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INTRODUCTION

The phytoplankton of the Suez Canal has not been studied in detail since the preliminary reports of Macdonald (1933) and Ghazzawi (1939). During the last few years the Suez Canal has been, for the first time since it was opened in 1869, free from traffic. The continuous stirring-up of bottom sediments caused by the propellers of ships traversing the canal and the processes of canal maintenance caused the canal waters to be almost always turbid. This condition drastically affected the plankton populations of the canal, particularly the phytoplankton. Coincident with this period, and by virtue of the erection of the Aswan High Dam, the flow of Nile water to the Mediterranean Sea has been drastically reduced. Consequently, the annual dilution of the waters of the northern part of the canal in late summer no longer occurs. The consequences have also affected the quantitative and qualitative distribution of phytoplankton inhabiting the canal.

In view of these unique conditions in the history of the canal and because of the lack of any particular study of the Suez Canal plankton during the last 40 years, the present investigation was deemed necessary.

METHODS AND MATERIALS

Three sites in the Suez Canal were chosen as representative of ecologically different habitats. The sites included Port Said Harbor at the extreme northern end of the canal, the Great Bitter Lake, and Suez Bay at the southern entrance of the canal. Sampling was conducted during summer and winter seasons. These two seasons represent the extreme conditions as regards temperature, salinity and current pattern in the canal. The summer samples were collected on 3, 4 and 7 July 1969 from Bitter Lake, Suez Bay and Port Said respectively. The winter samples at each site were collected on 7, 8 and 14 February 1970 respectively. Plankton samples were taken by a fine-net (200 mesh/inch) 50 cm in diameter. At each site 3 vertical as well as horizontal hauls were taken. Triplicates of surface water samples 2 L each (i.e., 6 L) were also collected from each site. All samples were preserved in 4 percent neutral formalin. Mixed vertical and horizontal net samples from each site were qualitatively examined to determine the species composition of the phytoplankton population. They were also used to determine the relative abundance of the species. This was arbitrarily done by counting the cells in 2 ml aliquots of the surface hauls and the percentage abundance of each species was obtained. Species constituting less than 5 percent were considered rare, 5 to 20 percent frequent, 20 to 40 percent common, and more than 40 percent abundant. Delicate forms of diatoms and all dinoflagellates were identified directly from untreated samples while other forms were identified from cleaned samples following the technique of Cupp (1943). The quantitative estimation of the phytoplankton standing crop was carried out following the sedimentation counting method of Utermöhl (1936). The 6 L collected from each site in each season were concentrated by sedimentation to a final volume of 200 ml. From this, 5 aliquots of 2 ml each were counted and the average numbers obtained were converted to represent the number of cells/L.

At each site, surface temperature was recorded; surface salinity was determined by the Mohr-Knudsen method using Knudsen Hydrographical tables and the hydrographical tables for high salinities (Morcos, 1960).

RESULTS

Composition of the Phytoplankton Population.

The present phytoplankton population of the Suez Canal is highly diversified. Altogether, 273 species and varieties were identified from both the net and water samples procured from the different regions in the canal in both summer and winter seasons (Table 1). These comprise 182 diatom species and varieties representing 58 genera, 88 dinoflagellates including 17 genera, one species of silicoflagellates and 2 species belonging to Ibriidae. Table 2 shows the number of species recorded in each region as well as the relevant temperature and salinity data recorded in both seasons. As shown in Table 2, the number of species varied widely in the different regions sampled. About 50 percent of the species recorded were widespread in the three regions while only 8 percent were confined to the Suez Bay and/or Bitter Lake regions.

Among the three sites sampled, the area of Port Said was the richest in phytoplankton species. At Port Said, 253 species and varieties were identified representing 93 percent of the total number recorded in the canal. The diatoms were represented by 172 species and varieties forming 68 percent of the number of species recorded at Port Said. About 32 percent (88 species) of the species recorded in Port Said were confined to this region, being absent from the Bitter Lake and Suez Bay regions (Table 3).

Table 1. Species of phytoplankton recorded from Port Said (PS), Bitter Lake (BL) and Suez Bay (SB) during summer 1969 (S) and winter 1970 (W). * = new to the Red Sea; 0 = new to the Eastern Mediterranean; x = new to the northern Red Sea being known from the Red Sea south of Latitude 20° (Halim 1969); + = rare; f = frequent; c = common; A = abundant.

