Surface Macrophytoplankton of the Pacific Ocean along the Equator

Information about the composition and abundance of the phytoplankton of the equatorial Pacific Ocean is limited. The most important contribution is the study by Hasle (1959, 1960*a*, *b*) of 23 bottle samples collected at three equatorial stations in the central Pacific Ocean. Semina (1960) and Kozlova and Mukhina (1967) have published counts from some stations near the Equator. Taxonomic observations may be found in Pavillard's (1935) and Rampi's (1952) papers. Sediment analysis as performed by Kolbe (1954) and Mukhina (1966), if handled with caution, also gives pertinent indications about the overlying plankton.

During the trans-Pacific cruise ALIZE (November 1964 to March 1965) of the RV *Coriolis* of the Centre O.R.S.T.O.M. de Nouméa, along the Equator from the Galapagos Islands to the New Guinea region, the study of phytoplankton was approached from several angles: determination of pigments, productivity measurements (*in situ* ^{14}C method), bottle samplings, and hauls of a Hardy indicator. This note considers the phytoplankton crops collected with the Hardy indicator.

MATERIALS AND METHODS

The cruise route and haul locations are shown in Fig. 1. From east to west, two series of 17 tows were made, respectively numbered 3 to 19 (24 November–10 December 1964) and 23 to 29 (18 February–7 March 1965).

The Hardy indicator used here conforms closely with the model described by Glover (1953) as "small plankton indicator," but the diving planes were taken off. Its main dimensions are: area of front aperture, 1.2 cm^2; area of filtering disk, 7.5 cm^2 (holes, 2.7 cm^2; threads, 4.8 cm^2); mesh size, 80 μ.

For sampling, the indicator was towed with a 15-m rope from the stern of the ship sailing at 18.5 km/hr. Under these circumstances, it works in the wake at 1 m deep; it is, however, assumed that the passing of the vessel and the propeller eddy make the water homogenous over a greater depth; therefore the catches are representative of the superficial first meters as a whole, even in smooth seas. Organisms thus collected are called surface macrophytoplankton.

The hauls took place daily at 1830 hours (local time) and lasted 10 min. The samples were preserved in a 4% neutralized formalin solution. Diatoms and dinoflagellates were identified (to genus or species) and counted under a microscope in a shallow cell engraved with a cross-ruling which permits either a sample count of abundant taxa or a total count of less common taxa.

According to Barnes (1951), Glover (1953), and Glover and Pope (1956), the filtered volume of water is a function of the haul length and of the area of the front aperture (i.e., 0.36 m^3 in this case). It is here assumed that the filtered volume is contained between this minimum value and a maximum value proportional to the effective filtering area (2.7 cm^2) of the sampling grid (i.e., 0.81 cm^3 in this case). The average value 0.5 m^3 will be used as an order of magnitude.

Although absolute measurements are illusive, the repetition of hauls under circumstances as identical as possible permits comparison of catches. Comparison with previous works demands a great deal of caution since sampling techniques may drastically affect the results (Hasle 1959, 1960*a*; Grall and Jacques 1964); Semina (1962) even mentions that she found almost no species common to samples collected by nets and by Nansen bottles.

Sampling with the Hardy indicator, which takes place over a rather long distance, has the advantage over pinpoint sampling of at least partially neutralizing the erratic effects of patchiness.

RESULTS

Surface equatorial waters of the Pacific Ocean are characterized by a consistent change with longitude in their physical and

