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The Plankton of the St. Andrew Bay System, Florida

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Abstract

Plankton investigations were carried out in 1959–60 and 1961–62 in the St. Andrew Bay System, a complex of shallow estuaries on the north Gulf Coast of Florida. The bay complex is a two-layered system with the vertical salinity gradient averaging 1 ppt near the Gulf to over 9 ppt near the heads of North and East Bays. Mean annual salinity for stations located throughout the bay complex ranged from 19.4 to 32.7 ppt and annual water temperature ranged from 11.5 to 28.8 C.

Samples for phytoplankton and chlorophyll *a* analyses were taken from surface waters and in 1961–62 eight separate diatom genera exceeded 1% of the total diatom volume. In order of importance they were *Chaetoceros, Rhizosolenia, Skeletonema, Cyclotella, Thalassiothrix, Coscinodiscus, Bacteriastrum,* and *Thalassionema. Chaetoceros, Rhizosolenia,* and *Thalassiothrix* occurred in greatest numbers in relatively high salinities while *Skeletonema* was most abundant at intermediate salinities. Distributional patterns of the other major planktonic genera were somewhat less distinct. Diatom volume increased with increasing salinity whereas diatom numbers were greatest at intermediate stations. Chlorophyll *a* concentrations were highest at stations farthest into the estuaries. The annual mean for surface chlorophyll *a* was 2.13 mg/m^3 and means for diatom numbers and volume were 8×10^5 cells/l and 0.5 mm^3/l respectively. Seasonal peaks for chlorophyll *a*, diatom numbers, and diatom volume did not correspond in time.

Zooplankton was collected by oblique tows with Clarke-Bumpus samplers fitted with #10 mesh nets. Zooplankton standing crop in the bay system varied within relatively narrow limits with the largest populations occurring near the head of West Bay and the smallest near the heads of the East and North bays of the system. Average counts and biomass (dry weight) for 1961–62 were 40,100/m^3 and 42.7 mg/m^3. Seasonal peaks occurred in June of 1959 and in August, September, January, and June of 1961–62. Standing crop minima were recorded for August and February of 1959–60 and for February and April of 1962.

Copepods constituted the most important zooplankton group and accounted for 60% of the zooplankton number and 56% of the dry weight. The two next most important zooplankton groups were larvae of benthic invertebrates and appendicularians. Together these three groups totalled 79% of the zooplankton number and 92% of the dry weight. Other groups seasonally important were rotifers, cladocerans, and *Noctiluca.*

The most abundant zooplankton species were, in order of importance, *Acartia tonsa, Paracalanus crassirostris, Oikopleura dioica, Oithona brevicornis, Noctiluca scintillans, Oithona nana,* and *Synchaeta* sp. These seven species constituted over 50% of the zooplankton dry weight.

Both diatom and zooplankton diversity increased towards the Gulf with increasing salinity. Zooplankton diversity tended to decrease in winter with the annual low occurring in February but diatom diversity evidenced no clear seasonal trends.

Results of multiple-linear regression analyses indicated that little of the total variance in plankton biomass could be attributed to physical parameters such as salinity and temperature and that there was little correlation between zooplankton and diatom biomass fluctuations. It was suggested that large predators such as scyphomedusae and ctenophores play a major role in regulating microzooplankton abundance in the St. Andrew Bay System.

A comparison of St. Andrew Bay phytoplankton and zooplankton standing crop with that of other areas along the Gulf and Atlantic coasts revealed that St. Andrew Bay standing crop was somewhat less than that of other estuaries but greater than most open sea areas considered.

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[1] Based on a Doctoral Dissertation submitted to the graduate school of the Florida State University.

Introduction

Plankton were collected in the St. Andrew Bay System, Florida from 1959 to 1962. Data are presented on seasonal changes in plankton composition and biomass and on some of the environmental parameters which may have strongly influenced observed biological variations.