Species	PS		BL		SB	
	S	W	S	W	S	W
Diatoms						
Centricae						
* *Melosira moniliformis* (Müller) Agardh	f	c	+	+	+	+
M. nummuloides (Dillw.) Agardh	+	+	—	—	—	—
M. borreri Grev.	f	—	—	—	—	—
M. granulata (Ehr.) Ralfs	+	f	—	—	—	—
M. sulcata (Ehr.) Kütz.	+	f	+	+	+	+
* *Melosira (Discosira) sulcata* Rabenhorst	+	+	—	+	—	+
M. varians Agardh	—	+	—	—	—	—
Podosira montagnei Kütz.	+	+	—	—	—	—
P. stelliger (Bail.) Mann	+	+	—	—	—	+
Hyalodiscus laevis Ehr.	—	+	—	—	—	—
* *Skeletonema costatum* (Grev.) Cleve	f	c	+	f	+	f
Coscinosira polychorda Gran	+	c	—	—	—	—
Thalassiosira decipiens (Grun.) Jorg.	c	c	—	—	—	—
T. rotula Meunier	c	f	—	—	—	—
* *T. subtilis* (Ost.) Gran	+	+	+	f	+	f
Cyclotella bodanica Eulenstein	—	+	—	—	—	—
C. meneghiniana Kütz.	f	f	—	—	—	—
* *Coscinodiscus centralis* Ehr.	c	c	f	f	+	c
C. concinnus W. Smith	f	f	—	—	—	—
C. excentricus Ehr.	f	c	f	c	c	c
C. gigas Ehr.	A	c	+	c	+	c
* *C. granii* Gough	c	c	+	+	+	f
C. lineatus Ehr.	f	+	—	—	—	—
* *C. nitidus* Greg.	f	+	+	f	f	f
C. nobilis Grun.	—	+	c	c	c	c
C. nodulifer Schmidt	f	—	—	—	—	—
* *Coscinodiscus oculus-iridis* Ehr.	c	c	c	c	f	c
C. pavillardii Forti	f	f	—	—	—	—
* *C. perforatus Ehr.*	f	c	—	—	+	c
C. radiatus Ehr.	—	—	—	+	—	f
* *C. subtilis* Ehr.	—	—	+	f	+	c
C. thorii Pavill.	f	+	—	—	—	—
Planktoniella sol (Wallich) Schütt	—	—	—	—	+	+
* *Actinoptychus undulatus* Ralfs	+	+	—	—	+	—
Asterolampra marylandica Ehr.	+	+	—	—	—	+
Asteromphalus flabellatus Grev.	+	—	—	—	+	+
* *A. heptactis* Bréb.	+	+	—	—	—	+
* *Gossleriella tropica* Schütt	—	—	—	—	+	—
Corethron criophilum Castr.	—	—	—	—	+	+
Lauderia borealis Gran	f	+	—	—	—	—
Schroederella delicatula (Pérag.) Pavill.	—	f	—	—	—	—
* *S. schroederi* Bergon	—	—	—	—	+	—
* *Detonula confervacea* (Cleve) Gran	+	+	—	—	+	—
Dactyliosolen mediterraneus Péragallo	c	f	f	+	+	f
Leptocylindrus danicus Cleve	f	c	+	c	c	c
L. minimus Gran	f	+	—	—	+	—
Guinardia blavyana Péragollo	—	+	—	—	—	—
G. flaccida Castr.	c	c	f	c	c	c
Rhizosolenia alata Brightw.	f	c	A	c	c	c
R. var. *curvirostris* Gran.	—	+	—	—	—	—

Table 1. Cont'd.

Species	PS		BL		SB	
	S	W	S	W	S	W
R. var. *gracillima* Cleve	+	f	A	f	c	f
R. var. *indica* Péragollo	f	f	A	f	c	c
R. calcaravis M. Schültze	c	c	c	c	c	c
* *R. cochlea* Brun	—	—	—	—	+	—
* *R. cylindrus* Cleve	—	—	f	—	f	—
* *R. delicatula* Cleve	f	A	+	c	+	f
R. fragillissima Bergon	f	f	—	—	—	—
R. hebetata Bail. f. *semispina* (Hen.) Gran	f	+	—	—	—	—
R. imbricata Brightw.	+	f	f	f	—	f
R. robusta Norman	+	+	—	—	—	—
* *R. setigera* Brightw.	—	+	—	+	—	+
R. shrubsolei Cleve	c	A	+	A	f	A
R. stolterfothii Péragollo	f	+	f	+	f	+
R. styliformis Brightw.	—	+	—	+	—	+
Bacteriastrum delicatulum Cleve	c	c	c	f	c	+
B. elegans Pavill.	+	+	—	—	—	—
B. hyalinum Lauder	A	—	+	—	—	—
Chaetoceros affinis Lauder	f	f	+	+	f	+
C. borealis Bail.	—	+	—	—	—	—
C. brevis Schütt	f	f	—	—	—	—
C. coarctatus Lauder	—	—	—	—	—	f
C. compressus Lauder	c	f	—	—	+	—
C. costatus Pavill.	—	+	—	—	—	—
C. concavicornis Mangin	—	+	—	—	—	—
C. crinitus Schütt	+	—	—	—	—	—
C. curvisetus Cleve	c	f	—	—	—	—
C. danicus Cleve	—	+	—	—	—	—
C. decipiens Cleve	c	c	—	+	—	+
C. densus Cleve	—	+	—	—	—	—
* *C. didymus* Ehr.	c	c	+	f	+	f
C. diversus Cleve	c	c	—	—	—	—
C. gracilis Schütt	—	+	—	—	—	—
* *C. holsaticus* Schütt	c	f	—	—	—	+
* *C. laciniosus* Schütt	—	+	—	—	—	+
C. lorenzianus Grun.	f	+	—	—	—	+
C. peruvianus Brightw.	+	—	—	—	—	+
C. rostratus Lauder	—	+	—	—	—	—
C. simplex Ost.	—	+	—	—	—	—
C. socialis Lauder	—	+	—	—	—	—
* *C. tetrastichon* Cleve	—	—	—	—	—	+
C. tortissimus Gran	—	+	—	—	—	—
* *Streptotheca thamesis* Schrubsole	c	A	—	—	—	+
Bellerochea malleus (Brightw.) Van Heurck	—	f	—	—	—	—
* *Ditylum brightwellii* (West) Grun.	+	f	—	+	—	+
Lithodesmium undulatum Ehr.	f	c	—	f	—	+
Triceratium alternans Bail.	f	+	—	—	—	—
* *T. antidiluvianum* (Ehr.) Grun.	+	+	—	+	—	+
* *T. favus* Ehr.	+	f	—	+	—	+
* *Biddulphia aurita* (Lyngb.) Bréb.	+	f	—	—	—	+
B. biddulphiana (W. Smith) Boyer	—	+	—	—	—	—
B. levis Ehr.	—	+	—	—	—	—
* *B. mobiliensis* (Bail.) Grun.	c	f	+	f	+	f
* *B. obtusa* Kütz.	c	f	—	—	—	+
B. rhombus (Ehr.) W. Smith	+	f	—	—	—	—
* *B. schroederiana* Schussnig	+	+	+	+	f	+
* *B. sinensis* Grev.	—	+	—	+	—	f
B. pelagica Schröder	—	+	—	f	—	f
B. pulchella Gray	—	+	—	—	—	—

Table 1. Cont'd.

