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Two Year Time-Series Fluxes of Silicoflagellates and *Actiniscus*: Size Fractioned Results from Subarctic Pacific Station PAPA, 1982-1984

by

Kozo Takahashi

December 1985

Technical Report

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under grant No. OCE 85-02472.*

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SIZE FRACTIONED RESULTS FROM SUBARCTIC PACIFIC STATION PAPA,
1982-1984.

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Abstract

A seasonal flux study of silicoflagellates and Actiniscus was conducted at subarctic Pacific Station PAPA (50°N, 145°W; water depth 4200 m) during September, 1982 through August, 1984 using PARFLUX time series sediment traps deployed at 1000 m and 3800 m depths. The time series sediment trap samples were collected for 4 to 16-day periods depending on the samples; most of the samples were collected for 14 to 16-day periods. A total of 47 continuous samples represents nearly a two-year record of the fluxes of silicoflagellate and Actiniscus taxa at 3800 m depth. An additional 12 samples from 1000 m represent a continuous 6-month period which provides a pair of samples from two depths of each time series. Analysis of the paired samples is essential to understand particle sinking processes. Seven silicoflagellate taxa, several additional variants of silicoflagellates, and Actiniscus pentasterias group were enumerated, based on a census of four wet sieved size fractions: 250-1000µm, 125-250µm, 63-125µm, and <63µm. A total of more than 32×10^3 specimens were identified to species level and counted in this study. Statistics of the counts are given. The fluxes of silicoflagellate taxa of all four size fractions are graphically presented. This report provides a detailed data base for further investigations of seasonal silicoflagellate fluxes in the area.

Introduction

Silicoflagellates are marine chrysophytes which dwell in the euphotic zones of essentially all parts of the world oceans. Their microplankton size skeletons (20–80 μ m) are made of biogenic opal which makes their fossil preservation in the sedimentary record possible. The numerical abundance of silicoflagellates in siliceous plankton standing stocks is generally less than diatoms and is followed in abundance by radiolarians, protozoans.

Due to the small size of silicoflagellates, their contribution to SiO_2 flux is a few percent or less, but numerous fluxes of the skeletons make them good tracers for the vertical transport of settling particles (Takahashi, in press). Some taxa of silicoflagellates are known to be useful as environmental indicators, especially productivity and oceanic waters (Murray and Schrader, 1983; Takahashi, in press).

High resolution samples of seasonal fluxes of sinking particles were collected during a two-year period, 1982–1984, at subarctic Pacific Station PAPA (Fig. 1; Table 1) using fully automated PARFLUX time series sediment traps (Mark V) with an aperture size of 1.167 m^2 (Honjo, 1984; Honjo and Wong, 1985). A pair of flux samples were collected simultaneously from two depths, 1000 m and 3800 m, during deployment II (PAPA II: March–October, 1983) and the remainder are from 3800 m. Among various siliceous components, silicoflagellates fluxes are numerically

Fig. 1. A map showing the location of PARFLUX sediment trap Station PAPA. Bathymetric contours are shown in meters.

the second most abundant after diatoms. These time series silicoflagellate flux data are not only important in documenting intra-annual flux variability but also for future studies in interannual flux comparisons with many more years of data. Station PAPA has been the site of Canadian Weather Station P. From this station a wealth of hydrographic data had been collected from 1956 to 1981 (Anonymous; Tabata and Peart, 1985). Subsequent frequent cruises since 1981 (after termination of the weather station) by the Institute of Ocean Sciences, Patricia Bay, British Columbia, Canada, have yielded additional hydrographic data which are still to be published.

The major objective of this report is to provide a detailed data base for time-series silicoflagellate fluxes, most of which cannot be published in international journals due to space limitations. Much of the primary information that I wish to present here is size fractionated representations of the flux data. I studied fluxes in all of the four size fractions mentioned below for an initial two years, thus providing enough information for subsequent studies at Station PAPA in terms of minimizing effort and yet yielding a similar level of information. Interpretations based on present data will be published elsewhere (Takahashi, in prep.).

The Actiniscus pentasterias group was also studied and is included in this report. A. pentasterias is a dinoflagellate which secretes a pair of siliceous endoskeletons in the cell. No ebridians occurred in the materials studied.

Methods

The microslide preparation method was similar to that employed for a diatom study (Takahashi et al., 1985). Briefly, a sample was sieved through 1000 and 63 μm mesh stainless screens. Both 63–1000 and <63 μm size fractions were split into four aliquots (1/4 of original size) using an Erez-Honjo precision liquid rotary splitter. The splitting was repeated until a desirable aliquot size was obtained, requiring several repetitions. For example, splitting was performed 5 times in order to generate a 1/1024 aliquot. Because silicoflagellate fluxes varied greatly with seasons, the aliquot size had to be changed often in consecutive samples. An appropriately split aliquot of 63–1000 μm was wet sieved through 250 and 125 μm mesh. The size fractioned aliquot of the appropriate sample size (see Table 2 for details) was filtered through a 47 mm HA Millipore® grid membrane filter with a nominal 0.45 μm pore size using a rectangular stainless steel filtration funnel with a 19 x 42 mm opening. The filter was rinsed with distilled water to remove salts and then dried in an oven. After trimming off the excess margins, the dried filter was mounted with Gargile® type B immersion oil on a standard glass microslide.

Silicoflagellate counts were performed on an Olympus® BH microscope with wide-field, 10X eyepiece lenses and a 20X S Plan Apochromat objective lens with a total magnification of 200X. One slide per size fraction of each sample was studied for census. One to nine traverses of

vertical strips (along the minor axis of a microslide) were studied for silicoflagellate counts (Table 2). Each strip represents $15.1 \times 10^6 \mu\text{m}^2$ which is equal to 1/35.9th of an entire filtered area of the membrane filter on a slide. One or more traverse was counted on slides of size fractions greater than $63 \mu\text{m}$. Since most silicoflagellates are inferred to be in $<63 \mu\text{m}$ fraction main counting effort was expended for this size fraction (Tables 2, 5).

Raw counts for a sample combining all of the four slides ranged from 74 to 1558 with a mean of 552 (Table 5). Possible major sources of errors in silicoflagellate counts reported here include (i) splitting; (ii) imperfectly homogeneous distribution of filtered silicoflagellates; and (iii) counting errors. The second category of the sources of errors is determined to be the largest, based on statistical assessments performed on the representative samples. The first and third categories caused less than 5 percent of the errors, each. Overall reproducibility for silicoflagellate flux assessment reported here is considered better than 85 percent.

Results

Seven silicoflagellate taxa, their several variants, and the Actiniscus pentasterias group were encountered during the census (Table 3). Several forms were not readily separated from one taxon to another because there was no clear discontinuity of morphologies between the

taxa. In these cases, a boundary line was drawn at the mid-point between the two taxon's morphologies as commonly illustrated in the literature. For example, D. mandrai and D. messanensis ? spinosa generally show a continuous morphologic form between the typical octagonal D. mandrai form and the quadrate D. messanensis form. Therefore, it is possible that these two taxa may actually be a single taxon. In this report these forms are separated. Detailed morphologic and taxonomic discussions with illustrations will be published elsewhere. Since more than one taxon of Actiniscus was encountered, they were lumped together as a group.

The counts were converted into flux and reported as the number of individuals $m^{-2}d^{-1}$ (Table 4). The fluxes in four different size fractions are presented graphically (Figs. 2-16). Highly variable fluxes of silicoflagellate and Actiniscus taxa were observed, both intra-annually and interannually, during the 1982-1984 period. D. speculum and D. mandrai represent two major flux taxa throughout the period studied. The combined fluxes of the two species generally make up greater than 75% of the total silicoflagellate flux. During August, 1984, the combined fluxes decreased to about 50% of total silicoflagellates.

Acknowledgments

I am grateful to Dr. Susumu Honjo at Woods Hole Oceanographic Institution for his enthusiastic and continuous encouragement throughout all phases of this study. I thank Steve Manganini, Vernon Asper for discussions and technical assistance on board ship and in the laboratory throughout and Ron Bellegay, Rindy Ostermann, other members of the scientific party, the Captains and crews of the C.F.A.V. Endeavour and Parizeau which cruise regularly to Station PAPA. Discussions with Dr. David Lazarus were useful. I also thank John Billings for his able technical assistant. Emily Evans skillfully typed the manuscript.

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Table 1. Sampling intervals for PAPA I - IV deployments of PARFLUX time-series sediment trap experiment at subarctic Pacific Station PAPA. Dates represent opening and closing times of sample cups placed with a tight seal under the conical PARFLUX Mark 5 traps (surface area = 1.167 m²). For deployment II there are two depth samples from 1000 m and 3800 m of each sequenced sample number. Collections of these paired samples of the same sample numbers were electronically synchronized.