Since an understanding of plankton dynamics first requires estimates of standing crop, considerable effort in this investigation was devoted to assaying plankton biomass. Most papers of quantitative data on Gulf of Mexico plankton have expressed abundance in terms of numbers of a plankton species per given volume of water (King, 1950; Pierce, 1951; Grice, 1953; Curl, 1959; Thomas and Simmons, 1960). Grice (1957) estimated volume contributions for individual plankton species, but only for copepods. The St. Andrew Bay program attempted to assay more adequately the contribution of individual species to total standing crop.

The St. Andrew Bay System

The St. Andrew Bay System (Fig. 1) is a complex of shallow coastal plain estuaries located on the northern Gulf Coast of Florida. The bay complex occupies 90 square miles between longitudes 85° 23′–85° 53′ West and latitudes 30° 00′–30° 20′ North. This system is formed by three estuaries, North, West, and East Bays, which flow into a central basin, St. Andrew Bay. Two of the bays, North and West Bays, merge to form the upper arms of a "Y" before opening into St. Andrew Bay. Centrally located St. Andrew Bay has access to the Gulf through two passes, West Pass to the south and East Pass to the southeast. Hypsographic curves (Waller, 1961), show West, North, and East Bays to be comparatively shallow, mean depths being 2.1 m, 1.8 m, and 2.1 m respectively. St. Andrew Bay is deeper, the mean depth being 5.2 m. Sediments of the bay complex were investigated by Waller (1961) who found well sorted sands along the shallow margins and finer grained, more poorly sorted silt-clay sediments in the central troughs.

Ichiye and Jones (1962), in a paper on the hydrography of the St. Andrew Bay System, state that North, West and East Bays are positive estuaries according to Pritchard's (1952) classification in that drainage inflow exceeds evaporation. This results in a net inflow of saline water along the bottom towards the heads of the estuaries and a net outflow towards the Gulf of less dense surface water. St. Andrew Bay itself, having direct access to the Gulf, contains water which is only slightly less saline than coastal Gulf water. Vertical stratification of the water column is generally greatest at points farthest from the Gulf where surface salinities are comparatively low as a result of fresh water discharge. Exceptions can be found in regions of West Bay where wind mixing is often effective in destroying vertical stability (Hopkins, 1963). The tidal cycle in St. Andrew Bay is predominantly diurnal and the tidal amplitude averages between 0.3 and 0.6 m. According to Ichiye and Jones (1962) most of the tidal exchange with the Gulf is accomplished through East Pass which accommodates 65 to 75% of the tidal volume. The chief source of runoff into the bay system has been the Econfina River which empties into the head of North Bay. Recently a dam has been extended across North Bay (completed April 1962) approximately one mile north of station N1. The effects of this dam on the hydrography of the bay system await investigation.

Methods

The St. Andrew Bay complex was sampled monthly in 1961–62 at the eleven stations indicated on the base map (Fig. 1). A preliminary quarterly survey was carried out at eight of the eleven stations (W1, W2, N1, N2, S2, S3, E1, E2) in 1959–60. In 1959–60 oblique plankton tows were made along with hydrographic casts for temperature and salinity determinations. In 1961–62 Secchi disk readings and water samples for phytoplankton and chlorophyll *a* were obtained.

Most of the chlorinity measurements were made by silver nitrate titration though in some instances hydrometers were used.

Phytoplankton samples were obtained from surface water and preserved in a 4% formalin-seawater solution. Slides were prepared for phytoplankton counts by filtering up to 100 cc of preserved sample through 0.45μ pore diameter membrane filters. The volume filtered depended on the turbidity of the sample. The filters were placed on slides and cleared with immersion oil. Cell counts were made at 300 × magnification with the diatoms in twenty 0.03 mm^2 Whipple disk fields being counted. No distinction was made between cells containing chlorophyll and those without. Estimates of cell volume were obtained by measuring the major axes of five of each type of cell (predominantly diatoms) on every slide and substituting these dimensions into simple geometric formulae.

