparison of the average March standing crop at the permanent station with those during the 1958 survey reveals a considerably lower diatom density during the latter period (Table 28).

TABLE 28. A Comparison of the Average March Phytoplankton Densities in the Upper 10 Meters at 8°45′N, 79°23′W with Those Observed During the Gulf Survey of 18-21 March, 1958 (in cells/liter).

	1955-1957	**1958**	
Stations:	**Permanent**	**26-56**	**Omitting 34-36; 48-52**
Diatoms	907,645	333,900	449,096
Dinoflagellates	3,415	1,516	1,903
Gymnodiniaceae	2,864	2,374	2,535
Coccolithophores	9,628	4,400	5,000
Monads	21,156	12,707	14,430

This deviation persists even when the sparse stations 34-36 and 48-52 are omitted in the comparison. The average abundance of the Gymnodiniaceae was similar, whereas the means for the other flagellate groups were 50 per cent lower during 1958. A general increase in the average standing crops for all components occurred since the November survey, as at the permanent station (Tables 10, 28).

The considerably lower standing crop during March 1958 relative to the permanent station undoubtedly reflects the unusually high temperatures prevalent during this survey. As noted previously, the thermal conditions reveal a lower rate of upwelling than normally encountered during March which can be related to the meteorological conditions then prevalent (Anoymous, 1958). This demonstrates that *annual,* as well as *regional,* differences in upwelling intensity and associated phytoplankton production occur.

DISCUSSION

The surveys are ideally suited to evaluate to what extent the phytoplankton dynamics observed at the permanent station are representative of the entire Gulf of Panama, since they were conducted during the three major "seasons" of the annual cycle:

1. During the height of the upwelling season—March.

2. During the transition to the rainy season at a time when mild upwelling winds reappear—July.

3. During the height of the rainy season—November.

The occurrence of maximum phytoplankton populations during the upwelling season, followed by a considerable reduction in abundance during July, and further subsidence during November is consistent with observations at the permanent station from 1955-1957 (Smayda, in prep.). The surveys also reveal that the environmental conditions characteristic of a given "season," when present, occur throughout the Gulf of Panama. However, regional variations in phytoplankton growth occurred. During all surveys the innermost regions, generally north of 8°30′N, were the most productive, while the least productive areas were in the offing of Parita and San Miguel Bays. The latter observation indicates that nutrient accretion *via* runoff is inadequate to sustain sizable autotrophic populations in those regions, contrary to Allen's (1925, 1939) general conclusions. The average standing crops during the surveys, except for March, compared favorably with those characteristic of the permanent station. The significantly lower populations during the March survey could be attributed to the unusually warm conditions then prevalent accompanying adverse meteorological conditions.

A remarkable regional uniformity in species composition occurred during all surveys despite regional differences in growth conditions. The communities observed during the surveys were generally similar to those occurring at the permanent station during an equivalent period. The unusually warm conditions during the March survey could be shown to have retarded succession three to five weeks relative to that observed at the permanent station. As at the permanent station, the diatoms overwhelmingly dominated the phytoplankton during all surveys.

These observations indicate, then, that *the phytoplankton dynamics observed at the permanent station are indeed generally representative of the Gulf of Panama,* and that this station lies within the most productive region of the Gulf.

Prior to the HANNIBAL Cruise in March 1933 (Allen, 1939), only nine surface net samples were collected in the Gulf of Panama, all during the upwelling season (Allen, 1925; Cupp, 1930, 1934). These authors reported that the phytoplankton abundance, which varied from approximately 6,000 to 700,000 c/l, was primarily due to a *Chaetoceros* community. Allen (1939) briefly reported on 66 net samples collected at the surface over a two-week interval in March, 1933. He observed that the eastern half of the Gulf was more productive than the western region, as during the 1958 survey. However, the inner regions of the Gulf were poorer than the outer ones, unlike in 1958. Allen could find no correlation between phytoplankton abundance and the physico-chemical conditions accompanying upwelling. However, he appears to have underestimated the significance of upwelling. A review of his original data indicates that *Chaetoceros debilis* dominated, accompanied by prominent stands of *Ch. curvisetus, didymus, lorenzianus,* and *Nitzschia seriata.* The conspicuous paucity of *Rhiz. delicatula, stolterfothii* and *Nitz. delicatissima,* normally important during March at the permanent station, is notable.

The following new forms included in the survey tables will be described in the biogeographical and floristic portion of this series. (Smayda, in prep.):

Actinoptychus undulatus f. *catenata*	n.f.
Asterionella japonica f. *tropicum*	n.f.
Leptocylindrus maximus	n. sp.
Skeletonema costatum f. *tropicum*	n.f.

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APPENDIX TABLES I - V

In the format adopted here, governed by space considerations, the results of the phytoplankton enumeration are presented in two ways. For those species presented in *tabular* form, the population density is given as cells per 10 ml., whereas the less important species are presented in *text* form as cells per liter. The following example illustrates the manner in which the *text* tables are to be read:

Biddulphia mobiliensis **20** 11s; **40** 14, 15s, 22t, 24s;

Biddulphia mobiliensis occurred during the November survey with a density of 20 cells per liter at the surface (subscript s) at Station 11 (11s), and as 40 cells per liter at both the surface and 10 meters at Station 14 (no subscript), at the surface at Stations 15 and 24 (15s, 24s) and at 10 meters (subscript t) at Station 22 (22t). This species was not observed at any other station during the November survey.

The symbol – in the tabular presentation indicates that the species in question was not observed at that depth.

A phytoplankton census was not made at the following locations:

Station	Depth (m)	Station	Depth (m)
1	10	26	0
5	10	27	0
16	0	31	10
19	10	46	0

March stations 34-36 and 49-52 are not included in the tables, the communities being similar to those observed at Stations 33 and 48, respectively.

TABLE 1—RESULTS OF THE PHYTOPLANKTON ENUMERATION FROM THE SURVEY OF 10-12 JULY, 1957. (cells per 10 ml.).