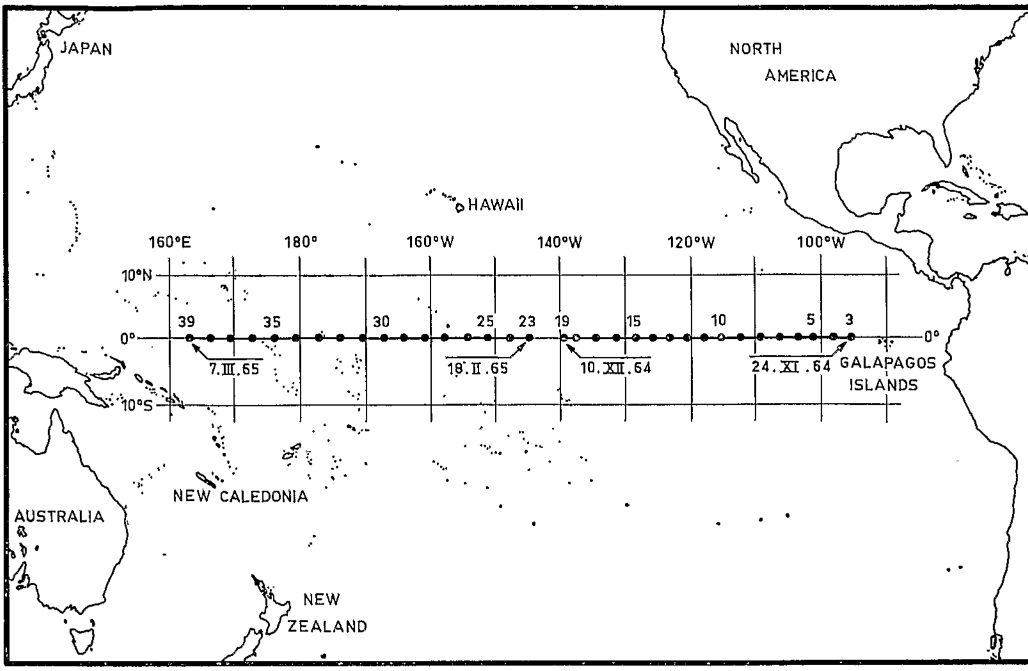

FIG. 1. Location of surface phytoplankton hauls during the cruise ALIZE of the RV *Coriolis* (November 1964–March 1965).

chemical properties: an increase in temperature from east to west and a decrease in phosphate and nitrate content, as shown in Fig. 2 (drawn from the data of Rotschi et al. 1967). Following a less regular, but marked pattern, the amount of macrophytoplankton decreases from the highest catches near the Galapagos Islands to practically nil by 160° E long (Fig. 3). The series of samples east of 140° W long is much richer than the western series; however, the long gap (over two months) between the two series makes the contrast less significant.

Records of the most abundant genera and species are given in Table 1 in which taxa under 1% of the catch are only mentioned as present.

The highest densities observed near the Galapagos are due to a few dominant species: *Rhizosolenia bergonii, Planktoniella sol, Pseudoeunotia doliolus* and *Coscinodiscus* sp. for diatoms; *Ceratium azoricum* and *Ceratium furca* for dinoflagellates. The maximum richness in diatoms recorded at sta. 6 arises from an overwhelming dominance of *R. bergonii.* The secondary peak which appears in the peridinians at 130° W long is caused by *C. furca* and accessorily by *Ceratium candelabrum.*

All species encountered are either cosmopolitan or warm-water species. Some taxa show a characteristic distribution which does not follow the general pattern: the genus *Chaetoceros* is relatively much more abundant in the western area than in the eastern; a few individuals of *Chaetoceros pacificus* Semina 1961 have been recorded at only stas. 4, 5, and 7; *Ceratium buceros,* which is unimportant as far as sta. 23, westward becomes a considerable fraction of the catch (up to 26% at sta. 35); *Ceratium teres* does not appear before sta. 15; *Ceratium declinatum,* almost absent in the first part of the cruise is continually present in the second; *C. azoricum,* which is among the dominant species at the first two stations, nearly disappears farther west; the first occurrence of the *Histioneis-Parahistioneis* group is observed at sta. 24.