Chlorophyll *a* was extracted and measured in a manner similar to that outlined by Marshall (1956). Up to a liter of water was filtered through 0.80μ pore diameter membrane filters at 22 psi. The filters were placed in 5 cc of 90% acetone and extracted for at least 12 hours in the dark at approximately 4 C. The samples were centrifuged in a clinical centrifuge to remove undissolved portions of the filters and other debris. The clear supernatant was read at 660 $\text{m}\mu$ against a 90% acetone-dissolved filter standard. The amount of chlorophyll *a* in a cubic meter of water was calculated by the following formula (Marshall, 1956):

$$\frac{1.03 \text{ Klett readings} \times \text{vol. extract (ml)}}{\text{vol. sample (l)}} \times 0.034 = \text{mg chl. } a/\text{m}^3$$

Zooplankton was collected by oblique hauls with #10 nylon nets mounted on Clarke-Bumpus samplers. The catch was preserved in a 5% buffered formalin-seawater solution. Counts of smaller microcrustaceans were made on 1/100 or 2/100 of the sample while larger plankters such as thaliaceans, chaetognaths, sergestids, amphipods, ostracods, siphonophores, and hydromedusae were counted in 8/100 aliquots. Tintinnids were so small and on occasion so numerous that in some samples only those in 1/1000 of the total catch were enumerated. All aliquots were taken from samples using the zooplankton subsampler described by Hopkins (1962). The average number of zooplankters counted for each collection was 1216.

Zooplankton biomass was estimated by summing dry weight contributions of each plankton type in a sample. Dry weights of species in sample aliquots were estimated using either a standard species weight based on an average of several weighings, or by using species dimensions vs. dry weight curves. The mean of ten measurements of each plankton type in a sample aliquot was used to obtain dry weight from the curves. Species dry weights were obtained by weighing specimens which were dried on tared cover slips for 12 hours at 70 C. Prior to drying plankters were soaked in several changes of distilled water to remove salt. Weight and dimension data used to construct the curves for each plankton type except copepods are given in Table 1. Copepod weight curves were constructed utilizing dry weight and cylindrical volume data. Cylindrical volume of copepod species was computed from measurements of metasome lengths and widths. Cylindrical volume averages and dry weights of 67 groups of copepod naupliar and post naupliar stages gave the following regression equations from which copepod dry weights could be estimated:

$$V < 1000: W = 0.0123V + 0.24 \ (r = 0.87)$$
$$V > 1000: W = 0.0192V - 6.70 \ (r = 0.99)$$

where V = volume ($mm^3 \times 10^{-4}$) and W = dry weight ($mg \times 10^{-3}$).

TABLE 1

Dry weight data for various plankters

Plankter	Sample size	Dry wt per Individual (10^{-3} mg)	Mean Dimension (mm)	Characteristic measured
Hydromedusae	300	1.43	.29	bell diameter
	45	7.33	1.07	
	32	17.50	1.71	
	14	46.43	3.60	
Siphonophores	66	1.82	.98	eudoxid, bract or
	22	5.00	3.00	nectophore length
Creseis acicula	267	108.42	.70	shell length
	19	1.27	6.60	
Euconchoecia chierchiae	371	1.67	.49	valve length
	103	4.27	.75	
	87	12.87	1.08	
Lucifer faxoni	66	8.48	2.61	anterior tip of
	36	20.00	4.25	eye to telson tip
	25	59.20	6.36	
Chaetognaths	219	1.51	2.20	total length
	88	9.77	3.90	
	55	21.81	5.60	
	25	96.40	8.00	
Appendicularians	500	.36	.17	head length
	168	2.62	.38	
	125	6.48	.62	
Dolioletta gegenbauri	46	6.74	1.38	total length
	13	18.46	2.30	(of mixed stages)
Noctiluca scintillans	787	.37	dimension	
Immature ctenophores	22	13.64	not considered	
Synchaeta sp.	1488	.20	for *Noctiluca*	
	2200	.28	and succeeding	
Polychaete larvae	127	3.70	oragnisms	
Gastropod-Pelecypod veligers	853	2.66		
Evadne tergestina	300	1.20		
Podon polyphemoides	297	.73		
	123	1.11		
Penilia avirostris	120	1.67		
Hyperia atlantica	22	25.45		
Cirriped nauplii	147	.88		
Cirriped cypris	172	5.41		
Decapod larvae	106	6.13		
	83	4.70		
Brachiolaria[a]	130	.23		
	350	.29		
Plutei[a]	100	.44		
Branchiostoma larvae	73	4.25		
Fish eggs	130	8.77		
Fish larvae	98	6.57		

[a] May be an overestimate

Two regression analyses were appropriate since there was a natural break in the data at a copepod volume of $0.1 mm^3$.