STATION	1	2		3		4		5	6		7		8		9		10	
LOCATION N	8°45'	8°41'		8°29.5'		8°13.5'		7°58.5'	8°02.5'		7°57'		8°17.5'		8°38.5'		8°47'	
W	79°17'	78°57.5'		78°49.5'		78°34'		79°04.5'	79°41'		80°07.5'		79°29.5'		79°17.5'		79°31.5'	
DATE	10-VII	10-VII		10-VII		10-VII		11-VII	11-VII		12-VII		12-VII		12-VII		12-VII	
DEPTH (m)	0	0	10	0	10	0	10	0	0	10	0	10	0	10	0	10	0	10
TEMPERATURE (°C)	28.94	29.44	29.11	28.89	28.44	28.50	28.39	28.06	28.89	29.00	28.72	28.72	28.56	28.56	28.83	28.56	28.73	28.50
Bact. elegans	6.6	115	370	.6	109.6	65	.8	—	4	—	6	27.4	4.2	3	35	36	42	60
Bact. hyalinum var. princeps	17.6	11	110	—	20.4	—	—	—	2.8	—	1.4	17.2	.8	2.6	15.4	15	13.6	20
Cerataulina bergonii	2	.4	4.4	.2	1.6	1.4	—	—	.6	—	1.4	.8	.6	—	.4	1	.4	2.8
Chaetoceros affinis	5.4	3.2	4.6	—	4	—	—	—	5.4	—	2.4	5.2	.6	15	5	19.2	—	.8
Chaetoceros brevis	—	1.2	4.6	2	4.2	—	—	—	—	25	—	—	—	—	—	—	—	.4
Chaetoceros compressus	12.6	115	225	—	8.8	—	—	—	4.4	100	35	13.2	3.2	4.8	14.4	36.4	60	22.8
Chaetoceros constrictus	4.6	17.4	320	.6	22	—	—	—	2.2	—	—	—	—	—	4.6	—	85	—
Chaetoceros curvisetus	11.8	15	450	2	50	2.4	—	—	1.4	15	—	—	.8	—	3.6	30	135	37.8
Chaetoceros decipiens	15.6	2.4	15.2	—	17.2	.8	140	—	—	—	—	—	—	—	3.2	4.2	40	25.6
Chaetoceros didymus var. protuberans	—	7	135	.6	12.8	1	—	—	4.2	—	—	9.2	.8	2.2	8	25	110	10
Chaetoceros laciniosus	5.6	22.4	310	1.4	18.8	—	—	—	3.8	15	4.6	12.8	3	1.8	31.8	34	10	12.8
Chaetoceros laevis	9.4	5.6	—	1.4	20	3.2	1.4	—	4.2	—	—	1.6	90	10	1.6	10	4.4	12.4
Chaetoceros lorenzianus	20.4	33.2	190	2.4	55	1.6	1.4	—	5.6	—	4.8	30	5.6	14.2	41.6	34.8	60	68.8
Corethron hystrix	1.2	.6	2.8	.2	1.6	1	.2	—	.4	.2	.2	1.4	1.2	—	1	.8	.2	3.6
Coscinodiscus "lineati"	—	.2	1.2	—	1.2	.8	.6	—	.6	—	.4	.8	1	3.2	.8	2.8	3	1.2
Eucampia cornuta	2.2	1.4	32.8	—	5	—	—	—	.2	—	—	.6	1.4	.6	.8	5	2.6	2.8
Hemiaulus sinenis	4	25	2	2.4	.6	2.2	3.2	—	5	—	.6	4.4	3	.8	2.2	11.2	6.4	10
Nitz. closterium	25	10	30	—	15	—	—	—	—	—	10	10	20	5	—	—	10	10
Nitz. delicatissima	130	5	115	.8	45	—	1.6	—	—	—	—	40	65	20	5	5	—	65
Nitz. pacifica + pungens	45	2.8	115	1	40	25	10	—	—	10	.6	.4	1.2	—	—	—	25	1.6
Rhiz. delicatula	80	65	625	5	70	5	45	—	8.6	—	10	5.4	9.8	16	21.6	165	210	125
Rhiz. fragilissima	.8	2	90	—	—	—	.8	—	1.4	—	.4	5.2	1.2	.8	30	7.6	2	.8
Rhiz. imbricata var. shrubsolii	1.4	—	.6	—	—	—	—	—	1	.2	—	1.2	1	.2	.2	2	—	—
Rhiz. stolterfothii	8	5	13.6	5	8.8	4.4	5	—	10.4	45	3.6	1.8	4.2	.6	1	10.8	35	10.4
Schroederella delicatula	4	13.6	32.4	.4	9.4	—	.6	—	3.8	—	—	.6	—	—	2.6	2.8	4	4.6
Skeletonema costatum f. tropicum	12.6	—	40.5	155	105	—	—	—	14.6	—	5	5.2	3.4	4.2	18.6	9	70	21
Thalassionema nitzschioides	6	3.4	17.8	.6	10.4	4.4	14.2	—	1.4	—	—	7.4	.4	—	.4	1	4	9.2
Exuviaella baltica	—	—	10	—	5	—	—	—	10	5	5	5	5	—	—	5	5	5
Peridinium trochoideum	—	4.8	1.6	2.6	.2	—	—	.2	—	—	—	—	—	—	.2	—	.2	.6
Prorocentrum micans	.2	—	.6	.8	—	1.2	.2	.2	.6	—	—	—	.2	—	.2	—	1.4	.2
Prorocentrum spp.	—	.2	.4	.4	.4	7.2	5.2	—	—	—	—	.2	—	—	.2	—	3.6	2.0

TABLE I (Cont.) (Cells per liter)

DIATOMS: Actinoptychus undulatus **20** 3t,10t; Asterionella japonica f. tropicum **20** 1s, **80** 2t,4t,10s, **280** 3t; Asteromphalus flabellatus **20** 8t, **40** 3t,7s, **60** 2t; Bacteriastrum varians **440** 1s, **300** 2s; Biddulphia mobiliensis **20** 3t,6s,9; Bidd. sinensis **20** 1s,4t; Ch. aequatorialis **40** 8s; Ch. affinis var. circinalis **20** 2t,6s,10t, **60** 3t, **160** 8s; Ch. appendiculatus **40** 10t; Ch. atlanticus var. neapolitana **80** 2t; Ch. atlantidae **20** 4t, **300** 9s,10t, **420** 2s; Ch. coarctatus **60** 8s; Ch. debilis **120** 7t; Ch. densus **60** 7t; Ch. diversus **60** 2t, **80** 1s, **120** 9s,10s; Ch. pendulus **20** 4s, **40** 2s, **60** 9t, **80** 10t, **100** 1s; Ch. perpusillus **3000** 2s,10s; Ch. peruvianus **20** 6s,7t,10, **40** 9t; Ch. socialis **1000** 3t,9s, **17500** 2t; Ch. subsecundus **60** 2s, **80** 1s, **140** 9t; Ch. subtilis **420** 6s; Ch. wighami **2500** 8s; Corethron pelagicum **20** 2; Cosc. marginatus **40** 4t; Cosc. nobilis **40** 2s; Cyclotella cf. caspia **40** 8t,9t, **60** 6s,**80** 4t, **100** 2s, **220** 1s, **260** 10t; Dactyliosolen mediterraneus **40** 9s,8t, **120** 7t, **200** 6t; Ditylum brightwelli **40** 3t, **80** 1s,10, **180** 4t; Ditylum sol **20** 2,9s, **60** 3t; Guinardia flaccida **20** 1s,7s; Hemiaulus membranaceus **20** 1s,6s, **40** 2t,10t; Lauderia annulata **60** 2t, **80** 10t, **100** 1s, **120** 6s; Leptocylindrus danicus **2000** 6t; Lept. maximus **40** 3t,8t, **60** 10t, **120** 9s; Lept. minimus **6000** 7s; Nitz. sigma var. indica **80** 7t; Nitz. sigma var. intercedens **20** 9t, **40** 7t; Planktoniella sol **20** 1s; Rhizosolenia acuminata **20** 10s; Rhiz. alata f. genuina **20** 6t,9t; Rhiz. bergonii **20** 7t; Rhiz. calcar avis **80** 2t; Rhiz. setigera **20** 1s,6,8t, **40** 2t,7t,10s; Rhiz. styliformis var. latissima **20** 4s,7t; Stephanopyxis turris **120** 2s; Thalassiothrix delicatula **20** 4t; Thal. frauenfeldii **20** 2t,8s, **60** 4t, **100** 6s, **160** 10t, **260** ls,7t; Thal. mediterranea var. pacifica **20** 1s,6t,8t,9s, **40** 7; Tropidoneis antarctica **20** 1s,3t,6t,9t, **40** 2t, **60** 8t, **80** 7t; Tropidoneis lepidoptera **20** 2s.

DINOFLAGELLATES: Blepharocysta splendor-maris **20** 10s; Ceratium breve **40** 3s; Cer. furca var. eugrammum **20** 3s; Cer. fusus var. setaceum **20** 2t,4s,9t, **40** 7t,10s, **60** 3t; Cer. kofoidii **20** 1s,2t,4t,10t; Cer. macroceros **20** 4t,9s,10; Exuviaella compressa **40** 3s; Ex. vaginule **20** 4t,10s; Goniaulax minima **20** 10t; Gon. polygramma **20** 6s, **40** 3t,4t,8t,9t, **60** 2s, **200** 10s; Gon. scrippsae **60** 2s,10t; Oxytoxum crassum **20** 9t; Oxy. scolopax **20** 10; Oxy. variabile **20** 10t, **500** 3s,9t, **2000** 2t; Oxy. viride **60** 4s; Peridinium crassipes **20** 7t; Per. globulus **20** 9s; Per. globulus var. quarnerense **20** 7t,8s,10t, **60** 2s,3s; Per. granii **20** 2s; Per. heterospinum **20** 2; Per. inconspicuum **140** 4; Per. nipponicum **40** 6s, **80** 10s, **100** 7t, **140** 9t; Per. pellucidum **20** 7t,8t, **40** 4, **60** 6s, **80** 2t,3s; Per. subinerme **20** 2,6s,8t,10t, **40** 3s; Per. tuba **20** 2t,3,8t, **120** 4s; Prorocentrum maximum **20** 4t,9t,10t, **40** 2t, **80** 3t; Pror. obtusidens **20** 2s.