Species	PS S	PS W	BL S	BL W	SB S	SB W
B. subaequa (Kütz.) Ralfs	—	f	—	—	—	—
* *B. tuomeyi* (Bail.) Roper	—	+	+	—	+	+
* *Cerataulus smithii* Ralfs	f	+	—	—	—	+
* *Isthmia nervosa* Kütz.	—	—	—	—	+	—
Cerataulina bergonii Péragallo	—	+	—	—	—	—
Hemialus hauckii Grun.	f	f	c	—	c	+
H. membranaceus Cleve	—	+	—	+	—	f
H. sinensis Grev.	f	f	+	+	+	+
Hemidiscus cuneiformis Wall.	—	+	—	+	—	+
Pennatae						
* *Striatella unipunctata* (Lyngb.) Agardh	f	—	+	+	f	+
S. delicatula (Kütz.) Grun.	—	+	—	+	+	+
Grammatophora angulosa Ehr.	—	+	—	—	—	—
* *G. marina* (Lyngb.) Kütz.	f	c	—	+	—	+
G. oceanica Grun.	f	f	+	—	—	—
* *Rhabdonema adriaticum* Kütz.	f	f	—	+	f	+
Licmophora abbreviata Agardh	c	+	—	—	—	—
* *L. flabellata* Agardh	+	+	—	+	+	+
Climacosphenia elongata Bail.	—	+	—	—	—	—
Plagiogramma vanheurckii Grun.	—	+	—	—	—	—
* *Fragillaria oceanica* Cleve	+	+	—	f	—	+
Synedra crystallina (Agardh) Kütz.	+	+	—	+	—	+
* *S. hennedyana* Grég.	—	+	—	+	—	+
* *S. ulna* Nitz.	—	+	—	+	—	+
S. undulata Bail.	—	+	—	—	—	—
* *S. fulgens* W. Smith	—	f	—	—	+	—
Thalassionema nitzschioides Grun.	c	f	f	f	f	f
Thalassiothrix frauenfeldii (Grun.) Cleve and Grun.	f	c	—	c	—	c
T. longissima Cleve	f	f	+	f	f	f
T. mediterranea Pavill.	f	f	—	—	—	—
* *Asterionella japonica* Cleve	+	f	—	f	+	f
Achnanthes brevipes Agardh	f	f	—	—	—	—
* *A. longipes* Agardh	f	c	+	+	+	+
* *Cocconeis placentula* Ehr.	+	f	+	—	+	—
* *C. scutellum* Ehr.	+	+	—	+	—	+
* *Navicula lyra* Ehr.	—	+	—	+	—	+
N. lyroides Hendey	—	+	—	+	—	+
N. membranacea Cleve	+	+	—	+	—	c
Pleurosigma aestuarii (Bréb.) W. Smith	—	f	—	—	—	—
P. angulatum (Quèck.) W. Smith	+	+	—	—	—	—
* *P. formosum* W. Smith	+	+	—	+	+	+
* *Pleurosigma elongatum* W. Smith	+	+	—	+	+	—
* *P. latum* Cleve	+	—	+	—	+	+
* *P. naviculaceum* Bréb.	+	—	+	+	+	+
* *P. rectum* Donkin	—	+	—	+	+	+
* *P. normani* Ralfs	—	+	+	+	+	+
Gyrosigma acuminatum Rabenhorst	—	+	—	—	—	—
* *G. balticum* (Ehr.) Cleve	f	c	+	f	+	f
G. hippocampus (Ehr.) Hassall	—	+	—	—	—	—
* *G. spenecerii* (Quèck.) Cleve	—	+	f	—	f	+
* *G. strigile* W. Smith.	—	+	—	+	—	+
* *Trachyneis aspera* (Ehr.) Cleve	—	+	—	—	—	+
* *Tropidoneis lepidoptera* (Grég.) Cleve	+	+	—	f	+	+
Amphora ovalis Kütz.	—	+	—	—	—	—
* *Nitzschia bilobata* W. Smith var. *minor* Grun.	f	+	+	f	+	+
* *N. closterium* (Ehr.) W. Smith	+	f	+	+	+	+

Table 1. Cont'd.