Attempts to obtain dry weight data for tintinnids were unsuccessful. Dry weight for species in this group was roughly estimated by computing the volume enclosed by the mean-sized lorica for a given species, then, assuming a specific gravity of unity, multiplying half the computed volume by 0.2. The computed volume was halved because tintinnids rarely seemed to occupy the entire lorica and the value of 0.2 is a conversion factor (Giese, 1957) for obtaining dry from live weight.

Sources of Error

Sources of potential error in estimating phytoplankton numbers and biomass include patchiness, methods of sample collection and fixation, and error in counting and measuring cells. No data are available on phytoplankton patchiness in St. Andrew Bay. The principal limitation of the collecting method was that only surface samples were taken. A few preliminary investigations on the phytoplankton vertical distribution suggest that cell counts and volumes from surface samples underestimate mean values for the entire water column. Formalin preservation of phytoplankton undoubtedly resulted in an underestimate of total plant abundance since formalin may destroy small athecate cells.

An effort was made to estimate counting error by repeating the standard diatom counting procedure 15 times on the same filter. Traverses across the filter were arranged so that duplicate counts of the same field were avoided. Results of these counts (Table 2) show that variance decreases as mean number of cells counted increases. This is not a linear relationship and the distribution of the values, particularly those for *Chaetoceros* and *Skeletonema*, suggests that different species show varying degrees of clumping on the filters, presumably because of variations in cell numbers per chain and in cell spination. Differential clumping of cells has been noted by Kutkuhn (1958) in phytoplankton counting chambers as well. The coefficient of variation for the total count for 20 fields was 26%, which is probably an overestimate of diatom counting variability since the mean total of test counts was only half the mean of 1961–62 counts.

In regard to volume measurement errors, complex cell shapes were reduced to simple geometric forms. This simplification, along with errors in actual measurement of major cell axes, may have led to volumetric and consequently diatom biomass errors.

The influence of plankton patchiness and collecting and counting errors on estimates of abundance of copepods, the dominant plankton group in the bay system, has been discussed in detail in an earlier paper (Hopkins, 1963).

TABLE 2

Diatom count variance

Type of diatom	Mean[a] count for 20 × 0.03 mm^2 fields	Coefficient of variation (×100)
Bacteriastrum	4.3	90.0
Chaetoceros	21.2	33.0
Skeletonema	52.3	38.8
Total diatom count	94.7	26.0

[a] Mean computed from 15 sets of traverses (*i.e.*, 15 × 20 fields).