COCCOLITHOPHORES: Acanthoica lithostratus **20** 7t, **60** 3t; Calciosolenia sinuosa **500** 5s, **1000** 3t; Coccolithus huxleyi **500** 3t; Discosphaera tubifer **40** 5s, **160** 3t; Gephyrocapsa oceanica **500** 5s,7.

DIVERSE: Chilomonas marina **500** 4t; Halosphaera sp. **40** 8t; Cyanophyceans **+** 3t, **c** 5s, **r** 6s; Oscillatoria nigro-virides **60** 7s.

TABLE II—RESULTS OF THE PHYTOPLANKTON ENUMERATION FROM THE SURVEY OF 7-8 NOVEMBER, 1957. (Cells per 10 ml.).

STATION	11		12		13		14		15		16	17		18	
LOCATION N	8°56′		8°39.5′		8°31′		8°24′		8°14′		8°04′	7°54′		7°52′	
W	79°23′		79°20.5′		79°11.5′		79°03′		78°59.5′		78°58′	78°56.5′		79°08.5′	
DATE	7-XI		7-XI		7-XI		7-XI		7-XI		7-XI	7-XI		7-XI	
DEPTH (m)	0	10	0	10	0	10	0	10	0	10	10	0	10	0	10
TEMPERATURE (°C)	27.9	27.9	28.3	28.1	28.1	27.2	28.6	27.8	28.9	27.6	27.7	28.1	27.8	28.1	27.4
Bact. elegans	2.8	28.8	10.4	25.2	45	3	240	85	100.4	305	8	5.4	6.2	8.4	—
Bact. hyalinum var. princeps	2.6	—	—	.4	—	.8	3.6	5	55	50	1	—	1.6	.4	—
Cerataulina bergonii	—	—	—	2	.2	1.4	—	—	1.2	1.6	2.8	.4	—	—	—
Chaetoceros affinis	2	3.8	3.2	24	—	1.4	19.2	80	54.8	535	2.6	1.6	—	—	—
Chaetoceros brevis	—	1.4	—	.6	.4	.4	55	—	2.6	140	1.6	—	—	—	—
Chaetoceros compressus	15	355	.2	55	—	6	315	140	275	755	3.2	—	3	—	—
Chaetoceros curvisetus	—	—	.8	.6	—	—	4	20	175	5.2	—	.6	—	—	—
Chaetoceros didymus var. protuberans	—	4.4	9.6	28.4	—	—	95	100	35	3.2	17.2	7.4	7.6	8.4	—
Chaetoceros diversus	—	—	.8	.8	—	—	—	.8	10	—	.6	1	1.2	.2	—
Chaetoceros laciniosus	1.8	3.6	3.2	19.2	—	2.2	110	85	100	120	14.6	7	3.8	—	—
Chaetoceros laevis	.4	.6	2.4	4	25	—	2.4	40	30	—	4.8	.4	.4	—	15
Chaetoceros lorenzianus	1.4	6	4.8	8.8	30	.2	65	15	75	35	1.6	.4	2.2	—	—
Cosc. "lineati"	.4	2.2	—	1.4	.2	2.4	—	.8	1.2	.4	—	—	—	—	—
Hem. membranaceus	—	—	.8	.4	.4	.8	—	—	2.8	—	.6	.4	1	—	—
Hem. sinensis	.2	.4	4.8	1.6	.6	1.6	.4	—	5.2	.4	—	—	—	—	—
Nitz. closterium	—	5	5	15	5	5	25	—	45	35	—	—	—	—	—
Nitz. delicatissima	10	.8	—	—	—	25	80	25	—	55	5	1	—	—	—
Nitz. pacifica + pungens	.8	10.8	.8	7.2	15	10.8	130	15	145	130	2.4	5	.6	5	—
Rhiz. calcar avis	—	.2	—	.6	—	.2	—	1.2	.2	1.2	—	—	.2	—	—
Rhiz. delicatula	—	3.2	1.2	50	25	15	285	60	190	110	25	—	20	—	—
Rhiz. fragilissima	1	2	—	.4	—	.8	120	—	60	.8	.4	—	.2	—	—
Rhiz. setigera	.4	1	1.2	.4	—	.8	2.4	.8	.4	.2	.2	—	—	—	—
Rhiz. stolterfothii	.2	3.2	1.6	3.6	35	2.2	10.8	95	15	15.6	3.4	.2	—	—	—
Rhiz. styliformis var. longispina	—	.2	1.2	2.8	—	—	—	—	—	—	—	—	—	—	—
Sch. delicatula	—	.4	—	.2	—	.4	.8	—	2.8	—	1.6	—	—	—	—
Sk. cost. f. tropicum	1.2	45	3.6	15.6	25	340	395	360	210	290	5.8	1	—	—	—
Thal. nitzschioides	1	4	6	2	.4	6.6	1.6	3.2	2	12	4.4	1.2	8	—	—
Exuviaella baltica	—	—	5	—	—	—	—	—	—	—	—	—	10	—	—
Calciosolenia sinuosa	5	10	—	5	—	35	35	15	—	5	5	—	—	—	—
Coccolithus huxleyi	10	10	—	15	5	15	—	10	40	20	5	5	5	—	—
Gephyrocapsa oceanica	.65	25	60	55	25	35	30	25	35	100	5	10	5	—	—
Halopappus adriaticus	—	.2	.4	15	—	5	5	10	—	5	.2	—	—	—	—

STATION	19	20		21		22		23		24		25	
LOCATION N	7°45.5′	7°47′		7°57′		8°07′		8°17′		8°26′		8°35.5′	
W	79°19′	79°32′		79°33′		79°29.5′		79°29.5′		79°29.5′		79°29.5′	
DATE	7-XI	8-XI		8-XI		8-XI		8-XI		8-XI		8-XI	
DEPTH (m)	0	0	10	0	10	0	10	0	10	0	10	0	10
TEMPERATURE (°C)	28.2	28.2	27.8	28.3	28.4	28.1	28.0	28.0	28.0	27.9	27.9	28.0	28.0
Bact. elegans	5.2	12.4	12.8	.6	—	6.4	11.6	6	15.2	6	70	50	60
Bact. hyalinum var. princeps	.8	—	—	—	—	—	—	—	—	—	—	—	—
Cerataulina bergonii	2.4	1.2	2.8	—	—	—	.4	—	—	—	—	—	—
Chaetoceros affinis	1.4	1.6	2	.4	5	3.2	12	—	7.2	4.4	15	15	18.4
Chaetoceros brevis	—	—	—	—	—	—	—	—	—	—	1.6	.8	2
Chaetoceros compressus	4.8	1.2	2.4	50	15	—	9.6	—	75	10	60	3.2	16.8
Chaetoceros curvisetus	—	—	—	—	—	—	—	—	—	—	3.6	—	—
Chaetoceros didymus var. protuberans	7.2	8.8	14.8	1.2	30	11.2	12	11.6	11.6	19.6	60	15	7.6
Chaetoceros diversus	.6	2.4	1.2	.2	—	.8	—	10	40	.8	10	.8	.8
Chaetoceros laciniosus	7	.8	6	.8	5	1.2	—	—	1.6	5.6	15	20	9.6
Chaetoceros laevis	1.6	.8	2.4	—	—	—	—	—	2.4	1.6	20	—	4
Chaetoceros lorenzianus	1.2	.8	6	—	—	—	1.6	—	1.2	—	2.4	1.6	.8
Cosc. "lineati"	.4	.4	.8	.2	—	.4	—	—	—	—	—	.4	.4
Hem. membranaceus	—	—	—	—	—	8.8	.8	—	.4	—	—	—	.8
Hem. sinensis	—	—	—	—	—	—	.4	.4	—	.4	1.6	—	—
Nitz. closterium	.2	—	10	—	—	—	—	10	—	—	.4	.4	1
Nitz. delicatissima	30	—	30	—	—	—	5	—	—	—	—	—	—
Nitz. pacifica + pungens	1.4	15	2.4	—	10	14.4	3.2	—	5.6	35.9	170	50	40
Rhiz. calcar avis	—	—	—	—	—	1.6	.4	—	.8	2.4	—	.4	.8
Rhiz. delicatula	.4	1.2	1.2	.4	—	1.2	—	5	1.6	2.4	2.4	3.2	2
Rhiz. fragilissima	.8	10	.8	—	—	—	.4	—	—	2	.8	.8	2.8
Rhiz. setigera	—	—	—	.2	—	.8	.4	.2	1.2	2	—	.8	.4
Rhiz. stolterfothii	.2	—	—	.2	—	1.6	.8	—	.4	4.8	10	.8	5
Rhiz. styliformis var. longispina	—	—	—	—	—	—	2.4	—	1.2	4.4	3.6	6.8	4.4
Sch. delicatula	1.4	—	.4	—	—	.8	—	—	1.2	1.2	.4	2.4	—
Sk. cost. f. tropicum	1.6	15	—	—	20	12.4	1.6	—	20.4	165	120	—	15
Thal. nitzschioides	3.6	.8	7.6	.4	—	—	5.2	—	1.2	3.6	4.8	.8	2.4
Exuviaella baltica	—	—	—	5	—	—	5	—	5	—	5	—	10
Calciosolenia sinuosa	—	—	—	5	—	—	—	—	—	—	5	—	—
Coccolithus huxleyi	5	10	15	—	—	—	—	—	—	—	15	—	—
Gephyrocapsa oceanica	10	5	15	15	5	15	70	10	15	35	40	15	35
Halopappus adriaticus	—	—	—	—	—	—	5	—	.4	—	—	5	1.2