Deployment	Sample #	Date Open	Date Closed	Duration (days)
PAPA I	# 1	9/23/82	10/8/82	15
	# 2	10/8/82	10/23/82	15
	# 3	10/23/82	11/7/82	15
	# 4	11/7/82	11/22/82	15
	# 5	11/22/82	12/7/82	15
	# 6	12/7/82	12/22/82	15
	# 7	12/22/82	1/6/83	15
	# 8	1/6/83	1/21/83	15
	# 9	1/21/83	2/5/83	15
	#10	2/5/83	2/20/83	15
	#11	2/20/83	3/7/83	15
	#12	3/7/83	3/18/83	11
PAPA II	#13	3/27/83	4/12/83	16
	#14	4/12/83	4/28/83	16
	#15	4/28/83	5/14/83	16
	#16	5/14/83	5/30/83	16
	#17	5/30/83	6/15/83	16
	#18	6/15/83	7/1/83	16
	#19	7/1/83	7/17/83	16
	#20	7/17/83	8/2/83	16
	#21	8/2/83	8/18/83	16
	#22	8/18/83	9/3/83	16
	#23	9/3/83	9/19/83	16
	#24	9/19/83	10/5/83	16
PAPA III	#25	10/14/83	10/30/83	16
	#26	10/30/83	11/15/83	16
	#27	11/15/83	12/1/83	16
	#28	12/1/83	12/17/83	16
	#29	12/17/83	1/2/84	16
	#30	1/2/84	1/18/84	16
	#31	1/18/84	2/3/84	16
	#32	2/3/84	2/19/84	16
	#33	2/19/84	3/6/84	16
	#34	3/6/84	3/22/84	16
	#35	3/22/84	4/7/84	16
	#36	4/7/84	4/23/84	16

Deployment	Sample #	Date Open	Date Closed	Duration (days)
PAPA IV	#37 *	4/29/84	5/13/84	14
	#38	5/13/84	5/27/84	14
	#39	5/27/84	6/10/84	14
	#40	6/10/84	6/24/84	14
	#41	6/24/84	7/8/84	14
	#42	7/8/84	7/22/84	14
	#43	7/22/84	8/5/84	14
	#44	8/5/84	8/9/84	4
	#45	8/9/84	8/13/84	4
	#46	8/13/84	8/17/84	4
	#47	8/17/84	8/21/84	4
	#48	8/21/84	8/24/84	4

* No sample/data due to malfunction

Table 2. Information for sample split size, counted areas of microslides, and resulting multiplication factors. The factors account for sample periods and aperture size of the traps listed in Table 1.
 [Multiplication factor] x [raw counts] = [flux] ($\# \text{ m}^{-2} \text{ day}^{-1}$).

PAPA I, 3800 m

Size fraction (μm)	Sample	1		20X Objective lens		Sample	1		20X Objective lens	
		Aliquot	size	# of traverses	Multipl. factor		Aliquot	size	# of traverses	Multipl. factor
250-1000	# 1	64		1	44	# 7	64		1	44
125-250		64		1	44		64		1	44
63-125		256		1	175		64		1	44
< 63		1024		5	420		1024		5	420
250-1000	# 2	64		1	44	# 8	64		1	44
125-250		64		1	44		64		1	44
63-125		256		1	175		64		1	44
< 63		4096		5	1680		1024		5	420
250-1000	# 3	64		1	44	# 9	64		1	44
125-250		64		1	44		64		1	44
63-125		256		1	175		64		1	44
< 63		1024		5	420		256		3	175
250-1000	# 4	64		1	44	#10	64		1	44
125-250		64		1	44		64		1	44
63-125		256		1	175		64		1	44
< 63		1024		5	420		256		3	175
250-1000	# 5	64		1	44	#11	64		1	66
125-250		64		1	44		64		1	66
63-125		256		1	175		64		1	44
< 63		1024		5	420		256		3	175
250-1000	# 6	64		1	44	#12	64		1	60
125-250		64		1	44		64		1	60
63-125		256		1	175		64		1	60
< 63		1024		5	420		256		5	143

Table 2. (cont.)

Size fraction (μm)	Sample	20X Objective lens			Sample	10X Objective lens		
		Aliquot size	# of traverses counted	Multipl. factor		Aliquot size	# of traverses counted	Multipl. factor
125-1000 63-125 < 63	#13	64 64 1024	1 1 3	123 123 656	#19	64 64 64 4096	1 1 1 1/4 slide area*	123 123 123 439
125-1000 63-125 < 6325	#14	64 64 1024	1 1 3	123 123 656	#20	64 64 64 4096	1 1 1 1/4 slide area*	123 123 123 439
250-1000 125-250 63-125 < 63	#15	64 64 64 1024	1 1 1 3	123 123 123 656	#21	64 64 64 1024	1 1 1 3	123 123 123 656
250-1000 125-250 63-125 < 63	#16	64 64 64 4096	1 1 1 5	123 123 123 1575	#22	64 64 64 1024	1 1 1 3	123 123 123 656
250-1000 125-250 63-125 < 63	#17	64 64 64 1024	1 1 1 5	123 123 123 394	#23	64 64 64 1024	1 1 1 3	123 123 123 656
250-1000 125-250 63-125 < 63	#18	64 64 64 1024	1 1 1 5	123 123 123 394	#24	64 64 64 1024	1 1 1 3	123 123 123 656

* 10X objective lens was used.

Table 2. (cont.)

Size fraction (μm)	Sample	20X Objective lens			Sample	10X Objective lens		
		Aliquot size	# of traverses counted	Multipl. factor		Aliquot size	# of traverses counted	Multipl. factor
250-1000	#13	64	1	123	#19	64	1	123
125-250		64	1	123		64	1	123
63-125		64	1	123		64	1	123
< 63		1024	3	656		1024	5	394
250-1000	#14	64	1	123	#20	64	1	123
125-250		64	1	123		64	1	123
63-125		64	1	123		64	1	123
< 63		1024	3	656		4096	1/4 slide area*	877
250-1000	#15	64	1	123	#21	64	1	123
125-250		64	1	123		64	1	123
63-125		64	1	123		64	1	123
< 63		1024	3	656		4096	1/4 slide area*	877
250-1000	#16	64	1	123	#22	64	1	123
125-250		64	1	123		64	1	123
63-125		64	1	123		64	1	123
< 63		1024	3	656		4096	1/4 slide area*	877
250-1000	#17	64	1	123	#23	64	1	123
125-250		64	1	123		64	1	123
63-125		64	1	123		64	1	123
< 63		1024	3	656		1024	3	656
250-1000	#18	64	1	123	#24	64	1	123
125-250		64	1	123		64	1	123
63-125		64	1	123		64	1	123
< 63		1024	5	394		4096	1/4 slide area*	219

* 10X objective lens was used.

Table 2. (cont.)

PAPA III, 3800 m

Size fraction (μm)	Sample	1		20X Objective lens		Sample	1		20X Objective lens	
		Aliquot	size	# of traverses	Multipl. factor		Aliquot	size	# of traverses	Multipl. factor
250-1000	#25	128		1/4 slide area*	7	#31	16		3	10
125-250		128		1/4 slide area*	7		16		3	10
63-125		64			41		16		3	10
< 63		256			164		256		3	164
250-1000	#26	64			41	#32	16		3	10
125-250		64			41		16		3	10
63-125		64			41		16		3	10
< 63		256			164		256		3	164
250-1000	#27	64			41	#33	16		3	10
125-250		64			41		16		3	10
63-125		64			41		16		3	10
< 63		256			164		256		3	164
250-1000	#28	64			41	#34	16		3	10
125-250		64			41		16		3	10
63-125		64			41		16		3	10
< 63		256			164		64		3	164
250-1000	#29	64			41	#35	32		3	21
125-250		64			41		32		3	21
63-125		64			41		32		3	21
< 63		256			164		256		3	164
250-1000	#30	16			10	#36	64		3	41
125-250		16			10		64		3	41
63-125		16			10		64		3	41
< 63		256			164		256		3	164

* 10X objective lens was used.

Table 2. (cont.)

PAPA IV, 3800 m

Size fraction (μm)	Sample	20X Objective lens			Sample	20X Objective lens		
		1	Aliquot	Multipl.		1	Aliquot	Multipl.
		size		factor		size		factor
							# of traverses counted	
250-1000	#37	No Sample			#43	64	3	47
125-250						64	3	47
63-125						64	3	47
< 63						256	3	188
250-1000	#38			47	#44	64	3	164
125-250				47		64	3	164
63-125				47		64	3	164
< 63				750		256	3	656
250-1000	#39			47	#45	64	3	164
125-250				47		64	3	164
63-125				47		64	3	164
< 63				750		64	3	164
250-1000	#40			47	#46	64	3	164
125-250				47		64	3	164
63-125				47		64	3	164
< 63				188		64	3	164
250-1000	#41			47	#47	64	3	164
125-250				47		64	3	164
63-125				47		64	3	164
< 63				188		64	3	164
250-1000	#42			47	#48	64	3	164
125-250				47		64	3	164
63-125				47		64	3	164
< 63				188		64	3	164

Table 3. PAPA I - IV silicoflagellate counts (see Table 2 for details of traverses examined).