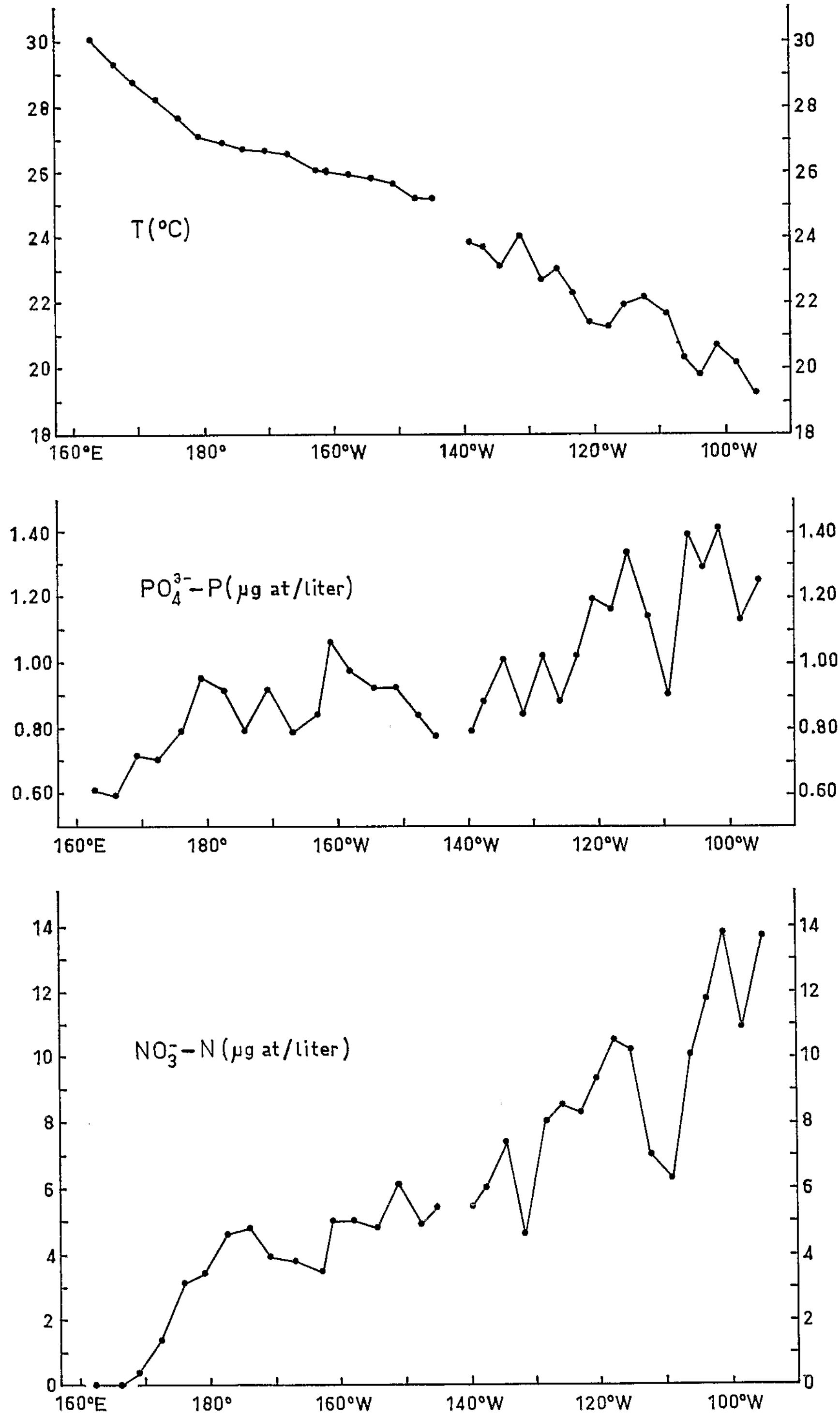

FIG. 2. Temperature, inorganic phosphate-phosphorus concentration, and nitrate-nitrogen concentration along the Equator surface.