TABLE II (Cont.) (Cells per liter)

DIATOMS: Actinoptychus undulatus **20** 11t, **40** 24s; Ast. bleakeleyi **720** 20t; Ast. japonica **160** 20t, **200** 24s, **720** 14s,15t, **1000** 15s; Asteromphalus flabellatus **20** 11s,14s,16t,17s, **40** 14t,25t, **60** 12t; Bacillaria paradoxa **240** 15t; Bact. comosum **1000** 15s; Bact. delicatulum **60** 17s, **100** 13t; Bact. hyalinum **120** 15s; Bact. mediterraneum **60** 12t; Bact. varians **80** 15s, **3500** 14s; Bidd. mobiliensis **20** 11s; **40** 14,15s,22t,24s; Brenneckiella sp. **40** 14s; Ch. affinis var. circinalis **60** 11s, **100** 14s, **120** 23t, **160** 20t, **360** 25t, **480** 15s; Ch. appendiculatus **120** 16s; Ch. atlantidae **20** 12t,13t, **40** 20t, **100** 16t, **120** 11s; Ch. constrictus **800** 15s; Ch. costatus **80** 15t, **160** 14s,16t, **500** 15s; Ch. decipiens **40** 14s, **80** 15t, **500** 15s; Ch. densus **40** 14t;

Ch. lauderi **40** 14t,19s, **60** 15s, **120** 15t; Ch. pelagicus **2000** 15s; Ch. pendulus **40** 12,24s,25t, **80** 22t; Ch. peruvianus **20** 19s,21s, **40** 11,12s,14s,20t,22, **60** 15s, **80** 25s; Ch. seiracanthus **160** 12s, **2500** 11t; Ch. subsecundus **20** 20s, **40** 24t, **360** 15s; Ch. tetrastichon **40** 21s,22s; Ch. van heurckii **120** 19s; Corethron hystrix **20** 12t,13t, **40** 14s,15t,22s,24t,25t, **80** 20t, **100** 11t, **120** 16t, **140** 15s; Corethron pelagicum **20** 13t, **40** 16t,24s, **60** 12t, **100** 11t; Cosc. concinnus **20** 15s; Cosc. marginatus **40** 14s,22s,24t,25s; Cosc. nobilis **20** 12t,13t, **40** 14t; Cyclotella cf. caspia **20** 11s, **80** 15t; Dactyliosolen mediterraneus **40** 19s,20s, **100** 16t, **360** 15s; Ditylum brightwelli **20** 11s,17, **40** 14s,15,16t; Ditylum sol **20** 15s; Eucampia cornuta **40** 12t,23t,24t, **360** 15s;

Grammatophora marina var. tropicum **320** 22s; Hemiaulus hauckii **20** 17t, **40** 25s, **60** 19s, **120** 25t, **180** 16t, **220** 20t; Lauderia annulata **20** 14s; **40** 22s, **80** 23t, **200** 15s; Lept. danicus **20** 11s, **40** 22s, **60** 11t, **80** 20t,22t, **120** 24t, **200** 16t; Lept. maximus **80** 11t, **120** 15t, **160** 14t; Mel. sulcata **100** 21t, **13880** 22t; Nitz. kolaizeckii **20** 12t,13t,16t,17t, **40** 22t,24, **80** 25t, **120** 20t,25s; Nitz. longissima **20** 11s; Nitz. sigma var. indica **40** 15s, **80** 15t; Pseudoeunotia doliolus **80** 19s, 20s, **200** 20t; Rhiz. alata f. genuina **20** 11s,13t, **120** 25t; Rhiz. alata f. indica **20** 13t, **60** 11t, **160** 24s; Rhiz. bergonii **20** 21t, **40** 13t,24t; Rhiz. imbricata var. shrubsolei **80** 22t, **100** 13t, **240** 15t, **280** 14s, **400** 14t; Step. palmeriana **160** 14s; Thalassiothrix delicatula **20** 16t,23s, **40** 19s,23t,25, **120** 24t; Thal. frauenfeldii **20** 13t,17s, **40** 22s, **60** 11t,15s, **80** 12t,23t, **100** 19s, **120** 20t, **160** 14s; Thal. mediterranea var. pacifica **20** 11t, 20t, **40** 13t,14t,19s,20s,22s,24t, **60** 11s, **80** 14s,15s,22t,23t, **160** 25s; Tropidoneis antarctica **20** 13t, 15s, **40** 11t.

DINOFLAGELLATES: Blepharocysta splendor-maris **20** 17s; Cer. furca var. eugrammum **20** 14s, **100** 15s; Cer. fusus var. seta **20** 11s,13t,15s,17t, **40** 22t, 23t,25s, **80** 20s,24t, **120** 24s; Cer. kofoidii **20** 11s, **40** 24, **80** 25t; Cer. macroceros **20** 16t, **40** 20s, 24s; Cer. massiliense f. macroceroides **40** 23t; Glen. lenticula f. minor **20** 13s,15s; Gon. digitata **20** 15s; Gon. minima **20** 11, **40** 12s; Gon. polyedra **40** 25s; Gon. polygramma **20** 11s,20t, **40** 12; Gon. spinifera **20** 11s, **40** 15s; Ornithocercus magnificus **20** 12t, **40** 25t; Oxytoxum crassum **20** 15s; Oxy. scolopax **20** 11t, **40** 20s; Oxy. variabile **40** 25s, **100** 12t, **500** 13t,22t,24s, **1000** 25t; Per. depressum **20** 17t; Per. divergens **20** 15s; Per. globulus **20** 15s; Per. globulus var. ovatum **20** 15s;

Per. globulus var. quarnerense **20** 15s, **40** 11s,20s,22,25s, **80** 11t; Per. inconspicuum **20** 15s; Per. nipponicum **20** 11t,13t,15s, **40** 19s,23t,24s,25s, **60** 11s, **80** 12s, **120** 14s; Per. pellucidum **20** 13s; Per. pyriformis **40** 15s,24t; Per. pyriformis f. oviformis **60** 15s; Per. steinii **40** 15s; Per. subinerme **40** 20t, **80** 15s; Per. trochoideum **20** 14s, **40** 15t, **80** 12s, **100** 15s, **140** 13t, **520** 12t; Per. tuba **20** 17t, **60** 15s; Podolampas spinifer **20** 19s; Pror. maximum **20** 19s, **40** 24s,25s; Pror. micans **20** 11s, **40** 12s,14s,15t,19s,22s,23t,24, **60** 15s, **80** 22t.