Taxon	Distephanus speculum				Distephanus speculum (7 sided)				Distephanus quinquangellus				
Size fraction	250-1000	125-250	63-125	(63	250-1000	125-250	63-125	(63	250-1000	125-250	63-125	(63	
(μ m)													
PAPA I	#1	6	94	45	463	0	0	0	0	0	2	0	1
3800m	#2	209	207	59	306	0	0	0	0	2	0	1	3
	#3	178	62	104	617	1	0	0	0	2	0	0	5
	#4	7	12	54	545	0	0	0	0	0	0	0	7
	#5	14	26	36	459	0	0	0	0	0	1	1	3
	#6	8	16	2	492	0	0	0	0	1	0	0	7
	#7	10	10	22	431	0	0	0	0	0	0	0	5
	#8	1	1	10	225	0	0	0	0	0	0	0	1
	#9	2	8	3	210	0	0	0	0	0	0	0	0
	#10	0	0	2	109	0	0	0	0	0	0	0	1
	#11	0	0	0	48	0	0	0	0	0	0	0	0
	#12	0	0	3	49	0	0	0	0	0	0	0	0
PAPA II	#13 *		41	57	460		0	0	0		1	0	1
1000m	#14 *		5	49	181		0	0	0		0	1	0
	#15	6	12	10	91	0	0	0	0	0	0	0	0
	#16	5	0	6	25	0	0	1	0	0	0	0	0
	#17	6	2	3	56	0	0	0	0	0	0	0	0
	#18	1	4	3	33	0	0	0	0	0	0	0	0
	#19	6	2	25	61	0	0	0	0	0	0	0	0
	#20	2	0	27	132	0	0	3	0	0	0	0	3
	#21	18	38	104	251	0	0	1	0	0	0	1	2
	#22	51	203	95	209	0	0	0	0	0	2	1	4
	#23	1	41	46	163	0	0	0	0	0	1	0	1
	#24	26	95	128	113	0	0	0	0	1	0	0	2
PAPA II	#13	52	176	213	338	0	2	0	0	0	3	0	4
3800m	#14	42	57	78	196	0	0	1	0	0	1	0	3
	#15	30	27	39	148	0	1	1	0	1	0	0	1
	#16	9	26	27	164	0	0	0	0	0	0	0	1
	#17	6	6	9	99	0	0	0	0	0	0	0	1
	#18	17	18	25	88	0	0	0	0	0	0	0	0
	#19	15	6	31	101	0	0	0	0	1	0	0	1
	#20	6	0	20	64	0	0	0	0	0	0	0	0
	#21	23	6	28	189	1	0	0	0	1	0	0	2
	#22	55	22	53	328	0	0	0	0	0	0	0	5
	#23	28	20	38	132	0	0	1	0	1	0	2	0
	#24	13	23	77	149	0	0	0	0	0	2	0	0

* Treated as 125-1000 μ m (250-1000 & 125-250 μ m were not separated).

Table 3. (cont.)

Taxon		Distephanus speculum				Distephanus speculum (7 sided)				Distephanus quinquangellus			
Size fraction	250-1000	125-250	63-125	(63	250-1000	125-250	63-125	(63	250-1000	125-250	63-125	(63	
(μ m)													
PAPA III	#25	82	175	40	233	0	0	0	0	2	0	0	7
3800m	#26	14	18	23	196	0	0	0	0	0	0	0	0
	#27	7	4	9	139	0	0	0	0	0	0	0	1
	#28	5	3	8	95	0	0	0	0	0	0	0	1
	#29	10	5	6	78	0	0	0	0	0	0	0	0
	#30	16	11	11	66	0	0	0	0	0	0	0	0
	#31	11	1	24	48	0	0	0	0	0	0	0	1
	#32	0	6	28	58	0	0	0	0	0	0	0	0
	#33	6	4	4	37	0	0	0	0	0	0	0	0
	#34	7	1	14	55	0	0	0	0	0	0	1	1
	#35	61	28	84	79	0	0	0	0	0	2	1	2
	#36	32	8	4	63	0	0	0	0	0	0	0	0
PAPA IV	#37	No sample											
3800m	#38	28	7	14	28	0	0	0	0	0	0	0	0
	#38	25	13	24	38	0	0	0	0	0	0	0	0
	#40	4	7	7	95	0	0	0	0	0	0	0	0
	#41	13	12	10	40	0	0	0	0	1	0	0	0
	#42	4	2	6	53	0	1	0	0	0	0	0	1
	#43	4	0	2	4	0	0	0	0	0	0	0	0
	#44	6	0	2	2	0	0	0	0	0	0	0	0
	#45	8	0	2	2	0	0	0	0	0	0	0	0
	#46	2	2	0	0	0	0	0	0	0	0	0	0
	#47	0	3	1	4	0	0	0	0	0	0	0	0
	#48	3	0	1	1	0	0	0	0	0	0	0	0

Table 3. (cont.)

Taxon		Distephanus boliviensis ?			D.boliviensis? pentagonus			D.boliviensis? (7 sided)					
Size fraction		250-1000	125-250	63-125	(63	250-1000	125-250	63-125	(63	250-1000	125-250	63-125	(63
	(μ m)												
PAPA I 3800m	#1	1	9	6	5	0	0	0	1	0	0	0	0
	#2	27	9	9	8	0	0	0	0	0	0	0	0
	#3	20	8	23	19	0	0	0	0	0	0	0	0
	#4	0	2	10	14	0	0	0	0	0	0	0	0
	#5	1	5	12	19	0	0	0	0	0	0	1	0
	#6	5	7	1	34	0	0	0	1	0	0	0	0
	#7	3	1	2	45	0	0	0	0	0	0	0	0
	#8	0	1	0	19	0	0	0	0	0	0	0	0
	#9	6	5	2	18	0	0	0	0	0	0	0	0
	#10	1	0	0	17	0	0	0	0	0	0	0	0
	#11	0	0	1	6	0	0	0	0	0	0	0	0
	#12	0	0	0	6	0	0	0	0	0	0	0	0
PAPA II 1000m	#13 *		2	1	8		0	0	0		0	0	0
	#14 *		1	7	3		0	0	0		0	0	0
	#15	2	0	5	9	0	0	0	0	0	0	0	0
	#16	1	0	2	3	0	0	0	0	0	0	0	0
	#17	1	0	0	14	0	0	0	0	0	0	0	0
	#18	2	0	1	15	0	0	0	1	0	0	0	0
	#19	0	4	21	42	0	0	0	0	0	0	1	0
	#20	2	0	15	20	0	0	0	0	0	0	1	0
	#21	3	3	6	12	0	0	0	0	1	0	0	0
	#22	0	0	3	11	0	0	0	1	0	0	1	0
	#23	0	1	2	9	0	0	1	0	0	0	0	0
	#24	4	9	11	6	0	0	0	0	0	1	0	0
PAPA II 3800m	#13	5	21	5	6	0	0	0	0	1	1	0	0
	#14	0	2	3	5	0	0	0	0	0	0	0	1
	#15	1	1	2	8	0	0	0	0	0	0	0	0
	#16	1	3	9	3	0	0	0	0	0	0	0	0
	#17	0	3	3	8	0	0	0	0	0	0	0	0
	#18	1	0	4	9	0	0	0	0	0	0	0	0
	#19	4	1	6	9	0	0	0	0	0	0	0	0
	#20	3	1	6	7	0	0	0	0	0	0	0	0
	#21	1	0	4	13	0	0	0	0	0	0	0	0
	#22	4	0	9	21	0	0	0	1	0	0	0	0
	#23	4	2	5	8	0	0	0	0	0	0	0	0
	#24	1	1	9	2	0	0	0	0	0	0	0	0

* Treated as 125-1000 μ m (250-1000 & 125-250 μ m were not separated).

Table 3. (cont.)

Taxon		Distephanus boliviensis ?			D. boliviensis? pentagonus				D. boliviensis? (7 sided)				
Size fraction		250-1000	125-250	63-125	(63	250-1000	125-250	63-125	(63	250-1000	125-250	63-125	(63
		(µm)											
PAPA III	#25	4	17	16	17	0	0	0	0	0	0	0	0
3800m	#26	2	1	5	15	0	0	0	0	1	0	0	0
	#27	2	1	1	9	0	0	0	0	0	0	0	0
	#28	0	0	1	12	0	0	0	0	0	0	0	0
	#29	2	0	2	6	0	0	0	0	0	0	0	0
	#30	1	2	2	9	0	0	0	0	0	0	0	0
	#31	1	0	1	6	0	0	0	0	0	0	0	0
	#32	0	0	5	5	0	0	0	0	0	0	0	0
	#33	2	2	3	9	0	0	0	0	0	0	0	0
	#34	3	0	3	5	0	0	0	1	1	0	0	0
	#35	13	11	8	13	0	0	0	0	0	0	0	0
	#36	3	2	7	15	0	0	0	0	0	0	0	0
PAPA IV	#37	No sample											
3800m	#38	24	3	9	5	0	0	0	0	0	0	0	1
	#38	7	6	3	7	0	0	0	0	0	0	0	0
	#40	0	0	0	18	0	0	0	0	0	0	0	0
	#41	0	0	4	8	0	0	0	0	0	0	0	0
	#42	2	1	1	9	0	0	0	0	0	1	0	0
	#43	11	7	3	4	0	0	0	0	1	0	0	0
	#44	3	1	0	2	0	0	0	0	0	0	0	0
	#45	7	4	4	4	0	0	0	0	0	0	0	0
	#46	4	3	3	4	0	0	0	0	0	0	0	0
	#47	1	0	0	1	0	0	0	0	0	0	0	0
	#48	1	0	0	2	0	0	0	0	0	0	0	0

Table 3. (cont.)