Species	PS S	PS W	BL S	BL W	SB S	SB W
* *N. delicatissima* Cleve	+	f	—	+	+	+
N. longissima (Bréb.) Ralfs	c	+	+	+	+	f
N. lorenziana Green	f	+	+	+	+	+
N. paradoxa (Gmelin) Grun.	c	f	f	+	+	f
N. punctata (W. Smith) Grun.	—	+	—	+	—	—
N. seriata Cleve	f	f	—	f	+	f
* *N. sigma* W. Smith	f	f	+	f	+	f
* *Nitzschia* spp.	—	—	+	+	+	f
* *Surirella fastuosa* (Ehr.) Kütz.	+	f	—	+	f	f
* *S. fluminensis* Grun.	—	f	—	f	+	+
* *S. gemma* (Ehr.) Kütz.	+	f	+	+	f	+
* *S. striatella* Turp	—	f	—	f	—	+
* *S. ovalis* Kütz.	—	+	—	+	+	+
S. ovata Kütz.	—	+	—	—	—	—
Surirella spp.	—	—	+	f	+	f
Campylodiscus balearicus Cleve	+	f	—	—	—	—
* *C. decorus* Bréb.	+	f	—	+	—	+
* *C. echeneis* Ehr.	—	c	+	+	+	f
C. fastuosus Ehr.	—	+	+	+	+	+
Dinoflagellates						
Exuviaella baltica Lohm.	f	c	—	—	—	—
E. compressa Ost.	+	+	f	f	f	f
E. cordata Ost.	f	+	—	—	—	—
E. marina Cienk.	f	f	—	+	+	—
E. oblonga Ost.	—	—	+	+	f	f
Prorocentrum adriaticum Schiller	c	f	—	—	—	—
P. dentatum Stein	—	+	—	—	—	—
P. micans Ehr.	f	+	+	f	+	f
P. rotundatum Schiller	+	+	—	—	—	—
Dynophysis caudata Saville Kent	f	f	+	f	+	c
D. tripos Gourret	—	—	—	—	—	+
Ornithocercus magnificus (Stein) Schultz	+	+	—	—	—	+
O. quadratus Schütt	—	—	—	+	—	+
Amphisolenia bidentata Schröder	+	+	—	f	f	c
Pyrophacus horologicum Stein	f	c	f	f	f	f
Diplopsalis asymmetrica Mangin	+	+	—	+	+	—
D. lenticula (Bergh) Lebour	—	+	—	+	+	—
Peridinium abei Paulsen	—	+	—	—	+	+
P. achromaticum Levander	+	—	—	—	—	—
P. africanoides Dangeard	—	+	+	+	—	+
P. breve Paulsen	—	+	—	—	—	—
* *P. brochii* Kof. and Swezy	+	+	—	—	+	+
* *P. cerasus* Paulsen	f	c	c	f	f	f
P. conicum (Gran) Ost. and Schm.	+	+	c	—	+	—
P. crassipes Kofoid	—	—	+	+	c	f
P. depressum Bail.	c	c	+	c	f	c
P. divergens Ehr.	c	+	—	—	—	—
P. grande Kof.	—	—	+	+	c	+
P. granii Ost.	+	+	—	—	—	—
P. mite Pavill.	+	—	—	—	—	—
P. nipponicum Abé	—	+	—	—	—	+
* *P. pallidum* Ost.	+	f	—	+	+	f
Peridinium pentagonum Gran	f	f	—	—	—	—
P. punctulatum Paulsen	+	f	—	—	—	—
P. steinii Jorg.	+	+	—	—	—	—
P. trochoideum (Stein) Lemm.	+	c	—	—	—	—
Goniaulax dicantha Meunier	—	+	—	—	—	—

Table 1. Cont'd.

Species	PS		BL		SB	
	S	W	S	W	S	W
G. digitale (Pauchet) Kof.	+	+	—	—	—	—
G. polyedra Stein	+	+	—	—	—	—
G. polygramma Stein	+	c	f	+	+	f
G. turbynei Murr. and Whitt.	+	+	+	—	+	+
Ceratium arietinum Cleve	—	+	—	+	+	—
C. arietinum Cleve var. *gracilentum* Jörg.	f	f	c	f	c	f
C. belone Cleve	—	—	f	+	f	+
C. breve (Ost. and Schmidt) Schröder	—	+	f	f	f	c
C. candelabrum (Ehr.) Stein	f	+	+	f	f	c
C. carriense Gourret var. *volans* (Cleve) Jörg.	—	+	+	+	f	f
0 *C. contortum* (Gourret) Cleve	—	f	+	+	f	c
* *C. declinatum* Karst. var. *declinatum* Peters	—	f	+	f	c	c
C. contrarium Pavill.	f	f	+	+	f	f
C. egyptiacum Halim	+	f	+	+	f	f
C. extensum (Gourret) Cleve	+	f	c	f	c	f
* *C. falcatum* (Kor.) Jorg.	+	f	+	f	f	f
C. furca (Ehr.) Clap. and Lachm.	—	—	+	—	+	—
C. fusus (Ehr.) Dujardin	c	c	c	c	c	c
C. gibberum Gourret	c	c	c	c	c	c
C. hexacanthum Gourret	—	+	—	—	—	—
* *C. horridum* Gran	f	+	+	+	+	+
C. horridum Gran var. *molle* (Kof.) *Jörg.*	f	f	+	+	c	c
* *C. inflatum* (Kof.) Jörg.	+	+	+	f	+	c
C. karsteni Pavill.	+	f	+	f	+	c
* *C. kofoidii* Jörg.	+	+	f	f	f	+
* *C. longirostrum* Gourret	—	—	—	+	+	+
0 *C. lunula* Schimper	+	f	—	+	—	f
C. macroceros (Ehr.) Cleve subsp. *gallicum*	—	+	f	f	f	f
(Kof.) Schiller	+	+	+	c	+	c
* *C. massiliense* (Gourret) Jorg.	f	+	f	+	c	A
C. pentagonum Gourret	+	+	f	+	f	c
C. eupulchellum Jorg.	c	f	f	+	f	f
C. schmidtii Jorg.	—	—	f	f	f	f
C. strictum (Okam. and Nish.) Kof.	+	—	—	—	—	—
C. symmetricum Pavill.	—	+	+	f	+	f
C. tenue Ost. and Schmnd var. *inclinatum* (Kof.) Jörg.	+	+	+	f	f	c
* *C. teres* Schiller	+	+	—	+	f	+
C. trichoceros (Ehr.) Kof.	+	+	c	f	c	c
C. tripos (Müller) Nitz.	+	+	+	f	f	c
C. tripos var. *atlanticum* Ost.	—	+	—	—	—	—
Goniodoma polyedricum Pouchet	—	+	—	—	—	+
Ceratocorys armata Kof.	f	—	—	—	—	+
C. gourreti Paulsen	f	—	—	—	+	—
C. horrida Stein	+	+	—	—	+	+
Oxytoxum longiceps Schiller	—	+	—	—	—	—
O. milneri Murr. and Whitt.	—	+	—	—	—	—
Podolampas elegans Schütt	—	+	—	—	—	—
Cladopyxis brachiolata Stein	—	+	—	—	+	+
Pyrocystis lunula Schütt	+	+	—	—	+	+
P. pseudonoctiluca Thompson	—	+	—	—	—	+
Pyrodinium schilleri (Matz.) Schiller	—	—	—	+	—	+
Silicoflagellates						
Dictyocha octonaria Ehr.	—	+	—	—	—	—
Ibriidae						
* *Hermisenium adriaticum* Zacch.	+	—	—	—	+	—
Ibria tripartita Borg	+	—	—	—	—	—