COCCOLITHOPHORES: Anoplosolenia brasiliensis **40** 11t, **500** 20s; Discosphaera tubifer **20** 16t, **40** 12t,17t,25s, **500** 15t; Pontosphaera maxima **40** 25t.
DIVERSE: Chilomonas marina **500** 21t; Euglenaceae **2500** 19s, **3000** 18t; Halosphaera sp. **40** 22s.

TABLE III—RESULTS OF THE PHYTOPLANKTON ENUMERATION FROM THE SURVEY OF 18-21 MARCH, 1958, STATIONS 26-33. (Cells per 10 ml.).

STATION	26	27	28		29		30		31	32		33	
LOCATION N	8°54'	8°51'	8°44'		8°39'		8°30'		8°21'	8°13'		8°08'	
LOCATION W	79°18.5'	79°08'	78°58'		78°47.5'		78°41'		78°41'	78°33.5'		78°27.5'	
DATE	18-III	18-III	18-III		18-III		18-III		18-III	18-III		18-III	
DEPTH (m)	0	10	0	10	0	10	0	10	0	0	10	0	10
TEMPERATURE (°C)	25.8	23.4	25.8	23.1	26.0	23.1	27.3	23.6	27.5	27.5	25.3	27.2	25.5
Asterionella japonica	—	—	4.4	3.2	13.2	19.2	2.8	53.2	—	—	—	—	—
Biddulphia mobiliensis	.2	.4	.8	.4	.8	3.6	.2	2.4	.8	—	—	—	—
Biddulphia sinensis	—	1.2	10.4	19	6	50	.4	2	—	1.4	.2	—	—
Cerataulina bergonii	2.6	2	16.8	16.8	370	115	580	45	180	1.2	2.2	—	1.6
Chaetoceros affinis	—	—	—	—	3.6	6.8	27.6	5.6	95	—	.4	—	—
Chaetoceros brevis	—	—	—	—	.4	—	75	5	60	—	—	—	—
Chaetoceros compressus	—	—	—	—	—	—	130	—	30	—	—	—	—
Chaetoceros curvisetus	2.2	100.4	120	335	710	305	85	235	10	8.2	—	—	—
Chaetoceros lorenzianus	—	—	—	.8	2.4	1.2	27.6	12.4	25	—	—	—	—
Chaetoceros cf. vixvisibilis	—	330	235	1240	560	1230	—	20	—	285	30	145	70
Coscinodiscus "lineati"	.8	.8	1.2	2	1.2	6	1	1.6	—	1.6	.6	.4	.8
Eucampia cornuta	.8	—	1.6	6.8	90	245	135	95	25	—	.6	.2	—
Eucampia zoodiacus	—	—	—	—	340	230	290	75	45	—	—	—	—
Hemiaulus sinensis	.2	—	—	—	2	1.6	20	20	40	—	.2	—	—
Lauderia annulata	—	2.4	2.4	—	16.8	3.6	15	10.8	—	2	1.4	1.6	—
Leptocylindrus maximus	—	—	—	—	14	—	14.8	3.6	5.6	—	—	—	—
Melosira moniliformis	10.6	—	5.2	—	8	—	1	50.8	2.4	—	—	—	—
Nitz. closterium	125	.2	85	80	410	510	90	340	35	55	80	10	65
Nitz. delicatissima	25	20	—	210	180	360	—	40	55	400	615	110	175
Nitz. pacifica + pungens	190	25	80	160	580	460	160	170	115	10	20	65	—
Pennate spp.	330	25.4	97	203	301.2	221.2	33.6	7.2	1.2	10.2	5.4	.8	17
Rhiz. delicatula	3	.2	10	1.6	1260	330	1810	870	555	20	20	15	1.2
Rhiz. fragilissima	—	.4	1.6	—	40	35	390	50	25	—	1.2	—	—
Rhiz. setigera	.2	1.2	6	2.4	115	125	320	45	80	—	.2	—	—
Rhiz. stolterfothii	.2	3.6	28.4	90	195	205	270	235	750	.6	1	—	1.6
Skel. costatum f. tropicum	15	16.2	245	615	2060	1520	995	850	340	140	31.6	4.2	3.6
Thalassionema nitzschioides	16	10	335	410	205	410	135	50	210	205	2	.8	2.4
Thalassiothrix frauenfeldii	—	—	—	—	3.2	4	2.6	2.8	5.2	—	—	—	—
Thalassiosira spp.	—	2.8	4.8	2	320	311.2	15	53.2	—	25	—	—	—
Th. mediterranea var. pacifica	—	—	—	—	7.6	.4	6.2	—	9.2	—	—	—	—
Exuviaella baltica	—	—	—	—	—	—	5	5	5	5	15	10	5
Prorocentrum spp.	—	—	—	—	.4	—	1.2	.8	1.6	.8	—	60	—
Coccolithus huxleyi	10	—	—	—	15	5	30	10	30	10	20	30	5
Gephyrocapsa oceanica	10	—	5	5	20	—	60	10	120	—	—	5	5

TABLE III (Cont.) (Cells per liter)

DIATOMS: Actinoptychus undulatus var. catenata **40** 27t,32s, **60** 28t, **240** 28s, **320** 29t; Ast. japonica f. tropicum **120** 29s, **140** 32s, **160** 26s, **200** 30t, **240** 29t; Asteromphalus flabellatus **20** 30s, **40** 27t; Bacillaria paradoxa **500** 28t, **800** 28s; Bact. elegans **160** 30s; Bact. hyalinum **200** 29s; Bact. hyalinum var. princeps **520** 31s, **540** 30s; Bellerochea sp. **320** 30t; Bidd. alternans **20** 26s, **80** 28t, **120** 30t, **160** 29t; Bidd. longicruris **200** 30t;

Ch. aequatorialis **40** 30s; Ch. affinis var. circinalis **520** 30s; Ch. appendiculatus **80** 33t; Ch. atlanticus f. audax **60** 30s; Ch. atlantidae **60** 30s, **360** 29t. **500** 30t; Ch. constrictus **260** 30s, **480** 30t, **1000** 31s; Ch. costatus **7000** 30t, **9500** 30s; Ch. decipiens **80** 29s,33t, **100** 30s, **2000** 31s; Ch. densus **80** 29t,30s; Ch. didymus **500** 30t; Ch. didymus var. protuberans **80** 27t, **140** 30s; Ch. laciniosus **60** 26s, **160** 30s, **5000** 30t; Ch. laevis **140** 32s, **300** 31s; Ch. lauderi **40** 27t, **160** 28t, **240** 28s,30s; Ch. peruvianus **20** 26s, **40** 29s,33t, **120** 32s; Ch. subsecundus **2000** 30t; Ch. subtilis **12000** 29s;

Corethron hystrix **20** 28t,32t,33s, **40** 29t,32s,37,38t, **100** 30s, **120** 31s, **200** 30t, **240** 29s; Corethron pelagicum **80** 29t; Cosc. concinnus **20** 30s, **120** 31s, **160** 30t, **280** 28s; Cosc. costatus **120** 28s; Cosc. granii **40** 27t,29t, **80** 28s; Cosc. marginatus **20** 27t,28t,30s, **40** 33t, **80** 28s; Cosc. perforatus **40** 30t, **60** 27t; Cyclotella cf. caspia **40** 33t, **80** 29s, **160** 27t, **320** 30t, **440** 28t, **600** 29t; Ditylum brightwelli **20** 28t, **40** 32s,33t; Ditylum sol **20** 28t, **40** 30t; Guinardia flaccida **120** 30t, **280** 31s, **320** 30s, **400** 29s;

Hemiaulus membranaceus **20** 30s, **120** 31s; Lauderiopsis sp. **180** 32t, **280** 30t, **1440** 29t; Leptocylindrus minimus **37000** 29s; Lithodesmium undulatum **40** 31s, **80** 29t; Melosira sulcata **80** 28t, **320** 29t; Nitz. kolaizeckii **40** 29s; Nitz. sigma var. indica **20** 30s, **40** 28s,31s, **60** 26s; Rhiz. alata f. genuina **40** 30s, **80** 30t, **120** 31s; Rhiz. alata f. indica **40** 30t, **80** 29t, **160** 29s,31s, **200** 30s; Rhiz. alata f. genuina - indica intergrade **160** 31s, **300** 30s; Rhiz. bergonii **40** 31s, **60** 30s; Rhiz. calcar avis **40** 29s, **80** 30s,31s; Rhiz. imbricata var. shrubsolei **180** 30s; Schroederella delicatula **20** 33s, **100** 30s, **120** 30t; Stephanopyxis palmeriana **160** 30s; Step. turris **40** 30s, **120** 30t, **400** 29s; Thalassiosira subtilis **9280** 30t; Thalassiothrix delicatula **80** 30t; Tropidoneis antarctica **120** 30s, **200** 30t.