Taxon	Distephanus octangulatus				D.octangulatus(1 apical windows)				Dictyocha mandrai				(63
	Size fraction	250-1000	125-250	63-125	(63	250-1000	125-250	63-125	(63	250-1000	125-250	63-125	
	(µm)												
PAPA I	#1	0	0	1	7	0	0	0	0	0	21	2	22
3800m	#2	14	4	3	11	1	2	1	0	84	61	35	49
	#3	7	0	1	22	0	0	0	2	79	25	47	149
	#4	1	0	3	23	0	0	0	2	6	7	42	222
	#5	2	2	1	16	0	1	0	0	10	17	53	401
	#6	1	0	0	30	0	0	0	0	14	28	3	662
	#7	0	0	2	19	0	0	0	2	17	15	53	546
	#8	0	0	0	18	0	0	0	1	3	2	13	261
	#9	0	2	2	32	0	1	0	2	15	44	35	396
	#10	0	1	1	16	0	0	1	0	12	12	47	195
	#11	0	0	6	15	0	0	0	0	1	4	12	172
	#12	1	2	2	25	0	0	0	1	1	10	13	180
PAPA II	#13 *		1	5	36		0	0	0		10	14	48
1000m	#14 *		3	4	26		1	0	0		14	14	54
	#15	0	5	2	30	0	2	0	0	1	5	6	40
	#16	2	0	0	9	0	0	0	1	2	1	5	28
	#17	0	0	1	20	0	0	0	0	2	1	1	41
	#18	0	0	0	29	0	0	0	1	3	3	2	37
	#19	1	0	7	18	0	0	0	0	2	1	25	31
	#20	1	0	5	12	0	0	0	1	8	4	63	87
	#21	1	1	2	6	0	0	0	0	5	16	31	52
	#22	0	0	0	4	0	0	0	0	1	11	10	44
	#23	0	0	0	2	0	0	0	0	0	8	4	33
	#24	0	1	0	2	0	0	0	0	4	7	11	29
PAPA II	#13	3	6	17	31	1	0	0	1	16	51	75	79
3800m	#14	3	6	1	19	1	0	0	0	9	19	22	47
	#15	3	4	3	17	0	0	0	2	13	11	14	61
	#16	1	2	5	24	0	0	0	0	9	15	36	48
	#17	4	3	0	26	0	0	0	1	6	10	15	64
	#18	1	4	2	18	0	0	0	2	30	13	20	66
	#19	4	0	5	25	1	0	0	2	12	3	33	97
	#20	3	0	2	7	0	0	0	4	13	2	67	73
	#21	2	3	1	16	0	0	0	4	18	6	33	78
	#22	0	0	2	9	0	0	0	1	8	4	16	56
	#23	3	0	3	11	0	1	0	0	11	7	16	51
	#24	0	1	0	16	0	0	0	2	6	7	15	79

* Treated as 125-1000µm (250-1000 & 125-250µm were not separated).

Table 3. (cont.)

Taxon		Distephanus octangulatus				D.octangulatus(1 apical windows)				Dictyocha mandrai			
Size fraction	(μ m)	250-1000	125-250	63-125	(63	250-1000	125-250	63-125	(63	250-1000	125-250	63-125	(63
PAPA III	#25	4	5	1	17	0	0	0	1	28	50	10	123
3800m	#26	1	0	3	19	0	0	0	3	8	2	13	118
	#27	1	0	0	14	0	0	0	0	9	1	4	86
	#28	0	0	0	11	0	0	0	0	5	1	3	67
	#29	1	0	0	7	0	0	0	0	3	2	2	78
	#30	0	0	0	10	0	0	0	0	24	6	11	64
	#31	1	0	2	3	0	0	0	0	10	7	26	40
	#32	0	0	0	4	0	0	0	0	6	5	24	60
	#33	0	0	1	2	0	0	0	0	30	17	12	44
	#34	2	0	4	10	0	0	0	1	38	1	29	88
	#35	2	1	3	10	0	0	0	0	43	8	14	32
	#36	0	0	1	8	0	0	0	0	6	2	6	42
PAPA IV	#37	No sample											
3800m	#38	2	0	0	2	0	0	0	0	18	5	4	18
	#38	1	0	1	1	0	0	0	0	20	9	9	26
	#40	0	0	0	6	0	0	0	0	0	4	3	96
	#41	1	1	0	6	0	0	0	1	9	6	8	52
	#42	1	0	0	3	0	0	0	0	5	2	5	43
	#43	2	0	0	3	0	0	0	0	14	2	3	27
	#44	1	0	0	0	0	0	0	0	5	3	1	3
	#45	0	0	0	1	0	0	0	0	6	3	14	9
	#46	2	0	0	0	0	0	0	1	4	2	5	5
	#47	0	1	1	7	0	0	0	0	6	7	9	18
	#48	1	0	0	3	0	0	0	0	1	6	7	4

Table 3. (cont.)

		D. mandrai (variable-shaped apical rods)			Dictyocha mandrai pentagona				D. messanensis spinosa				
Taxon	Size fraction	250-1000	125-250	63-125	(63	250-1000	125-250	63-125	(63	250-1000	125-250	63-125	(63
	(μm)												
PAPA I	#1	1	0	1	0	0	0	0	0	0	0	0	2
3800m	#2	1	3	0	1	0	1	1	1	0	0	0	0
	#3	3	2	3	0	0	0	0	1	0	0	4	0
	#4	0	0	2	1	0	0	0	1	0	0	0	3
	#5	0	1	2	6	0	0	0	1	0	1	1	6
	#6	1	2	0	1	0	0	1	5	0	0	0	3
	#7	1	2	2	2	0	0	0	4	0	1	0	21
	#8	0	0	0	2	0	0	0	3	0	0	0	26
	#9	0	2	0	1	0	0	0	2	2	1	2	45
	#10	0	0	0	0	1	0	1	0	2	1	1	27
	#11	0	0	0	0	0	0	0	0	0	0	0	29
	#12	0	0	0	0	0	1	0	1	0	1	0	42
PAPA II	#13 *		0	0	0		0	0	0		0	1	35
1000m	#14 *		0	0	0		0	0	0		3	2	26
	#15	0	0	0	0	0	0	0	0	0	0	1	21
	#16	0	0	0	0	0	0	0	0	3	1	0	10
	#17	0	0	0	0	0	0	0	0	0	0	1	40
	#18	0	0	0	0	0	0	0	0	0	0	0	25
	#19	0	0	0	0	0	0	1	0	0	0	6	14
	#20	0	2	7	6	1	0	0	0	0	0	1	20
	#21	1	3	8	6	0	0	1	0	0	0	0	11
	#22	0	0	0	2	0	0	0	1	1	1	0	2
	#23	0	1	0	1	0	0	0	1	0	0	0	5
	#24	0	0	1	1	0	0	0	0	1	0	1	5
PAPA II	#13	0	1	3	0	1	1	1	0	0	2	3	19
3800m	#14	1	1	1	1	0	0	0	1	0	0	2	11
	#15	1	0	0	0	0	1	0	1	1	0	2	9
	#16	0	0	0	0	0	0	0	0	1	0	2	17
	#17	0	0	0	1	0	0	0	1	0	0	2	29
	#18	0	0	0	0	0	0	0	0	0	2	1	13
	#19	0	0	1	0	0	0	0	1	0	1	2	17
	#20	1	0	0	4	1	0	0	1	1	1	5	10
	#21	2	2	0	11	0	0	0	0	0	1	1	12
	#22	0	0	2	6	1	0	0	3	1	0	1	6
	#23	0	0	0	2	0	0	0	0	2	0	0	9
	#24	0	0	1	3	0	0	0	0	0	1	0	12

* Treated as 125-1000 μm (250-1000 & 125-250 μm were not separated).

Table 3. (cont.)

[illegible]

Table 3. (cont.)

Taxon		Dictyocha crux ?				Actiniscus pentasterias group			
Size fraction		250-1000	125-250	63-125	(63	250-1000	125-250	63-125	(63
(µm)									
=====									
PAPA I	#1	0	1	1	2	2	5	1	88
3800m	#2	2	2	4	3	7	7	1	94
	#3	1	0	0	8	15	3	7	140
	#4	0	0	0	6	2	3	0	237
	#5	0	1	0	8	2	9	2	173
	#6	0	1	0	9	4	6	0	156
	#7	0	0	1	5	2	2	6	187
	#8	0	0	0	3	1	1	0	117
	#9	0	0	1	6	2	6	8	111
	#10	0	0	1	1	4	4	6	97
	#11	0	0	0	3	0	2	11	72
	#12	0	0	0	2	0	1	0	81
=====									
PAPA II	#13 *		0	0	0		4	1	28
1000m	#14 *		0	0	0		5	11	54
	#15	0	0	0	0	4	27	10	59
	#16	0	0	0	0	4	10	11	83
	#17	0	0	0	0	3	6	17	127
	#18	0	0	0	1	1	3	6	129
	#19	0	0	0	1	21	9	33	187
	#20	0	0	0	4	18	15	20	225
	#21	0	0	0	2	6	5	31	110
	#22	0	4	0	1	1	11	5	38
	#23	0	0	0	0	1	14	5	47
	#24	0	0	0	0	9	17	32	53
=====									
PAPA II	#13	0	0	1	0	5	4	23	34
3800m	#14	0	0	0	0	5	6	3	28
	#15	0	0	0	2	5	14	7	48
	#16	0	0	0	1	10	33	23	79
	#17	0	0	0	2	13	32	24	83
	#18	0	0	0	0	28	34	30	97
	#19	0	0	0	2	15	6	9	112
	#20	1	0	1	2	29	2	29	129
	#21	1	0	1	2	16	10	25	158
	#22	0	0	0	2	14	5	15	82
	#23	1	0	0	2	19	10	15	77
	#24	0	0	0	1	9	8	31	114

* Treated as 125-1000µm (250-1000 & 125-250µm were not separated).