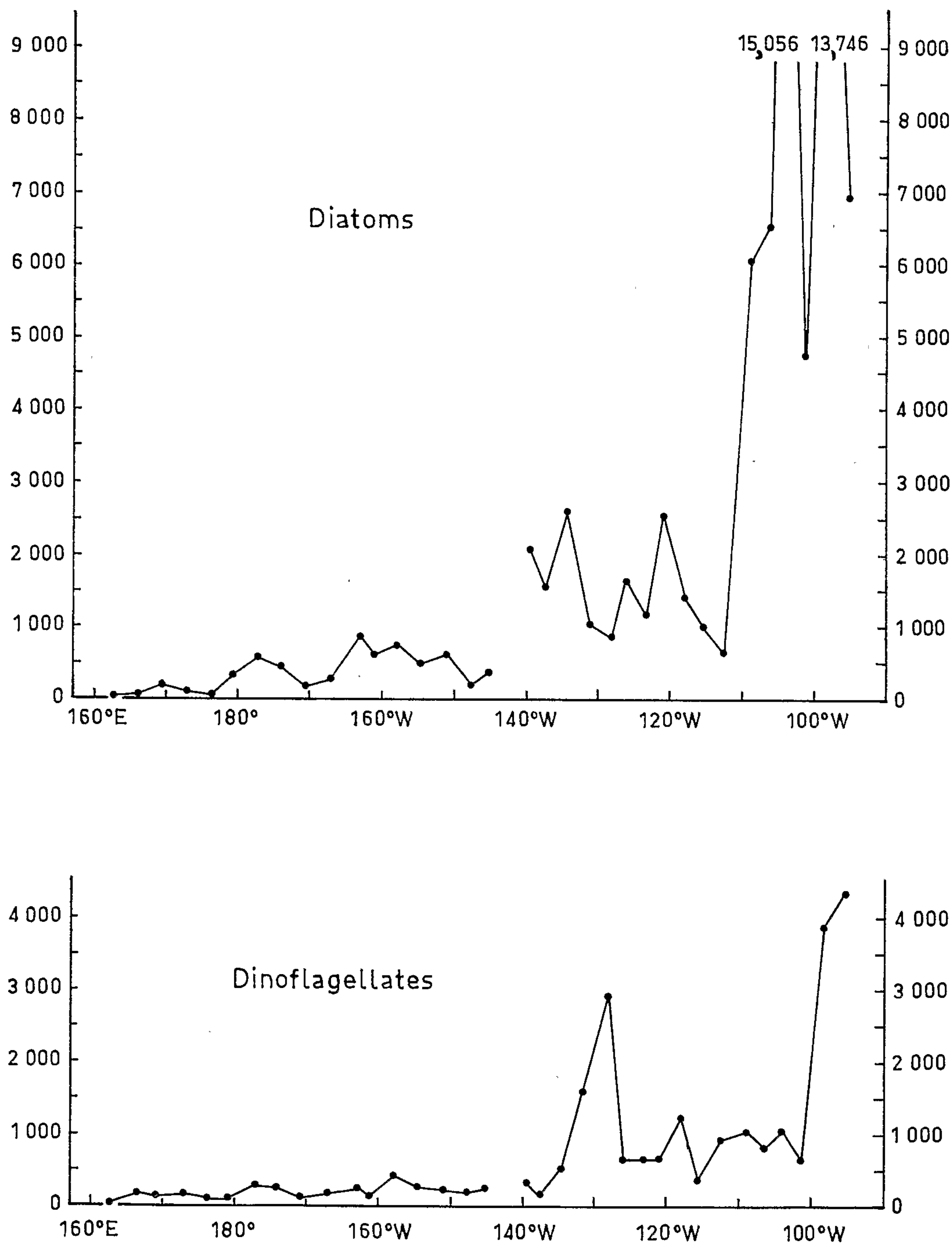

FIG. 3. Number of diatoms and dinoflagellates per 0.5-m^3 haul.

TABLE 1. *Number (or occurrence, noted p) of individuals of dominant taxa caught in a 0.5-m³ haul*