DINOFLAGELLATES: Ceratium furca var. eugrammum **40** 30s, **120** 28s,30t; Cer. fusus var setaceum **40** 30t; Cer. pentagonum f. turgidum **40** 28s; Glen. lenticula f. minor **20** 27t, **40** 28s, **80** 30t; Goniaulax polygramma **20** 33s, **80** 31s; Gon. scrippsae **20** 33s; Gon. spinifera **40** 30t; Oxytoxum curvatum **20** 32t; Oxy. variabile **500** 30t,33t; Peridinium claudicans **20** 30s; Per. decipiens **40** 30t; Per. globulus var. quarnerense **20** 26s, **40** 27t,28t,29t, **80** 30t; Per. inconspicuum **40** 30t, **80** 30s, **320** 33s; Per. leonis **40** 28s; Per. minutum **40** 30t; Per. tuba **40** 30t,32t,33t; Prorocentrum micans **20** 27t, **40** 28s,30s,31s,32s, **500** 33s.

COCCOLITHOPHORES: Calciosolenia sinuosa **20** 26s, **500** 32t,33s, **1000** 30s; Pontosphaera maximus **40** 33t, **500** 32t.

DIVERSE: Euglenaceae **20** 27t, **4000** 30s, **7000** 26s; Halosphaera sp. **40** 29s, **200** 30s; Laboea compressa **260** 33t, **3960** 33s; Lab. strobila **40** 33t, **640** 33s.

TABLE IV—RESULTS OF THE PHYTOPLANKTON ENUMERATION FROM THE SURVEY OF 18-21 MARCH, 1958, STATIONS 37-44. (Cells per 10 ml.).

STATION	37		38		39		40		41		42		43		44	
LOCATION N W	8°02' 79°06'		8°14' 79°03.5'		8°26' 79°05'		8°37' 79°08.5'		8°48' 79°15'		8°48' 79°25'		8°36' 79°25.5'		8°23' 79°26.5'	
DATE	19-III		19-III		19-III		19-III		19-III		20-III		20-III		20-III	
DEPTH (m)	0	10	0	10	0	10	0	10	0	10	0	10	0	10	0	10
TEMPERATURE (°C)	26.7	23.5	26.7	24.7	26.9	24.6	26.6	25.1	25.9	24.2	25.9	24.2	26.1	24.2	26.6	24.4
Biddulphia mobiliensis	.4	3.6	2	3.2	.8	.8	—	.4	.8	.8	.8	1.6	.4	.8	1.6	.8
Cerataulina bergonii	400	160	60	570	210	30	70	70	4.8	15.2	.8	2.8	1.6	5.2	4	—
Chaetoceros affinis	550	80	320	490	—	180	140	60	1.6	100	3.2	6.4	170	24.4	10	2.4
Chaetoceros brevis	55	390	150	620	270	280	220	150	2.4	170	—	—	110	7.2	2.4	2.4
Chaetoceros compressus	90	80	200	340	10	840	10	200	160	150	—	—	—	15.6	20	12
Chaetoceros costatus	280	610	370	610	—	450	—	50	80	100	—	—	—	2.4	—	—
Chaetoceros curvisetus	50	300	26	630	220	310	180	550	220	280	90	104	140	25.6	125.6	65.6
Chaetoceros decipiens	245	600	1900	2270	210	1350	240	150	1.6	60	1.6	4.8	6	4	32	10
Chaetoceros didymus	—	20	70	500	30	530	—	20	—	—	—	—	—	—	—	3.2
Chaetoceros laciniosus	—	—	—	110	—	200	—	220	60	—	—	—	10	—	—	—
Chaetoceros lauderi	20	—	30	3.2	—	—	—	—	18	4.4	—	4.4	—	1.2	2.4	5.6
Chaetoceros lorenzianus	75	—	100	240	100	250	50	130	1.6	—	3.6	6	6	3.6	16.8	8.8
Chaetoceros cf. vixvisibilis	—	—	—	—	—	90	—	1370	50	220	30	300	—	40	—	—
Chaetoceros spp.	170	—	—	710	160	780	200	200	240	120	—	—	80	3.6	—	3.2
Eucampia cornuta	4	80	19.6	270	220	19.2	3.2	30.8	6.8	5.6	1.6	10	—	20	8.8	1.6
Guinardia flaccida	.4	5.2	1.2	.8	—	—	—	1.2	.4	6	2.4	1.6	—	3.6	4	2.4
Hemiaulus sinensis	40	110	60	70	120	50	100	30	40	2.8	20	40	—	10	10	2.4
Lauderia annulata	1.6	13.2	4.4	17.6	—	16	4	16.4	5.2	7.6	1.6	10.4	—	4	5.6	19.2
Leptocylindrus maximus	4.4	10	5.2	9.6	9.2	7.6	—	5.2	4.8	10.8	—	10.4	—	.8	19.2	1.2
Nitz. closterium	230	640	940	2050	270	820	60	130	50	100	10	110	20	80	90	80
Nitz. delicatissima	440	90	340	280	370	250	360	610	250	460	90	340	250	100	60	140
Nitz. pacifica + pungens	480	515	1140	880	650	800	500	450	230	270	190	100	180	90	130	230
Pennate spp.	40.8	153.6	231.2	210.8	400.4	600.4	210	140	70.4	70.8	20.4	150	—	1.2	90.8	10.8
Rhiz. delicatula	1280	2200	770	1300	1450	1340	640	800	310	650	680	780	1090	630	590	1180
Rhiz. fragilissima	180	170	120	10	10	—	9.2	9.2	8.4	340	80	60	60	22	24	11.2
Rhiz. imbricata var. shrubsolei	—	2	—	.4	.4	3.6	.8	1.6	—	.8	3.6	—	1.6	.4	4	.8
Rhiz. setigera	110	120	90	90	180	220	110	120	3.6	5.2	2.8	7.2	60	9.6	30	110
Rhiz. stolterfothii	250	730	290	550	360	730	230	280	160	320	110	140	680	260	380	380
Skel. costatum f. tropicum	980	1140	16.4	250	710	800	960	1660	560	700	940	670	360	33.6	630	360
Thalassionema nitzschioides	15	40	210	330	340	380	23.2	50.8	5.2	470	22	25.6	—	5.2	12.8	6.4
Thalassiosira spp.	.8	2.4	—	—	—	—	60	100	30	3.2	—	20	—	—	—	—
Thalassiothrix mediterranea var. pacifica	16	24.8	4.8	1.2	8.8	9.6	15.6	8.4	8	10	4.8	6.8	—	3.6	5.6	5.6
Peridinium spp.	—	—	—	40	33.6	2	34.4	4.4	2	9.2	—	3.6	.8	6.8	2.4	2.4
Prorocentrum spp.	.4	—	81.8	—	.4	10	40	—	—	.4	—	—	.8	2.4	—	—
Coccolithus huxleyi	70	60	—	10	10	—	—	40	—	10	10	10	—	—	20	10
Gephyrocapsa oceanica	30	20	10	10	20	40	—	30	20	20	—	90	—	50	20	30