Table 3. (cont.)

Taxon		Dictyocha crux ?				Actiniscus pentasterias group			
Size fraction		250-1000	125-250	63-125	<63	250-1000	125-250	63-125	<63
(µm)									
PAPA III	#25	1	0	0	2	23	38	16	137
3800m	#26	1	0	0	0	13	8	5	123
	#27	0	1	0	2	6	0	7	92
	#28	0	0	0	2	6	3	7	95
	#29	0	0	0	0	3	1	6	73
	#30	0	0	1	0	2	2	7	77
	#31	0	0	0	2	6	8	16	71
	#32	1	0	0	1	5	7	25	86
	#33	0	0	0	0	10	9	15	65
	#34	1	0	0	0	10	2	13	90
	#35	1	0	0	0	23	12	30	37
	#36	0	0	0	0	2	2	3	57
PAPA IV	#37	No sample							
3800m	#38	0	0	0	0	16	7	9	43
	#38	0	0	0	0	6	1	5	25
	#40	0	0	1	0	1	0	3	54
	#41	0	1	0	1	6	9	4	47
	#42	0	0	0	0	2	2	3	53
	#43	0	0	0	0	10	8	8	68
	#44	0	0	0	0	5	6	4	10
	#45	0	0	0	0	13	11	19	34
	#46	0	0	1	0	8	6	12	48
	#47	0	0	0	1	2	8	7	44
	#48	0	0	0	0	4	2	11	27

Table 4. Time-series fluxes (skeletons $\text{m}^{-2}\text{day}^{-1}$) of silicoflagellate taxa at subarctic Station PAPA during September, 1982 through August, 1984. See Table 1 for details of specific dates and duration of each sample.

Taxon	Size fraction (μm)	Distephanus speculum					Distephanus speculum (7 sided)					Distephanus quinquangellus				
		250-1000	125-250	63-125	63	TOTAL	250-1000	125-250	63-125	63	TOTAL	250-1000	125-250	63-125	63	TOTAL
PAPA I 3800m	#1	263	4113	7875	194460	206710	0	0	0	0	0	0	88	0	420	508
	#2	9144	9057	10325	514080	542606	0	0	0	0	0	88	0	175	5040	5303
	#3	7788	2713	18201	259140	287841	44	0	0	0	44	88	0	0	2100	2188
	#4	306	525	9450	228900	239182	0	0	0	0	0	0	0	0	2940	2940
	#5	613	1138	6300	192780	200830	0	0	0	0	0	0	44	175	1260	1479
	#6	350	700	350	206640	208040	0	0	0	0	0	44	0	0	2940	2984
	#7	438	438	963	181020	182858	0	0	0	0	0	0	0	0	2100	2100
	#8	44	44	438	94500	95025	0	0	0	0	0	0	0	0	420	420
	#9	88	350	131	36750	37319	0	0	0	0	0	0	0	0	0	0
	#10	0	0	88	19075	19163	0	0	0	0	0	0	0	0	175	175
	#11	0	0	0	8400	8400	0	0	0	0	0	0	0	0	0	0
	#12	0	0	179	7007	7186	0	0	0	0	0	0	0	0	0	0
PAPA II 1000m	#13 *		5045	7014	301884	313943		0	0	0	0		123	0	656	779
	#14 *		615	6029	118785	125430		0	0	0	0		0	123	0	123
	#15	738	1477	1231	59721	63166	0	0	0	0	0	0	0	0	0	0
	#16	615	0	738	39375	40729	0	0	123	0	123	0	0	0	0	0
	#17	738	246	369	22051	23404	0	0	0	0	0	0	0	0	0	0
	#18	123	492	369	12994	13978	0	0	0	0	0	0	0	0	0	0
	#19	738	246	3076	26763	30823	0	0	0	0	0	0	0	0	0	0
	#20	246	0	3322	57912	61481	0	0	369	0	369	0	0	0	1316	1316
	#21	2215	4676	12797	164724	184412	0	0	123	0	123	0	0	123	1313	1436
	#22	6276	24979	11690	137160	180105	0	0	0	0	0	0	246	123	2625	2994
	#23	123	5045	5660	106972	117800	0	0	0	0	0	0	123	0	656	779
	#24	3199	11690	15750	74159	104798	0	0	0	0	0	123	0	0	1313	1436
PAPA II 3800m	#13	6399	21657	26210	221819	276085	0	246	0	0	246	0	369	0	2625	2994
	#14	5168	7014	9598	128629	150409	0	0	123	0	123	0	123	0	1969	2092
	#15	3692	3322	4799	97128	108941	0	123	123	0	246	123	0	0	656	779
	#16	1107	3199	3322	107628	115257	0	0	0	0	0	0	0	0	656	656
	#17	738	738	1107	64971	67555	0	0	0	0	0	0	0	0	656	656
	#18	2092	2215	3076	34651	42034	0	0	0	0	0	0	0	0	0	0
	#19	1846	738	3815	39770	46168	0	0	0	0	0	123	0	0	394	517
	#20	738	0	2461	56157	59357	0	0	0	0	0	0	0	0	0	0
	#21	2830	738	3445	165840	172854	123	0	0	0	123	123	0	0	1755	1878
	#22	6768	2707	6522	287807	303803	0	0	0	0	0	0	0	0	4387	4387
	#23	3445	2461	4676	86628	97210	0	0	123	0	123	123	0	246	0	369
	#24	1600	2830	9475	32685	46590	0	0	0	0	0	0	246	0	0	246

* Treated as 125-1000 μm (250-1000 & 125-250 μm were not separated).

Table 4. (cont.)

[illegible]

Table 4. (cont.)

Taxon	Size fraction (μm)	Distephanus boliviensis ?				D.boliviensis? pentagonus				D.boliviensis? (7 sided)			
		250-1000	125-250	63-125	(63 TOTAL	250-1000	125-250	63-125	(63 TOTAL	250-1000	125-250	63-125	(63 TOTAL
PAPA I	#1	44	394	1050	2100 3588	0	0	0	420 420	0	0	0	0 0
3800m	#2	1181	394	1575	13440 16590	0	0	0	0 0	0	0	0	0 0
	#3	875	350	4025	7980 13230	0	0	0	0 0	0	0	0	0 0
	#4	0	88	1750	5880 7718	0	0	0	0 0	0	0	0	0 0
	#5	44	219	2100	7980 10343	0	0	0	0 0	0	0	175	0 175
	#6	219	306	175	14280 14980	0	0	0	420 420	0	0	0	0 0
	#7	131	44	88	18900 19163	0	0	0	0 0	0	0	0	0 0
	#8	0	44	0	7980 8024	0	0	0	0 0	0	0	0	0 0
	#9	263	219	88	3150 3719	0	0	0	0 0	0	0	0	0 0
	#10	44	0	0	2975 3019	0	0	0	0 0	0	0	0	0 0
	#11	0	0	44	1050 1094	0	0	0	0 0	0	0	0	0 0
	#12	0	0	0	858 858	0	0	0	0 0	0	0	0	0 0
PAPA II	#13*		246	123	5250 5619		0	0	0 0		0	0	0 0
1000m	#14*		123	861	1969 2953		0	0	0 0		0	0	0 0
	#15	246	0	615	5906 6768	0	0	0	0 0	0	0	0	0 0
	#16	123	0	246	4725 5094	0	0	0	0 0	0	0	0	0 0
	#17	123	0	0	5513 5636	0	0	0	0 0	0	0	0	0 0
	#18	246	0	123	5906 6276	0	0	0	394 394	0	0	0	0 0
	#19	0	492	2584	18427 21503	0	0	0	0 0	0	0	123	0 123
	#20	246	0	1846	8775 10866	0	0	0	0 0	0	0	123	0 123
	#21	369	369	738	7875 9352	0	0	0	0 0	123	0	0	0 123
	#22	0	0	369	7219 7588	0	0	0	656 656	0	0	123	0 123
	#23	0	123	246	5906 6276	0	0	123	0 123	0	0	0	0 0
	#24	492	1107	1354	3938 6891	0	0	0	0 0	0	123	0	0 123
PAPA II	#13	615	2584	615	3938 7752	0	0	0	0 0	123	123	0	0 246
3800m	#14	0	246	369	3281 3897	0	0	0	0 0	0	0	0	656 656
	#15	123	123	246	5250 5742	0	0	0	0 0	0	0	0	0 0
	#16	123	369	1107	1969 3568	0	0	0	0 0	0	0	0	0 0
	#17	0	369	369	5250 5988	0	0	0	0 0	0	0	0	0 0
	#18	123	0	492	3544 4159	0	0	0	0 0	0	0	0	0 0
	#19	492	123	738	3544 4897	0	0	0	0 0	0	0	0	0 0
	#20	369	123	738	6142 7373	0	0	0	0 0	0	0	0	0 0
	#21	123	0	492	11407 12022	0	0	0	0 0	0	0	0	0 0
	#22	492	0	1107	18427 20026	0	0	0	877 877	0	0	0	0 0
	#23	492	246	615	13782 15135	0	0	0	0 0	0	0	0	0 0
	#24	123	123	1107	439 1792	0	0	0	0 0	0	0	0	0 0

* treated as 125-1000 μm (250-1000 & 125-250 μm were not separated).