	Diatoms							Dinoflagellates (*Ceratium* sp.)									
Sta. No.	*Coscinodiscus*	*R. bergonii*	*P. doliolus*	*P. sol*	*H. cuneiformis*	*Asteromphalus*	*Chaetoceros*	*C. azoricum*	*C. furca*	*C. teres*	*C. kofoidii*	*C. buceros*	*C. pentagonum*	*C. breve*	*C. trichoceros*	*C. candelabrum*	*C. tripos*
3	2,192	624	1,792	1,856	208	160	p	1,424	2,000		p		p	p	p	p	224
4	3,120	704	3,696	5,296	224	272	p	2,672	432		p		p		p	p	p
5	1,200	272	1,568	1,392	p	176	p	176	176		144		176	p	p		p
6	2,384	9,024	1,600	2,256	224	416	p	176	832		p		p			p	p
7	1,056	1,664	1,126	2,192	80	432	p	112	208		240		128		p		p
8	448	160	2,288	2,832	160	160	p	160	112		352		160		p		p
9	72	120	72	276	36	60	p		552		96		84	p	72		p
10	216	120	276	228	24	132			240		36		24	p	p		p
11	288	204	420	132	48	336	p	p	1,080		84		p	p		p	
12	216	492	900	588	36	216	84	p	468		60	p	p	p	p	48	p
13	168	168	372	204	60	168		p	360		24	24	48	108		36	24
14	264	192	360	252	120	384	p		120		p	p	p	204	24	108	96
15	132	216	120	276	p	120	p	p	1,728	p	96	p	204	p	p	708	72
16	84	96	168	540	p	72	48	p	924	48	48	p	108	p	48	264	p
17	264	444	540	696	48	348	84	p	96	p	60	p	48	132	p	48	p
18	180	204	156	396	p	84	192	p	48	p	p		p		p	48	24
19	360	288	276	612	72	48	348	p	48		48			60		48	36
23	26	p	19	134	10	10	149	p	12	p	p	p	17	34	22	38	17
24	34		28	104	10	12		6	16	4	p	18	10	8	14	34	8
25	81		30	321	p	30	96	p	9	p	9	18	33	p	18	15	18
26	42	12	18	180		15	192	p	p		21	21	45		21	18	12
27	72		27	486	p	21	99	p	30	24	24	51	57	p	48	33	27
28	42		28	286	10	10	190	8		p	14	24	14		10	p	p
29	36	p	18	498	p	15	219	p	12	12	24	30	42	p	p	p	33
30	18		6	196		6	34	8	16	6	8	24	38	p	14	p	28
31	14	4	4	122	4	4	26		6	p	p	6	10	p	8	p	4
32	26	8	16	314	10	8	58	p	16	8	14	28	54	p	12	8	22
33	28	p		330	p	6	208		52	18	20	46	80	12	10		10
34	12	6	p	196	p	4	80	p		6	10	12	14		8		8
35	2		2	18			16	2	4	8	13	35	3	2	3	p	3
36		11		33			41	p	7	18	13	22	5	10	23	p	8
37	5	10		120			47	p	5	7	9	30	p	6	17	p	10
38	5			15			15		18	58	49	8	p	p	5		p
39		1		3			5		1	4	1		1	9	3		21

Although the biomass falls off from east to west, the number of species collected at each station increases eastward. This tendency to tropicalization which characterizes both the hydrological features and the planktonic flora is confirmed by the fact that typical tropical species like *Ceratium reflexum* and *Climacodium frauenfeldianum* have only been recorded at the last two stations, which are also the poorest.

It is possible to some extent to compare these results with those of authors who used nets. Semina (1960), sampling with a No. 38 mesh net (Soviet standard), collected in the equatorial surface layer, at 174° W long, about 2,000 organisms/m^3, 250 of which were *P. sol*. Assuming a haul filtering 0.5 m^3 of water at the same longitude, I found 1,344 organisms/m^3, including 628 cells of *P. sol*. At 140° W long, Kozlova and Mukhina (1967), using membrane filters or Lisitsyn's separator, counted 19,500 diatom cells/m^3, while my catch was only 4,192.

With regard to species distribution, kind and abundance of the flora, confirmation of previous results may be noted, with now and then some discrepancies. Mukhina (1966) quoted as dominant species in the sediment surface layer of the central Pacific (besides *Coscinodiscus nodulifer*, which is not sampled with the Hardy indicator because of its minute size of 40 μ): *Hemidiscus cuneiformis, R. bergonii, Nitzschia marina, Asteromphalus imbricatus, Actinocyclus ellipticus, Coscinodiscus africanus, Triceratium cinnamomeum, P. doliolus*, and *P. sol*. If the origin of the sample is considered, this list reproduces rather faithfully the species found in the current investigation. Sediment samples studied by Kolbe (1954) are particularly rich in *P. doliolus* in the Galapagos area; similarly Pavillard (1935) mentioned this species as important in his samples from the same area, also with *Coscinodiscus excentricus, Coscinodiscus radiatus, C. nodulifer, P. sol, Asteromphalus elegans, Asteromphalus heptactis, R. bergonii*, and *H. cuneiformis*. According to Rampi (1952), dominant species in the central Pacific near the Equator are *P. sol* and *R. bergonii*, and also on occasion, *Thalassiothrix longissima* and *Chaetoceros peruvianus*. The locality and abundance of *C. azoricum* in the extreme eastern area of the ocean substantiate the observations on this species by Steemann Nielsen (1934) and Graham and Bronikovsky (1944). The scarcity of the plankton in the New Guinea area confirms the absence of diatoms in sediments in this region (Kolbe 1954).

CONCLUSION

In spite of the unrefined technique used, it has been possible to assemble some qualitative and quantitative information about the surface macrophytoplankton along the Equator throughout the whole Pacific Ocean. This study confirms the richness of the Galapagos Islands area at the start of the South Equatorial Current, which is a continuation of the highly productive waters of the Humboldt Current. From east to west, the environmental features become more and more tropical: nutrient content decreases and temperature increases as the standing crop declines markedly.