TABLE IV (Cont.) (Cells per liter)

DIATOMS: Act. undulatus var. catenata **80** 39t; Ast. japonica **120** 43t, **160** 38s,44t, **440** 42t, **1000** 37s, **1280** 28t; Ast. japonica f. tropicum **400** 41t, **1000** 42t, **2200** 37t; Bact. cf. comosum **7000** 38t; Bact. delicatulum **1500** 37s; Bact. elegans **3000** 40t, **13000** 37t; Bact. hyalinum **40** 40s, **120** 41t, **240** 37s,41s, **4000** 38s; Bact. hyalinum var. princeps **240** 44s; Bidd. alternans **240** 38t; Bidd. longicruris **40** 41t, **80** 38s, **120** 39s, **160** 44s; Bidd. sinensis **40** 40s, **80** 39t, **120** 41s, **280** 41t,43t, **480** 42t; Cerataulina compressa **120** 37s; Ch. affinis var. circinalis **48000** 39s; Ch. anastomosans **2000** 38t; Ch. constrictus **13000** 41t; Ch. didymus var. anglica **5000** 40s; Ch. didymus var. protuberans **1000** 42s, **11000** 38t; Ch. laevis **80** 41s, **1000** 37s, **3000** 37t, **4000** 38t;

Ch. pendulus **40** 39t; Ch. peruvianus **40** 37s,39s,44s, **80** 37t, **120** 41s; Ch. rostratus **40** 40s,41s,42t, **80** 38s, **120** 38t,39s, **160** 40t, **280** 39t; Ch. seiracanthus **20000** 38s; Ch. socialis **25000** 39t; Ch. subsecundus **1000** 37s, **2000** 39s, **5000** 38t, **12000** 38s; Ch. teres **2000** 38t; Ch. wighami **8000** 38t; Corethron hystrix **40** 41t,43t, **80** 39s,40t,44, **120** 39t; Cosc. "lineati" **120** 39s; Cyclotella cf. caspia **20** 41s, **40** 41t,42s; Dactyliosolen mediterraneus **120** 41s, **280** 37t; Ditylum brightwelli **40** 39s; Eucampia zoodiacus **160** 39t,40t,41t, **3000** 39s; Leptocylindrus minimus **8000** 38s, **9000** 39s;

Lithodesmium undulatum **80** 39s, **520** 38s, **1520** 38t, **2640** 39t; Melosira sulcata **440** 37s; Rhiz. alata **80** 37t; Rhiz. alata f. genuina **40** 38,41t,43t, **80** 42t, **120** 39s, **160** 37s,40t,41s, **320** 44s; Rhiz. alata f. indica **80** 41t, **160** 41s, **200** 37t, **240** 38t, **280** 40s, **320** 44s; Rhiz. alata f. genuina - indica intergrade **40** 37t,39s, **80** 38s, **120** 37t,40t; Rhiz. bergonii **40** 40s,42t, **80** 44s, **120** 37t; Rhiz. calcar avis **40** 40,43s, **80** 39t, **160** 42s; Schroederella delicatula **80** 38s, **320** 40s,44t, **440** 37s, **720** 37t; Stephanopyxis palmeriana **160** 42t; Step. turris **360** 38s; Streptotheca thamesis **40** 41s, **80** 38s,40t, **320** 37t; Thalassiosira subtilis **360** 42t, **1000** 37t,38s, **1120** 41t; Thalassiothrix frauenfeldii **40** 40s, **200** 37s, **280** 40t, **320** 38s, **520** 39t, **640** 38t, **760** 37t; Tropidoneis antarctica **80** 38s, **120** 43t, **160** 38t.

DINOFLAGELLATES: Ceratium furca **280** 39s; Cer. fusus var. setaceum **40** 37t; Cer. kofoidii **40** 37s; Cer. pentagonum f. robustum **40** 37s; Exuviaella baltica **1000** 39s,41s,44t; Glenodinium lenticula f. minor **40** 39s,42,43t, **80** 40t,44t, **120** 39t,41t, **160** 40s; Goniaulax polygramma **80** 38s; Oxytoxum curvatum **40** 37t; Oxy. variabile **1000** 38s,39s,42t,44t; Peridinium brochii **40** 39t; Per. crassipes **40** 37s,39t, **280** 39t; Per. divergens **40** 37t; Per. globulus **40** 38,40t, 41t, **80** 40s; Per. globulus var. quarnerense **80** 37s,40s,44s; Per. inconspicuum **120** 41t, **200** 40s, **360** 39s, **1000** 38s; Per. leonis **40** 37,38s,39s; Per. minusculum **40** 40t; Per. nipponicum **40** 38s,39; Per. oviforme **80** 37t; Per. subinerme **40** 39s,40s, **80** 37s, **240** 44s; Per. tuba 37t,39t; Prorocentrum micans **40** 38t,41s,43t, **80** 37,42t, **160** 40s, **200** 38s,39s, **320** 44s; Prorocentrum obtusidens **120** 39t; Pyrophacus horologicum **40** 38t.

COCCOLITHOPHORES: Anoplosolenia brasiliensis **1000** 41t; Calciosolenia sinuosa **1000** 40t,41t,44t, **2000** 38s,39t, **5000** 37s; Halopappus adriaticus **1000** 39t.

DIVERSE: Chilomonas marina **1000** 42t,43; Euglenaceae **500** 37s, **2000** 37t, **4000** 39s; Halosphaera sp. **40** 39s,40,41t,43t,44s, **80** 37t, **160** 37s.

TABLE V—RESULTS OF THE PHYTOPLANKTON ENUMERATION FROM THE SURVEY OF 18-21 MARCH, 1958, STATIONS 45-48, 53-56. (Cells per 10 ml.).