Table 2. Temperature, salinity and number of phytoplankton species recorded from Port Said (PS), Bitter Lake (BL) and Suez Bay (SB) in summer 1969 and winter 1970.

	Summer			Winter		
	PS	BL	SB	PS	BL	SB
Temperature (°C)	28.8	29.3	29.8	14.5	14.6	15.1
Salinity (‰)	38.2	45.8	41.8	38.8	44.6	41.2
Number of species						
Diatoms	112	54	76	160	88	105
Centricae	75	32	41	100	43	60
Pennatae	37	22	35	60	45	45
Dinoflagellates	56	42	55	72	50	58
Ceratia	23	29	32	31	32	31
Other genera	33	13	23	41	18	27
Silicoflagellates	—	—	—	1	—	—
Ibriidae	2	—	1	—	—	—
Total number of species	170	96	132	233	138	163

Most of the species recorded in Port Said belong to the Mediterranean flora, being known from various regions in the Mediterranean and Adriatic seas (Pavillard, 1916, 1925, 1937; Ercegović, 1936; Zanon, 1940; Tregouboff and Rose, 1957; Wawrik, 1961; Dowidar, 1965). Among the diatoms, tropical elements are few, while the dinoflagellate population contains a relatively large number of tropical and subtropical species. A few of the tropical species recorded at Port Said may be regarded as new to the Mediterranean, particularly the Eastern Basin including *Coscinodiscus nobilis, Thalassiosira subtilis, Biddulphia, chroederiana, Ceratium lunula, C. breve* and *C. contortum.* To these may be added a numebr of Indopacific species which have been previously reported in Port Said and/or off Alexandria (Dowidar, 1975; 1971; Halim, 1970) including *Coscinodiscus gigas, Biddulphia sinensis, B. pelagica, Peridinium affricanoides, P. nipponicum* and *Ceratium egyptiacum.* These species are immigrants into the Mediterranean

Table 3. Distribution of number of phytoplankton species recorded from the Suez Canal. W = species recorded from all 3 sites; PS = species only from Port Said; SB = species only from Suez Bay; PS-BL = species only from Port Said and Bitter Lake; PS-SB = species only from Port Said and Suez Bay; SB-BL = species only from Suez Bay and Bitter Lake.

Group	Total Number	W	PS	SB	PS-BL	PS-SB	SB-BL
Diatoms	182	89	63	7	4	16	3
Centricae	117	44	49	7	—	14	3
Pennatae	65	45	14	—	4	2	—
Dinoflagellates	88	44	23	1	—	11	9
Ceratia	36	29	3	—	—	—	4
Other genera	52	15	20	1	—	11	5
Silicoflagellates	1	—	1	—	—	—	—
Ebriidae	2	—	1	—	—	—	—
Total number of species	273	133	88	8	4	28	12

through the Suez Canal. The population of Port Said Harbor also contains some brackish water or estuarine elements including *Melosira granulata* var. *angustissima, M. varians, Hyalodiscus laevis, Cyclotella bodanica* and *Surirella ovata*. These are transported to Port Said Harbor from Lake Manzalah, an adjacent brackish water lake.

The phytoplankton population of the Suez Bay was composed of 181 species and varieties forming 66.5 percent of the total number recorded in the canal. The diatoms constituted 60 percent of the number of species. It is of interest to mention that although the plankton of the Suez Bay belongs primarily to that of the Red Sea, it was found that about 90 percent of the species recorded in the Suez Bay occured also in Port Said. Halim (1969) collected references of 204 phytoplankton species (80 diatoms and 124 dinoflagellates) occuring in different regions of the Red Sea. Most of them were, however, recorded from oceanic waters as the neritic waters of the Red Sea were rarely sampled. Judging from previous records (Halim, 1969) about 90 species of those recorded in Suez Bay in the present study may be regarded as new to the Red Sea (Table 1). Most of these new records are neritic forms with tropical and/or subtropical affinities and are widely distributed in the neritic waters of the Indian Ocean; a few are, however, cosmopolitan (Sournia, 1967, 1968).

The Bitter Lake population was relatively poor in species. A total of 149 species and varieties forming 55 percent of the total number were recorded in this region. Of these, the diatoms were represented by 96 species forming about 64 percent of the population. A total of 91 percent of the species present in the Bitter Lake were also recorded in Port Said.