Table 4. (cont.)

[illegible]

Table 4. (cont.)

Taxon	Size fraction (μm)	Distephanus octangulatus			FLUX		D.octangulatus(1 apical windows)			FLUX		Dictyocha mandrai			FLUX	
		250-1000	125-250	63-125	(63	TOTAL	250-1000	125-250	63-125	(63	TOTAL	250-1000	125-250	63-125	(63	TOTAL
PAPA I	#1	0	0	175	2940	3115	0	0	0	0	0	0	919	350	9240	10509
3800m	#2	613	175	525	18480	19793	44	88	175	0	306	3675	2669	6125	82320	94789
	#3	306	0	175	9240	9721	0	0	0	840	840	3456	1094	8225	62580	75355
	#4	44	0	525	9660	10229	0	0	0	840	840	263	306	7350	93240	101159
	#5	88	88	175	6720	7070	0	44	0	0	44	438	744	9275	168420	178877
	#6	44	0	0	12600	12644	0	0	0	0	0	613	1225	525	278040	280403
	#7	0	0	88	7980	8068	0	0	0	840	840	744	656	2319	229320	233039
	#8	0	0	0	7560	7560	0	0	0	420	420	131	88	569	109620	110408
	#9	0	88	88	5600	5775	0	44	0	350	394	656	1925	1531	69300	73413
	#10	0	44	44	2800	2888	0	0	44	0	44	525	525	2056	34125	37231
	#11	0	0	263	2625	2888	0	0	0	0	0	44	175	525	30100	30844
	#12	60	119	119	3575	3873	0	0	0	143	143	60	597	776	25740	27172
PAPA II	#13 *		123	615	23626	24364		0	0	0	0		1231	1723	31501	34454
1000m	#14 *		369	492	17063	17924		123	0	0	123		1723	1723	35439	38884
	#15	0	615	246	19688	20549	0	246	0	0	246	123	123	615	26251	27112
	#16	246	0	0	14175	14421	0	0	0	1575	1575	246	246	123	44100	44715
	#17	0	0	123	7875	7998	0	0	0	0	0	246	123	123	16144	16636
	#18	0	0	0	11419	11419	0	0	0	394	394	369	369	246	14569	15554
	#19	123	0	861	7897	8882	0	0	0	0	0	246	123	3076	13601	17046
	#20	123	0	615	5265	6003	0	0	0	439	439	984	492	7752	38170	47398
	#21	123	123	246	3938	4430	0	0	0	0	0	615	1969	3815	34126	40525
	#22	0	0	0	2625	2625	0	0	0	0	0	123	1354	1231	28876	31583
	#23	0	0	0	1313	1313	0	0	0	0	0	0	984	492	21657	23134
	#24	0	123	0	1313	1436	0	0	0	0	0	492	861	1354	19032	21739
PAPA II	#13	369	738	2092	20344	23544	123	0	0	656	779	1969	6276	9229	51845	69319
3800m	#14	369	738	123	12469	13700	123	0	0	0	123	1107	2338	2707	30845	36997
	#15	369	492	369	11157	12387	0	0	0	1313	1313	1600	1354	1723	40032	44708
	#16	123	246	615	15750	16735	0	0	0	0	0	1107	1846	4430	31501	38884
	#17	492	369	0	17063	17924	0	0	0	656	656	738	1231	1846	42001	45816
	#18	123	492	246	7088	7949	0	0	0	788	788	3692	1600	2461	25988	33740
	#19	492	0	615	9844	10951	123	0	0	788	911	1477	369	4061	38195	44101
	#20	369	0	246	6142	6757	0	0	0	3510	3510	1600	246	8244	64055	74145
	#21	246	369	123	14039	14778	0	0	0	3510	3510	2215	738	4061	68442	75456
	#22	0	0	246	7897	8143	0	0	0	877	877	984	492	1969	49138	52583
	#23	369	0	369	7219	7957	0	123	0	0	123	1354	861	1969	33470	37653
	#24	0	123	0	3510	3633	0	0	0	439	439	738	861	1846	17330	20775

* treated as 125-1000 μm (250-1000 & 125-250 μm were not separated).

Table 4. (cont.)

Taxon	Distephanus octangulatus					FLUX D.octangulatus(>1 apical windows)					FLUX Dictyocha mandrai					FLUX	
	Size fraction	250-1000	125-250	63-125	(63	TOTAL	250-1000	125-250	63-125	(63	TOTAL	250-1000	125-250	63-125	(63	TOTAL	
	(μ m)																
PAPA III	#25	27	34	41	2789	2892	0	0	0	164	164	192	343	410	20180	21125	
3800m	#26	41	0	123	3117	3281	0	0	0	492	492	328	82	533	19360	20303	
	#27	41	0	0	2297	2338	0	0	0	0	0	369	41	164	14110	14684	
	#28	0	0	0	1805	1805	0	0	0	0	0	205	41	123	10993	11362	
	#29	41	0	0	1148	1189	0	0	0	0	0	123	82	82	12797	13084	
	#30	0	0	0	1641	1641	0	0	0	0	0	246	62	113	10500	10921	
	#31	10	0	21	492	523	0	0	0	0	0	103	72	267	6563	7004	
	#32	0	0	0	656	656	0	0	0	0	0	62	51	246	9844	10203	
	#33	0	0	10	328	338	0	0	0	0	0	308	174	123	7219	7824	
	#34	21	0	41	1641	1702	0	0	0	164	164	390	10	297	14438	15135	
	#35	41	21	62	1641	1764	0	0	0	0	0	882	164	287	5250	6583	
	#36	0	0	41	1313	1354	0	0	0	0	0	246	82	246	6891	7465	
PAPA IV	#37	No sample															
3800m	#38	94	0	0	1500	1594	0	0	0	0	0	844	234	188	13500	14766	
	#38	47	0	47	750	844	0	0	0	0	0	938	422	422	19501	21282	
	#40	0	0	0	1125	1125	0	0	0	0	0	0	188	141	18001	18329	
	#41	47	47	0	1125	1219	0	0	0	188	188	422	281	375	9750	10828	
	#42	47	0	0	563	609	0	0	0	0	0	234	94	234	8063	8625	
	#43	94	0	0	563	656	0	0	0	0	0	656	94	141	5063	5953	
	#44	164	0	0	0	164	0	0	0	0	0	820	492	164	1969	3445	
	#45	0	0	0	164	164	0	0	0	0	0	984	492	2297	1477	5250	
	#46	328	0	0	0	328	0	0	0	164	164	656	328	820	820	2625	
	#47	0	164	164	1148	1477	0	0	0	0	0	984	1148	1477	2953	6563	
	#48	164	0	0	492	656	0	0	0	0	0	164	984	1148	656	2953	

Table 4. (cont.)