ROGER DESROSIERES

Centre O.R.S.T.O.M.,[1]
Boîte postale 4,
Nouméa, New Caledonia.

REFERENCES

BARNES, H. 1951. A statistical study of the variability of catches obtained with two models of the Hardy plankton indicator. Hull Bull. Marine Ecol., **2**: 283–293.

GLOVER, R. S. 1953. The Hardy plankton indicator and sampler: a description of various models in use. Hull Bull. Marine Ecol., **4**: 7–20.

———, AND J. A. POPE. 1956. The Hardy plankton indicator: a study of the variation between catches taken by day and by night. Hull Bull. Marine Ecol., **7**: 115–134.

GRAHAM, H. W., AND N. BRONIKOVSKY. 1944. The genus *Ceratium* in the Pacific and North Atlantic Oceans. Scientific results of cruise

[1] Office de la Recherche Scientifique et Technique Outre Mer (Head office: 24, rue Bayard, Paris 8e).

VII of the *Carnegie*, Biology-V. Carnegie Inst. Wash. Publ. No. 565. 209 p.

GRALL, J. R., AND G. JACQUES. 1964. Etude dynamique et variations saisonnières du plancton de la région de Roscoff. Cahiers Biol. Marine, **5**: 423–455.

HASLE, G. R. 1959. A quantitative study of phytoplankton from the equatorial Pacific. Deep-Sea Res., **6**: 38–59.

———. 1960*a*. Phytoplankton and ciliate species from the tropical Pacific. Skrifter Norske Videnskaps-Akad. Oslo, I: Mat.-Naturv. Kl., **1960**(2): 50 p.

———. 1960*b*. Plankton coccolithophorids from subantarctic and equatorial Pacific. Nytt Mag. Bot., **8**: 77–88.

KOLBE, R. W. 1954. Diatoms from equatorial Pacific cores. Rept. Swed. Deep-Sea Exped., **6**: 1–49.

KOZLOVA, O. G., AND V. V. MUKHINA. 1967. Diatoms and silicoflagellates in suspension and floor sediments of the Pacific Ocean. [Transl. from Russian.] Intern. Geol. Rev., **9**: 1322–1342; Geokhim. Kremnezema, Akad. Nauk SSSR. 1966.

MUKHINA, V. V. 1966. The boundary between sediments of quaternary and tertiary age in the Pacific (on the basis of diatom analysis). [Transl. from Russian.] Okeanologiya, **6**: 99–110.

PAVILLARD, J. 1935. Péridiniens et Diatomées pélagiques recueillis par Alain Gerbault entre les Iles Marquises et les Iles Galapagos. Bull. Inst. Oceanog. No. 669. 8 p.

RAMPI, L. 1952. Ricerche sul microplancton di superficie del Pacifico tropicale. Bull. Inst. Oceanog. No. 1014. 16 p.

ROTSCHI, H., P. HISARD, L. LEMASSON, Y. MAGNIER, J. NOEL, AND B. PITON. 1967. Résultats des observations physico-chimiques de la croisière ALIZE du NO *Coriolis*. Office Rech. Sci. Tech. Outre Mer, Cent. Nouméa, Rept. No. 2. 56 p.

SEMINA, G. I. 1960. Phytoplankton distribution in the central Pacific Ocean [in Russian]. Tr. Inst. Okeanol., Akad. Nauk SSSR, **41**: 17–30.

———. 1962. Phytoplankton from the central Pacific collected along the meridian 174°W, part I. Methods and taxonomy [in Russian, English summary]. Tr. Inst. Okeanol., Akad. Nauk SSSR, **58**: 3–26.

STEEMANN NIELSEN, E. 1934. Untersuchungen über die Verbreitung, Biologie und Variation der Ceratien im südlichen Stillen Ocean. Dana Rept. No. 4. 67 p.

SURFACE MACROPHYTOPLANKTON OF THE PACIFIC OCEAN ALONG THE EQUATOR

ROGER DESROSIERES

Made in the United States of America
Reprinted from LIMNOLOGY AND OCEANOGRAPHY
Vol. 14, No. 4, July 1969
pp. 626–632