A large number of the species recorded in the Suez Canal are probably perennial, occurring in both summer and winter seasons in one or more of the regions sampled. The winter populations were, however, predominant in species particularly in Port Said (Table 2). The total number of species recorded in Port Said, Bitter Lake and Suez Bay were 170, 96 and 132 in summer and 233, 138 and 163 in winter respectively. The seasonal and regional variation in the number of species were mostly due to variations in the number of diatom species; fluctuations in the number of dinoflagellate species were on the whole less pronounced. The number of dinoflagellate species in Port Said, Bitter Lake and Suez Bay were 56, 42 and 55 in summer and 72, 50 and 58 in winter respectively.

Quantitative Distribution

Regardless of the comparatively large number of species recorded in the Suez Canal, the greater bulk of the population was formed by a relatively small number of species. Furthermore, the numerical contribution of the dinoflagellates to the phytoplankton standing crop was very small and in most cases not exceeding 2 percent. Table 4 shows the results of analysis of the water samples taken in each region.

During summer, the standing crop decreased from north to south. The maximum (68,810 cells/L) was recorded in Port Said in July. This was mostly due to the diatom *Bacteriastrum hyalinum* which constituted about 50 percent of the total population. The species which were more or less common included *Chaetoceros didymus, C. affinis, C. compressus, Skeletonema*

Table 4. Standing crop of phytoplankton (cells/L) recorded from Port Said (PS), Bitter Lake (BL) and Suez Bay (SB) during summer 1969 (July) and winter 1970 (February).

Species	Summer			Winter		
	PS	BL	SB	PS	BL	SB
Standing crop (cels/L)	68,810	53.620	6,870	31,400	37,580	12,330
Skeletonema costatum	2600			3200	2000	1200
Coscinosira polychorda				300		
Thalassiosira decipiens	1800	120		500		
T. rotula	1040			200		
T. subtilis	1800			800		
Coscinodiscus centralis	270	50		150		200
C. excentricus		50	80	200	250	150
C. gigas	630	60	120	300	120	250
C. grani	180			150		
C. nobilis		80	100		150	180
C. oculus-iridis	450	60	40	200	200	180
C. perforatus				150	100	150
C. subtilis						200
Dactyliosolen mediterraneus	650			200		
Leptocylindrus danicus	500	120	700	2000	1800	1200
Guinardia flaccida	1200	960	1200	1200	1600	800
Rhizoselnia alata	300	44,040	1200	800	3200	1600
R. alata var. *gracillima*		1800	800			
var. *indica*		960	600			400
R. calcaravis	250	240	500	600	200	200
R. delicatula	1200	600	800	5800	4500	2000
R. shrubsolei	1800			8800	23,000	3300
Bacteriastrum hyalinum	34,200	800		1200		
B. delicatulum	1630			800		
Chaetoceros affinis	5220	200				
C. compressus	2790	120				
C. curvisetus	900			600		
C. decipiens	450					
C. didymus	5400	300		1200		
C. diversus	900			400		
Lithodesmum undulatum				600		
Hemiaulus hauckii	50	480	200			
H. sinensis	800	120				
Grammatophora marina				400		
Thalassionema nitzschioides	1160	1140	150			
Pleurosigma balticum	50	240	80	200	150	250
Pleurosigma spp.	50	300	50			
Nitzschia spp.	160	60	80			
Surirella spp.	20	60				
Exuviaella compressa	80	120	50		80	
Prorocentrum adriaticum	50	120		120	60	
Goniaulax polygrama	50				60	
Goniaulax spp.				80		
Peridinium trochoideum				100		
P. depressum		60				
P. extensum						20
Ceratium furca	40	60		30	30	
Other dinoflagellates	100	300	120	120	80	50

costatum, *Rhizosolenia* spp. (particularly *R. shrubsolei* and *R. delicatula*) *Thalassionema nitzschioides*, *Thalassiosira* spp., *Bacteriastrum delicatulum*, and *Guinardia flaccida*. In the Bitter Lake, the summer standing crop (53,620 cells/L) was about 80 percent of that of the Port Said region. The dominant species were, however, different. *Rhizosolenia alata* (including var. *gracillima* and var. *indica*) dominated the population by 87 percent. *Thalassionema nitzschioides*, *Guinardia flaccida*, *Bacteriastrum hyalinum*, *Rhizosolenia delicatula* and *Hemiaulus hauckii* followed in abundance. The standing crop in the Suez Bay during summer (6870 cells/L) was very low, being less than 10 percent of that in Port Said. The leading species were, *Rhizosolenia alata* (including var. *gracillima* and var. *indica*), 40 percent; *Guinardia flaccida*, 19 percent; *Rhizosolenia delicatula*, 12 percent; and *Leptocylindrus danicus*, 10 percent.

The winter phytoplankton population throughout the canal was, on the whole, numerically lower than in summer. In the Port Said region, the standing crop (31.400 cell/L) was less than half its summer value (Table 4). In the Bitter Lake, the standing crop was also low (37,580 cells/L), yet it represented the highest value recorded during this season. On the other hand, the standing crop in Suez Bay was almost twice the corresponding summer value, though still much lower than that in the Bitter Lake. A remarkable feature during this season was that the population, particularly the dominant components, were almost the same throughout the canal. The following species dominated the winter phytoplankton in the three regions sampled with nearly the same sequence of abundance: *Rhizosolenia shrubsolei*, *R. delicatula*, *Skeletonema costatum*, *Rhizosolenia alata*, *Leptocylindrus danicus* and *Guinardia flaccida*.