		D. mandrai (variable-shaped apical rods)					Dictyocha mandrai pentagona					D. messanensis spinosa ?				
Taxon		250-1000	125-250	63-125	63	FLUX TOTAL	250-1000	125-250	63-125	63	FLUX TOTAL	250-1000	125-250	63-125	63	FLUX TOTAL
Size fraction (µm)																
PAPA I	#1	44	0	175	0	219	0	0	0	0	0	0	0	0	840	840
3800m	#2	44	131	0	1680	1855	0	44	175	1680	1899	0	0	0	0	0
	#3	131	88	525	0	744	0	0	0	420	420	0	0	700	0	700
	#4	0	0	350	420	770	0	0	0	420	420	0	0	0	1260	1260
	#5	0	44	350	2520	2914	0	0	0	420	420	0	44	175	2520	2739
	#6	44	88	0	420	551	0	0	175	2100	2275	0	0	0	1260	1260
	#7	44	88	88	840	1059	0	0	0	1680	1680	0	44	0	8820	8864
	#8	0	0	0	840	840	0	0	0	1260	1260	0	0	0	10920	10920
	#9	0	88	0	175	263	0	0	0	350	350	88	44	88	7875	8094
	#10	0	0	0	0	0	44	0	44	0	88	88	44	44	4725	4900
	#11	0	0	0	0	0	0	0	0	0	0	0	0	0	5075	5075
	#12	0	0	0	0	0	0	60	0	143	203	0	60	0	6006	6066
PAPA II	#13*		0	0	0	0		0	0	0	0		0	123	22969	23093
1000m	#14*		0	0	0	0		0	0	0	0		369	246	17063	17678
	#15	0	0	0	0	0	0	0	0	0	0	0	0	123	13782	13905
	#16	0	0	0	0	0	0	0	0	0	0	369	123	0	15750	16242
	#17	0	0	0	0	0	0	0	0	0	0	0	0	123	15750	15873
	#18	0	0	0	0	0	0	0	0	0	0	0	0	0	9844	9844
	#19	0	0	0	0	0	0	0	123	0	123	0	0	738	6142	6881
	#20	0	246	861	2632	3740	123	0	0	0	123	0	0	123	8775	8898
	#21	123	369	984	3938	5414	0	0	123	0	123	0	0	0	7219	7219
	#22	0	0	0	1313	1313	0	0	0	656	656	123	123	0	1313	1559
	#23	0	123	0	656	779	0	0	0	656	656	0	0	0	3281	3281
	#24	0	0	123	656	779	0	0	0	0	0	123	0	123	3281	3527
PAPA II	#13	0	123	369	0	492	123	123	123	0	369	0	246	369	12469	13084
3800m	#14	123	123	123	656	1025	0	0	0	656	656	0	0	246	7219	7465
	#15	123	0	0	0	123	0	123	0	656	779	123	0	246	5906	6276
	#16	0	0	0	0	0	0	0	0	0	0	123	0	246	11157	11526
	#17	0	0	0	656	656	0	0	0	656	656	0	0	246	19032	19278
	#18	0	0	0	0	0	0	0	0	0	0	0	246	123	5119	5488
	#19	0	0	123	0	123	0	0	0	394	394	0	123	246	6694	7063
	#20	123	0	0	3510	3633	123	0	0	877	1001	123	123	615	8775	9636
	#21	246	246	0	9652	10144	0	0	0	0	0	0	123	123	10530	10776
	#22	0	0	246	5265	5511	123	0	0	2632	2755	123	0	123	5265	5511
	#23	0	0	0	1313	1313	0	0	0	0	0	246	0	0	5906	6153
	#24	0	0	123	658	781	0	0	0	0	0	0	123	0	2632	2755

* Treated as 125-1000µm (250-1000 & 125-250µm were not separated).

Table 4. (cont.)

[illegible]

Table 4. (cont.)

Taxon	Size fraction (μm)	Dictyocha crux ?			TOTAL FLUX		TOTAL Distep.	TOTAL Dicty.	TOTAL Silico.	Actiniscus pentasterias group				TOTAL FLUX
		250-1000	125-250	63-125	(63	TOTAL	FLUX	FLUX	FLUX	250-1000	125-250	63-125	(63	TOTAL
PAPA I 3800m	#1	0	44	175	840	1059	214340	12626	226967	88	219	175	36960	37441
	#2	88	88	700	5040	5915	584597	104458	689055	306	306	175	157920	158708
	#3	44	0	0	3360	3404	313864	80623	394486	656	131	1225	58800	60813
	#4	0	0	0	2520	2520	260908	106129	367037	88	131	0	99540	99759
	#5	0	44	0	3360	3404	219940	188353	408293	88	394	350	72660	73491
	#6	0	44	0	3780	3824	239068	288313	527380	175	263	0	65520	65958
	#7	0	0	44	2100	2144	213028	246785	459813	88	88	263	78540	78978
	#8	0	0	0	1260	1260	111449	124688	236136	44	44	0	49140	49228
	#9	0	0	44	1050	1094	47206	83213	130419	88	263	350	19425	20125
	#10	0	0	44	175	219	25288	42438	67725	175	175	263	16975	17588
	#11	0	0	0	525	525	12381	36444	48825	0	88	481	12600	13169
	#12	0	0	0	286	286	12060	33726	45786	0	60	0	11583	11643
PAPA II 1000m	#13*		0	0	0	0	344706	57547	402252		492	123	18376	18991
	#14*		0	0	0	0	146553	56562	203116		615	1354	35439	37407
	#15	0	0	0	0	0	90729	41017	131746	492	3322	1231	38720	43765
	#16	0	0	0	0	0	61942	60957	122899	492	1231	1354	130725	133801
	#17	0	0	0	0	0	37038	32510	69548	369	738	2092	50008	53207
	#18	0	0	0	394	394	32461	25791	58252	123	369	738	50795	52025
	#19	0	0	0	439	439	61331	24488	85819	2584	1107	4061	82043	89795
	#20	0	0	0	1755	1755	80597	61914	142511	2215	1846	2461	98714	105236
	#21	0	0	0	1313	1313	199875	54593	254469	738	615	3815	72190	77358
	#22	0	492	0	656	1148	194092	36259	230351	123	1354	615	24938	27030
	#23	0	0	0	0	0	126291	27850	154141	123	1723	615	30845	33306
	#24	0	0	0	0	0	114683	26046	140729	1107	2092	3938	34782	41919
PAPA II 3800m	#13	0	0	123	0	123	311646	83387	395034	615	492	2830	22313	26251
	#14	0	0	0	0	0	170999	46144	217143	615	738	369	18376	20098
	#15	0	0	0	1313	1313	129408	53199	182607	615	1723	861	31501	34700
	#16	0	0	0	656	656	136217	51066	187283	1231	4061	2830	51845	59967
	#17	0	0	0	1313	1313	92780	67719	160499	1600	3938	2953	54470	62961
	#18	0	0	0	0	0	54930	39228	94158	3445	4184	3692	38195	49515
	#19	0	0	0	788	788	63445	52469	115913	1846	738	1107	44101	47793
	#20	123	0	123	1755	2001	76997	90415	167412	3568	246	3568	113192	120575
	#21	123	0	123	1755	2001	205165	98377	303541	1969	1231	3076	138639	144914
	#22	0	0	0	1755	1755	338115	68115	406230	1723	615	1846	71952	76135
	#23	123	0	0	1313	1436	120918	46554	167472	2338	1231	1846	50533	55947
	#24	0	0	0	219	219	52700	24531	77231	1107	984	3815	25008	30914

* Treated as 125-1000 μm (250-1000 & 125-250 μm were not separated).

Table 4. (cont.)

Taxon	Dictyocha crux ?				TOTAL		TOTAL		TOTAL		Actiniscus pentasterias group				
	Size fraction	250-1000	125-250	63-125	(63	FLUX	Distep.	Dicty.	Silico.		250-1000	125-250	63-125	(63	FLUX
	(μ m)					TOTAL	FLUX	FLUX	FLUX						TOTAL
PAPA III	#25	7	0	0	328	335	49438	24113	73550		158	260	656	22477	23552
3800m	#26	41	0	0	0	41	41017	21534	62551		533	328	205	20180	21247
	#27	0	41	0	328	369	27768	16899	44667		246	0	287	15094	15627
	#28	0	0	0	328	328	20221	12879	33101		246	123	287	15586	16243
	#29	0	0	0	0	0	15997	14561	30558		123	41	246	11977	12387
	#30	0	0	10	0	10	14387	11813	26200		21	21	72	12633	12746
	#31	0	0	0	328	328	9936	8009	17945		62	82	164	11649	11956
	#32	10	0	0	164	174	11392	10726	22118		51	72	256	14110	14489
	#33	0	0	0	0	0	8101	8490	16591		103	92	154	10664	11013
	#34	10	0	0	0	10	12346	15986	28332		103	21	133	14766	15022
	#35	21	0	0	0	21	21452	6891	28343		472	246	615	6070	7404
	#36	0	0	0	0	0	16448	8162	24610		82	82	123	9352	9639
PAPA IV	#37	No sample													
3800m	#38	0	0	0	0	0	31079	15610	46689		750	328	422	32251	33751
	#38	0	0	0	0	0	38251	22876	61127		281	47	234	18751	19313
	#40	0	0	47	0	47	23157	19126	42283		47	0	141	10125	10313
	#41	0	47	0	188	234	12282	11672	23954		281	422	188	8813	9703
	#42	0	0	0	0	0	13266	9235	22501		94	94	141	9938	10266
	#43	0	0	0	0	0	4031	6188	10219		469	375	375	12750	13969
	#44	0	0	0	0	0	4758	3938	8696		820	984	656	6563	9024
	#45	0	0	0	0	0	5250	5578	10828		2133	1805	3117	5578	12633
	#46	0	0	164	0	164	3445	3281	6727		1313	984	1969	7875	12141
	#47	0	0	0	164	164	3117	7219	10336		328	1313	1148	7219	10008
	#48	0	0	0	0	0	1969	2953	4922		656	328	1805	4430	7219

Table 5. Number of counted specimens in each sample (sum of four size fractions).
The mean of the counted specimens per deployment (6 months) are also given
as well as total mean and counts (2 years).