STATION	45		46		47		48		53		54		55		56	
LOCATION N	8°11'		7°58.5'		7°47'		7°44'		8°22.5'		8°31'		8°42'		8°54'	
W	79°27.5'		79°29'		79°34'		79°47'		79°41'		79°36'		79°32'		79°29'	
DATE	20-III		20-III		20-III		20-III		21-III		21-III		21-III		21-III	
DEPTH (m)	0	10	0	10	0	10	0	10	0	10	0	10	0	10	0	10
TEMPERATURE (°C)	26.9	26.1	26.6	25.8	26.8	26.0	27.3	26.9	27.7	27.2	25.5	22.9	25.4	23.9	25.2	23.2
Bacteriastrum elegans	3.2	3.2	—	230	130	—	—	—	—	.4	—	2	—	—	—	—
Biddulphia longicruris	—	—	—	—	—	—	—	—	—	—	85	115	1.6	1.6	—	.2
Cerataulina bergonii	1.6	5.6	390	410	230	380	—	35	2.8	.6	19.2	60	2.4	40	7.2	390
Chaetoceros affinis	21.6	16.4	640	240	210	240	—	5	2.4	1.8	36.8	40	4.8	5.2	2.4	.4
Chaetoceros brevis	6.4	15.6	470	730	310	320	—	5	1.6	1.2	—	10	.8	15	8	—
Chaetoceros compressus	—	8.4	250	270	—	—	—	—	—	2.8	25	90	3.6	2	—	16.8
Chaetoceros costatus	—	3.2	—	270	—	50	—	—	—	—	—	155	2.4	3.2	8	170
Chaetoceros curvisetus	53.6	560	180	3.2	40	20	—	—	—	8	300	465	38.4	450	720	10550
Chaetoceros decipiens	—	1.6	20	—	—	—	—	—	—	3.6	1.6	90	3.2	.8	4	2.4
Chaetoceros laciniosus	—	—	—	—	—	—	—	—	—	.4	55	75	1.6	—	5.6	—
Chaetoceros lauderi	—	—	—	—	—	—	—	—	—	—	1.6	—	2.8	1.6	16.8	440
Chaetoceros lorenzianus	8.8	17.2	260	130	140	190	—	—	—	1.6	8.8	65	6.8	1.2	4.8	—
Chaetoceros cf. vixvisibilis	4.8	60	—	240	50	510	—	—	—	—	—	—	30	—	—	—
Chaetoceros spp.	—	—	360	140	150	100	—	—	—	—	5.6	40	—	—	—	—
Coscinodiscus "lineati"	.8	1.2	—	—	—	—	—	—	—	2.2	17.6	.4	1.2	2.4	2.4	.4
Eucampia cornuta	1.6	10.8	330	270	220	700	—	—	—	—	—	—	—	1.2	—	45
Eucampia zoodiacus	—	—	—	20	—	—	—	—	—	1.2	55	40	25	—	—	55
Guinardia flaccida	.4	1.2	2.4	—	—	.4	.8	20.4	38	154.4	—	—	2.4	—	—	—
Hemiaulus sinensis	5	2.4	50	80	80	50	—	—	—	5	—	25	5	2.8	10	40
Lauderia annulata	2.4	4	4.8	8	.8	2.8	—	—	—	2.2	15	1.6	.4	3.2	10.4	53.2
Leptocylindrus maximus	—	1.6	4	2.8	1.6	—	—	2.8	—	.4	—	2	3.6	.4	5.6	3
Nitzschia closterium	20	230	40	60	50	40	20	25	—	25	120	235	50	5	120	210
Nitzschia delicatissima	15	120	440	280	90	120	15	15	1.2	30	70	75	65	55	45	—
Nitzschia pacifica + pungens	20	20	360	290	310	190	—	5	.8	55	250	215	90	10.8	130	350
Pennate spp.	10	.4	70	40	10.4	30.4	—	—	.4	—	15.8	26.2	15.4	15.2	60	76.4
Rhiz. delicatula	12	380	520	1020	860	1120	—	5	5	45	230	205	620	105	970	750
Rhiz. fragilissima	2.4	28	480	460	440	560	—	—	—	.8	5	3.2	50	35	60	.8
Rhiz. setigera	5	4.8	190	210	130	120	—	.2	—	.2	65	80	8.8	10	65	210
Rhiz. stolterfothii	16	400	300	530	160	290	—	—	1.2	1.6	60	60	190	115	190	1050
Skel. costatum f. tropicum	90	190	400	250	170	150	—	1	25.6	270	3270	10840	1030	1025	910	1100
Thalassionema nitzschioides	3.6	—	5.6	90	—	—	—	.4	—	3	175	85	8	200	5.6	45
Thal. mediterranea var. pacifica	.8	4.8	28	9.6	11.2	4	.4	—	—	.2	2.4	2.4	5.2	.4	5.6	2.6
Prorocentrum micans	2.4	.4	1.6	.8	4.8	.4	.8	.2	—	.8	—	—	—	.4	—	.4
Prorocentrum spp.	10.4	10.4	20	—	5.2	—	—	—	—	.2	—	—	—	—	—	—
Coccolithus huxleyi	20	40	10	50	20	10	5	15	10	5	15	10	10	5	10	10
Gephyrocapsa oceanica	80	60	20	20	70	70	5	5	15	40	30	60	45	80	20	40

TABLE V (Cont.) (Cells per liter)

DIATOMS: Actinoptychus undulatus var. catenata **80** 54t; Asterionella japonica **80** 55s, **880** 56t, **3500** 54t, **4500** 54s; Ast. japonica f. tropicum **200** 55t, **360** 56t; Asteromphalus flabellatus **40** 53s, **80** 45t; Bact. hyalinum **160** 45t,56t; Bact. hyalinum var. princeps **60** 53t, **240** 56t, **320** 55t, **440** 45s; Bact. varians **320** 45s; Biddulphia alternans **120** 54t; Bidd. aurita **120** 54t, **400** 55t; Bidd. mobiliensis **20** 53t, **80** 45,55t, **120** 55s, **140** 56t, **160** 54t, **320** 54s; Bidd. sinensis **40** 55s, **160** 55t, **520** 56t; Chaetoceros affinis var. circinalis **4000** 47s; Ch. anastomosans **3000** 46t; Ch. constrictus **31000** 46t;

Ch. densus **120** 46t, **160** 46s, **480** 45t; Ch. didymus **480** 45t, **800** 53t, **3000** 47t; Ch. didymus var. anglica **6000** 54s, **7000** 46t; Ch. didymus var. protuberans **160** 56s, **1000** 55t, **5500** 54t; Ch. diversus **400** 45t; Ch. laevis **40** 53t, **200** 45t, **320** 45s, **1000** 54t; Ch. rostratus **40** 45t, **80** 56s; Ch. socialis **500** 56s; Ch. subsecundus **400** 56s; Ch. teres **900** 45t; Corethron hystrix **40** 45t,46t,47, **80** 54t; Cosc. marginatus **40** 45t; Ditylum sol **40** 56t, **80** 54s,55t; Hemiaulus membranaceus **400** 54s, **420** 53t; Lauderiopsis sp. **240** 56t; Lithodesmium undulatum **40** 55s, **80** 56t, **120** 54t, **240** 54s; Melosira sulcata **320** 55t;

Rhiz. alata f. genuina **20** 56t, **40** 55t,53t, **160** 47s, **200** 53s, **280** 46t; Rhiz. alata f. indica **20** 53t, **40** 56t, **80** 45t,47t; Rhiz. alata f. genuina - indica intergrade **80** 45t; Rhiz. bergonii **20** 56t, **40** 55t, **80** 47s,55s; Rhiz. calcar avis **20** 48t, **40** 53s, **60** 53t; Rhiz. imbricata var. shrubsolei **80** 47t, **140** 53t, **280** 46t, **400** 56t; Rhiz. styliformis var. latissima **40** 53s; Schroederella delicatula **40** 53t, **80** 55t, **120** 47,55s, **160** 46,56s, **1600** 54s; Stephanopyxis turris **80** 56s, **200** 45t; Thalassiosira subtilis **320** 55t, **43000** 56t; Thalassiosira spp. **40** 55s, **60** 48t,54s, **160** 55t, **500** 48s, **680** 54t; Thalassiothrix frauenfeldii **160** 54t, **180** 53t, **640** 54s; Tropidoneis antarctica **40** 53t,55, **80** 56s.

DINOFLAGELLATES: Ceratium breve **40** 56t; Cer. falcatum **20** 56t; Cer. furca var. eugrammum **180** 56t; Cer. fusus var. setaceum **80** 46s; Cer. kofoidii **40** 45t,46t; Cer. pentagonum f. turgidum **20** 56t; Exuviaella baltica **1000** 47s,54s, **1500** 55s; Glenodinium lenticula f. minor **40** 45, **80** 55s,56t, **120** 46t,47t; Goniaulax scrippsae **80** 47s; Gon. spinifera **80** 45s; Noctiluca sp. **80** 56s; Oxytoxum variabile **500** 53t,54s, **1000** 46t; Peridinium claudicans **40** 47s; Per. depressum **20** 56t, **40** 55t, **80** 56s; Per. globulus **80** 56s; Per. leonis **20** 56t, **40** 47s,55t; Per. nipponicum **40** 55s, **120** 46t,55t; Per. oviforme **160** 46s, **880** 47s; Per. ovum **40** 45s; Per. subinerme **80** 45s, **240** 47s, **720** 46s; Per. trochoideum **3040** 47s; Per. tuba **40** 55s; Peridinium spp. **60** 56t, **80** 45, **160** 55t, **200** 47t, **400** 46s, **720** 47s; Prorocentrum gracile **40** 53t.

COCCOLITHOPHORES: Anoplosolenia brasiliensis **500** 53t; Calciosolenia sinuosa **500** 48s,54t,55s,56s, **1000** 53t; Halopappus adriaticus **500** 48s; Pontosphaera maximus **500** 55t.

DIVERSE: Chilomonas marina **500** 53t,54s,55t; Euglenaceae **500** 55t, **1000** 56t; Halosphaera **40** 46t, **80** 54s.