DISCUSSION

The relatively large number of phytoplankton species now inhabiting the canal is most probably due to the absence of disturbances caused by the ships traversing the canal and various other processes of canal maintenance. These disturbances caused the canal water to be almost always turbid and not favored by many phytoplankton organisms. In addition, the absence of the annual dilution of the water of the northern part of the canal previously caused by the Nile flood in late summer seems to have improved the environmental conditions for many species that cannot tolerate this drastic change in salinity.

The paucity of phytoplankton species recorded in the Bitter Lake is probably correlated with the local environmental conditions in this region. The relatively high salinity (ca 46‰), the absence of vertical mixing and the abnormal chemical composition of the water and bottom sediments make the environment of the Bitter Lake a unique and exceptional habitat probably not favored by many phytoplankton organisms. On the other hand, the northern end of the canal seems to be more suitable; the salinity is always within the normal range tolerated by many species and nutrient salts are probably also abundant as the harbor water receives variable amounts of brackish water rich in nutrients from the adjacent Lake Manzalah.

One of the important results in this study is the increase of the number of phytoplankton species of the Red Sea by 90 species (12 dinoflagellates; 39

centric and 30 pennate diatoms). Most of them are neritic of littoral warm-water forms, a few have oceanic tropical and subtropical affinities (J o r g e n s e n, 1920, 1923; D o w i d a r, 1965; S o u r n i a, 1968). Most of these species are probably endemic in the Red Sea and were not recorded in previous published work due to insufficient and in adequate sampling. Of the 20 species reported in this study, as confined to the Suez Bay and/or Red Sea, 10 species are already known in the Mediterranean Sea while the following are probably absent from available records in the Eastern Mediterranean: *Gossleriella tropica, Corethron criophillum, Rhizosolenia cylindrus, Chaetoceros coarctatus, Isthmia nervosa, Peridinium grande, Ceratium belone, C. kofoidii, C. schmidtii* and *Pyrodinium schilleri.* All of them have tropical affinities and many of them are widely distributed in the Indian Ocean and the Red Sea.

The problem of immigration of plankton organisms, particularly holoplanktonic forms, via the Suez Canal is complicated by the presence of many species in common at both ends. As previously shown, over 90 percent of the species recorded in both Suez Bay and Bitter Lake occur in Port Said. A few of them are, however, not known from the Red Sea including *Podosira stelliger, Coscinodiscus granii, Detonula confervacea, Rhizosolenia delicatula, Ditylum brightwellii* and *Triceratium antidiluvianum.* The occurrence of these species in Suez Bay is most probably due to their being transported from Port Said. On the other hand, about 12 Erytharen and Indopacific species were reported as new immigrants in the Eastern Mediterranean and/or Port Said as indicated above.

The abundance and distribution of phytoplankton species throughout the Suez Canal in summer and winter is noteworthy. The winter population is more diverse in species in the three regions, while the standing crop in Port Said and Bitter Lake is much higher in summer than in winter (Table 4). Furthermore, the species composition is almost homogeneous throughout the canal in winter, while in summer the populations of Bitter Lake and Suez Bay were more similar (at least as regards dominant species) both being significantly different from that in Port Said. The homogeneity of the winter phytoplankton in the Suez Canal (at least for the dominant species) would be attributed to the current regime in the canal. For about nine months, October—July, the current in the canal is northward, while during summer (July—October) the current is reversed, i.e., southward. The latter condition usually concided with the period of the Nile flood (F o x, 1926); since 1966, with the completion of the Aswan High Dam, there is evidence that the northward current is reduced in velocity during summer and is probably no longer reversed (M o r c o s, 1967; D o w i d a r, 1971). The northward current in the canal reaches its maximum velocity during winter, thus driving the water of the Suez Bay, with its plankton content, up the canal to the Bitter Lake and further north to Port Said. The abundant population of *Rhizosolenia shrubsolei* in Port Said during the winter season may be regarded of allochthonous origin, being, together with other species, transported from the Bitter Lake by the strong northward current. This species never occured in large numbers in the Mediterranean waters off the Nile Delta. Its abundance in Port Said during winter may indicate enrichment from the southern part of the canal. The same explanation may be applied to the winter populations of *Guinardia flaccida, Rhizosolenia* alata and *R. calcar avis,* in Port Said. As pointed out by Steinitz (1968) »introduction of individuals of species already represented in the involved area, is immigration at least from the numerical point of view«. Furthermore, most of the Red Sea species listed above as immigrants to the Mediterranean were mostly recorded in Port Said in winter.

CONCLUSIONS

The unique conditions that have prevailed in the Suez Canal in the last few years have improved the environment of the canal as a habitat for phytoplankton organisms. Up to 1936, only 60 valid phytoplankton species (43 diatoms and 17 dinoflagellates) were recorded from the Suez Canal (Ghazzawi, 1939; Macdonald, 1933). The present population of the Suez Canal as shown from this study comprise 273 species.

The Suez Canal, as an interoceanic link, connects two populations which has been frequently described as totally dissimilar, i.e. Mediterranean—Atlantic and Reg Sea—Indopacific, and more than 90 percent of the phytoplankton population of the Suez Bay are common to the Mediterranean. The phytoplankton of the Red Sea, particularly the neritic forms, is not well known. The present list contains about 90 species from Suez Bay that are new records to the Red Sea. Further investigation of the plankton of the Red Sea in all seasons would probably add more species and would increase the present list of Suez Bay (181 species) to nearly reach that of Port Said (253 species).