Deployment/Depth	Sample #	<i>D. speculum</i>	<i>D. speculum</i> (7 sided)	<i>D. quinquangellus</i>	<i>D. boliviensis</i> ?	<i>D. boliviensis</i> ? pentagona	<i>D. boliviensis</i> ? (7 sided)	<i>D. octangulatus</i> (>1 apical windows)	<i>D. mandrai</i>	<i>D. mandrai</i> (variable apical rods)	<i>D. mandrai</i> pentagona	<i>D. messanensis</i> ? spinosa	Total silicoflagellates	A. pentastemias group		
PAPA I	#1	608	0	3	21	1	0	8	0	45	2	0	2	4	694	96
3800m	#2	781	0	6	53	0	0	32	4	229	5	3	0	11	1124	109
	#3	961	1	7	70	0	0	30	2	300	8	1	4	9	1393	165
	#4	618	0	7	26	0	0	27	2	277	3	1	3	6	970	242
	#5	535	0	5	37	0	1	21	1	481	9	1	8	9	1108	186
	#6	518	0	8	47	1	0	31	0	707	4	6	3	10	1335	166
	#7	473	0	5	51	0	0	21	2	631	7	4	22	6	1222	197
	#8	237	0	1	20	0	0	18	1	279	2	3	26	3	590	119
	#9	223	0	0	31	0	0	36	3	490	3	2	50	7	845	127
	#10	111	0	1	18	0	0	18	1	266	0	2	31	2	450	111
	#11	48	0	0	7	0	0	21	0	189	0	0	29	3	297	85
	#12	52	0	0	6	0	0	30	1	204	0	2	43	2	340	82
MEAN		430	0	4	32	0	0	24	1	342	4	2	18	6	864	140
PAPA II	#13	558	0	2	11	0	0	42	0	72	0	0	36	0	721	33
1000m	#14	235	0	1	11	0	0	33	1	82	0	0	31	0	394	70
	#15	119	0	0	16	0	0	37	2	52	0	0	22	0	248	100
	#16	36	1	0	6	0	0	11	1	36	0	0	14	0	105	108
	#17	67	0	0	15	0	0	21	0	45	0	0	41	0	189	153
	#18	41	0	0	18	1	0	29	1	45	0	0	25	1	161	139
	#19	94	0	0	67	0	1	26	0	59	0	1	20	1	269	250
	#20	161	3	3	37	0	1	18	1	162	15	1	21	4	427	278
	#21	411	1	3	24	0	1	10	0	104	18	1	11	2	586	152
	#22	558	0	7	14	1	1	4	0	66	2	1	4	5	663	55
	#23	251	0	2	12	1	0	2	0	45	2	1	5	0	321	67
	#24	362	0	3	30	0	1	3	0	51	2	0	7	0	459	111
MEAN		241	0	2	22	0	0	20	1	68	3	0	20	1	379	126
PAPA II	#13	779	2	7	37	0	2	57	2	221	4	3	24	1	1139	66
3800m	#14	373	1	4	10	0	1	29	1	97	4	1	13	0	534	42
	#15	244	2	2	12	0	0	27	2	99	1	2	12	2	405	74
	#16	226	0	1	16	0	0	32	0	108	0	0	20	1	404	145
	#17	120	0	1	14	0	0	33	1	95	1	1	31	2	299	152
	#18	148	0	0	14	0	0	25	2	129	0	0	16	0	334	189
	#19	153	0	2	20	0	0	34	3	145	1	1	20	2	381	142
	#20	90	0	0	17	0	0	12	4	155	5	2	17	4	306	189
	#21	246	1	3	18	0	0	22	4	135	15	0	14	4	462	209
	#22	458	0	5	34	1	0	11	1	84	8	4	8	2	616	116
	#23	218	1	3	19	0	0	17	1	85	2	0	11	3	360	121
	#24	262	0	2	13	0	0	17	2	107	4	0	13	1	421	162
MEAN		276	1	3	19	0	0	26	2	122	4	1	17	2	472	134

Table 5. (cont.)

Deployment/Depth	Sample #	<i>D. speculum</i>	<i>D. speculum</i>	<i>D. speculum</i> (7 sided)	<i>D. quinquangellus</i>	<i>D. boliviensis</i> ?	<i>D. boliviensis</i> ? pentagona	<i>D. boliviensis</i> ? (7 sided)	<i>D. octangulatus</i>	<i>D. octangulatus</i> (>1 apical windows)	<i>D. mandrai</i>	<i>D. mandrai</i> (variable apical rods)	<i>D. mandrai</i> pentagona	<i>D. messanensis</i> ? spinosa	Total silicoflagellates	<i>A. pentasterias</i> group
PAPA III	#25	530	0	9	54	0	0	27	1	211	7	1	12	3	855	214
3800m	#26	251	0	0	23	0	1	23	3	141	4	2	2	1	451	149
	#27	159	0	1	13	0	0	15	0	100	9	0	3	3	303	105
	#28	111	0	1	13	0	0	11	0	76	4	0	4	2	222	111
	#29	99	0	0	10	0	0	8	0	85	5	0	4	0	211	83
	#30	104	0	0	14	0	0	10	0	105	2	0	9	1	245	88
	#31	84	0	1	8	0	0	6	0	83	1	0	5	2	190	101
	#32	92	0	0	10	0	0	4	0	95	2	1	1	2	207	123
	#33	51	0	0	16	0	0	3	0	103	2	0	3	0	178	99
	#34	77	0	2	11	1	1	16	1	156	2	0	5	1	273	115
	#35	252	0	5	45	0	0	16	0	97	1	0	6	1	423	102
	#36	107	0	0	27	0	0	9	0	56	0	0	5	0	204	64
MEAN		160	0	2	20	0	0	12	0	109	3	0	5	1	314	113
PAPA IV	#37	No sample														
3800m	#38	77	0	0	41	0	1	4	0	45	0	0	3	0	171	75
	#38	100	0	0	23	0	0	3	0	64	0	0	4	0	194	37
	#40	113	0	0	18	0	0	6	0	103	0	1	3	1	245	58
	#41	75	0	1	12	0	0	8	1	75	0	0	4	2	178	66
	#42	65	1	1	13	0	1	4	0	55	1	0	3	0	144	60
	#43	10	0	0	25	0	1	5	0	46	2	0	3	0	92	94
	#44	10	0	0	6	0	0	1	0	12	0	0	3	0	32	25
	#45	12	0	0	19	0	0	1	0	32	0	0	2	0	66	77
	#46	4	0	0	14	0	0	2	1	16	0	0	3	1	41	74
	#47	8	0	0	2	0	0	9	0	40	1	0	2	1	63	61
	#48	5	0	0	3	0	0	4	0	18	0	0	0	0	30	44
MEAN		44	0	0	16	0	0	4	0	46	0	0	3	0	114	61
TOTAL MEAN		233	0	2	22	0	0	18	1	139	3	1	13	2	434	116
TOTAL COUNTS		13771	14	115	1292	7	14	1040	53	8191	170	49	746	128	25590	6833

a

Distephanus speculum

PAPA II 1000m

b

Distephanus speculum

PAPA I - IV 3800m

Fig. 2.

a *Distephanus speculum* (7 sided)

PAPA II 1000m

b *Distephanus speculum* (7 sided)

PAPA I - IV 3800m

Fig.3.

Fig. 4.

a

Distephanus boliviensis ?

PAPA II 1000m

b

Distephanus boliviensis ?

PAPA I - IV 3800m

Fig. 5.

a *Distephanus octangulatus*

PAPA II 1000m

b *Distephanus octangulatus*

PAPA I - IV 3800m

Fig. 6.

a *D. octangulatus* (>1 apical windows)

PAPA II 1000m

b *D. octangulatus* (>1 apical windows)

PAPA I - IV 3800m

Fig. 7.

a

Dictyocha mandrai

PAPA II 1000m

b

Dictyocha mandrai

PAPA I - IV 3800m

Fig. 8.

a *Dictyocha mandrai*(variable apical rods)

PAPA II 1000m

b *Dictyocha mandrai*(variable apical rods)

PAPA I - IV 3800m

Fig. 9.

a

Dictyocha mandrai pentagona

PAPA II 1000m

b

Dictyocha mandrai pentagona

PAPA I - IV 3800m

Fig. 10.

Fig. 11.

a

b

Fig. 12

a

Total Distephanus

PAPA II 1000m

b

Total Distephanus

PAPA I - IV 3800m

Fig. 13.

a

Total Dictyocha

PAPA II 1000m

b

Total Dictyocha

PAPA I - IV 3800m

Fig. 14.

Fig. 15.

Fig. 16.

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16. Abstract (Limit: 200 words) A seasonal flux study of silicoflagellates and <u>Actiniscus</u> was conducted at subarctic Pacific Stations PAPA (50°N, 145°W; water depth 4200 m) during September, 1982 through August, 1984 using PARFLUX time series sediment traps deployed at 1000 m and 3800 m depths. The time series sediment trap samples were collected for 4- to 16-day periods depending on the samples; most of the samples were collected for 14- to 16-day periods. A total of 47 continuous samples represents nearly a two-year record of the fluxes of silicoflagellate and <u>Actiniscus</u> taxa at 3800 m depth. An additional 12 samples from 1000 m represent a continuous 6-month period which provides a pair of samples from two depths of each time series. Analysis of the paired samples is essential to understand particle sinking processes. Seven silicoflagellate taxa, several additional variants of silicoflagellates, and <u>Actiniscus pentasterias</u> group were enumerated, based on a census of four wet sieved size fractions: 250-1000µm, 125-250µm, 63-125µm, and <63µm. A total of more than 32x10 ³ specimens were identified to species level and counted in this study. Statistics of the counts are given. The fluxes of silicoflagellate taxa of all four size fractions are graphically presented. This report provides a detailed data base for further investigations of seasonal silicoflagellate fluxes in the area.			
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