The relative paucity of species recorded from the Bitter Lake may indicate that the extraordinary habitat of this region is as yet, not favored by many phytoplankton species. However, in both seasons, the standing crop in the Bitter Lake was much higher than that of Suez Bay. The species that were able to build up relatively large populations in the Bitter Lake include *Rhizosolenia alata* (including var. *gracillima* and var. *indica), R. shrubsolei, R. delicatula, R. calcar avis, Guinardia flaccida, Skeletonema costatum, Leptocylindrus danicus* and *Thalassionema nitzschioides.*

The problem of immigration of phytoplankton organisms via the Suez Canal is complicated by the presence of many species in common at both ends of the canal. The current pattern in the canal, the extraordinary habitat of the Bitter Lake and the affinities of the species seem to be the major factors in this concern. Northward immigration and/or transport seem to be more successful. About 12 species were recorded as new Red Sea immigrants to the Mediterranean against 6 Mediterranean species that have crossed the canal to the Suez Bay. In addition to these, there is evidence of Mediterranean species whose populations are enriched by stocks from the southern part of the canal particularly in winter as a result of the increased velocity of the northward current in the canal.

The distribution of nutrient salts in the canal was not studied, nor was it possible to determine the blooming season of phytoplankton in the different regions of the canal as only two seasons were sampled. However, it appears that in Suez Bay the population was numerically large in winter while in Port Said and Bitter Lake the standing crop was significantly high in summer.

SUMMARY

A quantitative and qualitative study of the phytoplankton of the Suez Canal was carried out during summer 1969 and winter 1970. Several fine-net plankton hauls, both vertical and horizontal, together with water samples (2 L each) were taken from Port Said, Bitter Lake and Suez Bay in each season. The population is highly diversified. A total of 273 species and varieties were identified from the different regions sampled. Most of them are new records for the Suez Canal. Of the species identified, 182 species and varieties representing 58 genera belong to the diatoms and 88 species representing 17 genera belong to the dinoflagellates. The greater number of species (253) were recorded from Port Said region which harbored about 93 percent of the total number, followed by Suez Bay, 181 species (66 percent), while only 149 species (55 percent) were recorded from the Bitter Lake. A total of 133 species and varieties were widespread throughout the canal; only 20 species were confined to the southern end. About 50 percent (90 species) of the species recorded from Suez Bay may be regarded as new to the Red Sea.

Many of the species recorded in the canal are perennial, occurring both in summer and winter seasons in one or more of the regions sampled. The number of species occuring in winter was, however, predominantly larger than in summer. As for immigration of plankton organisms through the canal, it was found that at least 12 species of Red Sea origin have crossed the canal northward to Port Said; some of them are now more or less established in the Eastern Mediterranean; while only 6 species have immigrated southward to Suez Bay.

Quantitatively the standing crop was numerically much higher at Port Said than at Suez in both seasons. The standing crops of Port Said and Bitter Lake regions were numerically higher in summer than in winter (maximum 68,810 cells/L in Port Said in July); while in Suez Bay the winter standing crop was almost twice that of the summer. The winter population was dominated by almost the same species throughout the canal including *Rhizosolenia shrubsolei, R. delicatula, R. alata, Guinardia flaccida, Skeletonema costatum* and *Leptocylindrus danicus.* In summer, the population of Port Said was dominated by *Bacteriastrum hyalinum, Chactoceros affinis, C. didymus, C. compressus, Skeletonema costatum, Thalassiosira spp., Rhizosolenia shrubsolei,* and *Guinardia flaccida,* while the populations of Bitter Lake and Suez were both dominated by *Rhizosolenia alata, Guinardia flaccida, Rhizosolenia delicatula* and *Thalassionema nitzschioides.* In all regions, the diatoms constituted more than 98 percent by number of the standing crop. The distribution of phytoplankton species in winter and summer in the regions sampled is related to the current regime in the canal.

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FITOPLANKTON SUESKOG KANALA

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KRATAK SADRŽAJ

U radu se iznose rezultati kvantitativnih i kvalitativnih istraživanja fitoplanktona u Sueskom kanalu koja su vršena tokom ljeta 1969. i zime 1970. Materijal je uziman vertikalnim i horizontalnim potezima planktonske mreže sitnog oka, a osim toga su pomoću crpca uzimani i uzorci od 2 l morske vode.

Populacija istraživanog područja je vrlo raznolika. Ukupno su identificirane 273 vrste i varieteta. Većina je vrsta nova za Sueski kanal. 182 vrste i varieteta pripadaju dijatomejskim rodovima (58), a 88 vrsta rodovima dinoflagelata (17). Veći dio vrsta (273), tj. 95% od ukupnog broja, naseljava područje Port Saida. Slijede Sueski kanal sa 181 (66%) i Bitter Lake sa 149 vrsta (55%). 133 vrste i varieteta nađeno je u Sueskom kanalu. Samo 20 vrsta je ograničeno na njegov južni dio. 90 vrsta (oko 50%) Sueskog kanala predstavlja nove nalaze za Crveno more.

Mnoge vrste Sueskog kanala su perenantne. Broj vrsta, inače, je zimi znatno veći nego ljeti. Za barem 12 vrsta se smatra da su migrirale iz Crvenog mora prema sjeveru do Port Saida, a za 6 vrsta obrnuto, tj. prema jugu do Sueskog zaljeva.

Gustoća fitoplanktona mnogo je veća u obe sezone u Port Saidu nego u Suezu. U Port Saidu i području Bitter Lake gustoća populacije je ljeti veća nego zimi, dok je u Sueskom kanalu zimski »standing crop« najmanje 2 puta veći nego ljetni. U zimskoj populaciji dominiraju uglavnom iste vrste uzduž čitavog kanala. U svim područjima dijatomeje sačinjavaju više od 98% gustoće populacije. Raspodjela fitoplanktonskih vrsta je zimi i ljeti usko povezana s režimom struja u kanalu.