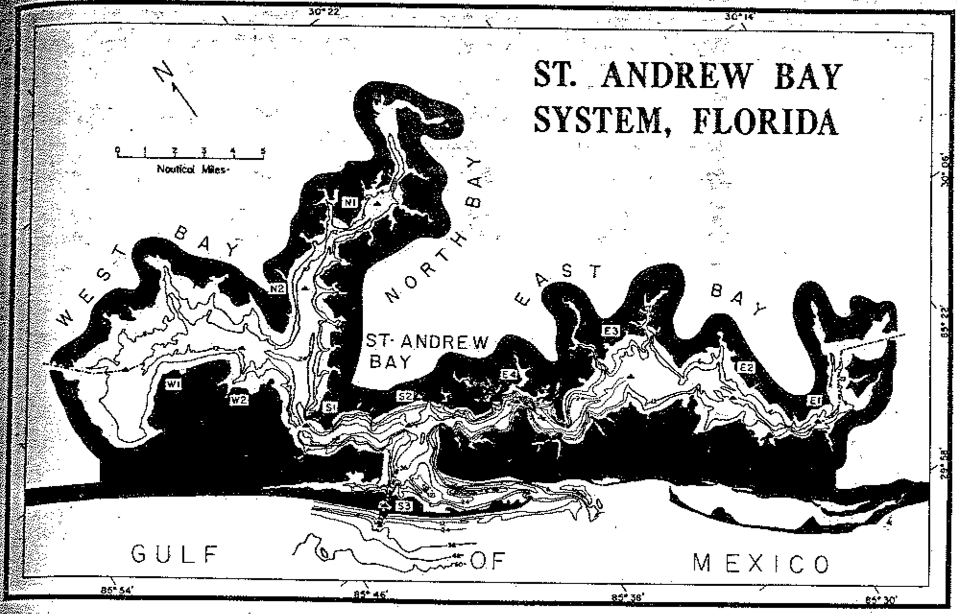

FIG. 1. The St. Andrew Bay System, Florida, showing station locations.

Some data are also available on relative filtering efficiency of nets of different mesh sizes. Filtering efficiency was investigated by making a series of surface tows with new #10 (0.155 mm mesh diagonal) and #20 (0.099 mm mesh diagonal) nets. Four tows were made, two with each net, while circling about a marker in an outboard skiff at normal towing speed. Counts were made on 1/100th sample aliquots and were prorated to numbers/m^3. Average catch data for the two nets are presented in Table 3 and differences in catch between the two nets are expressed as percent of total #20 net catch. Assuming that the #20 net filtered out virtually all the plankters listed in Table 3, 46% of the total number of plankters was lost through the meshes of the #10 net. In terms of dry weight, percent lost by the #10 net was about the same (43%), though weight losses were differently distributed. The major numerical losses can be attributed to the small copepods *Oithona brevicornis* (9.7%) and *Paracalanus crassirostris* (4.8%), to cope-

TABLE 3

Comparison of the catch of #20 and #10 mesh nets

	#20 mean no. per m^3	#10 mean no. per m^3	Loss (% total #20 catch)	#20 mean dry wt (mg/m^3)	#10 mean dry wt (mg/m^3)	Loss (% total #20 catch)
Oithona brevicornis	23,724	10,391	9.7	11.38	7.42	3.5
Paracalanus crassirostris	29,886	23,263	4.8	13.75	16.75	—2.7
Other copepods	5,624	5,835	—0.2	4.29	6.58	—2.0
Copepod nauplii	18,865	5,085	10.0	6.51	2.13	3.9
Tintinnids	6,517	1,889	3.4	.92	.24	0.6
Oikopleura dioica	27,644	18,284	6.8	10.75	7.58	2.8
Other holoplankters	1,173	1,212	......	.81	2.52	—1.5
Pelecypod veligers	18,787	2,615	11.7	49.97	6.96	38.2
Other larvae	5,637	6,214	—0.4	14.36	14.54	—0.2
Total	137,856	74,787	45.7	112.72	64.71	42.6

pod nauplii (10%), tintinnids (3.4%), and appendicularians (6.8%), and to pelecypod veligers (11.7%). Dry weight loss was somewhat smaller in each of the above groups and in some categories an even slightly greater dry weight was computed for the #10 net. Pelecypod veligers were responsible for most (90%) of the #10 net loss, though much of the veliger dry weight was composed of inorganic shell crystals. Tintinnid loss was undoubtedly underestimated since most of these are capable of passing through the meshes of both nets.

In light of this series of tows the loss of microzooplankton through the meshes of #10 nets is great and comparatively fine #20 mesh nets would seem to have been more suitable for this survey. However, Yentsch and Duxbury (1956) have shown that on occasions fine mesh nets can clog rapidly and even yield reverse meter readings. Since #10 mesh nets are relatively free from mesh clogging, they were used in routine sampling.

Dry weights reported in this paper are based on preserved material rinsed with distilled water. No conversion factor was applied to relate preserved plankton weight to that of fresh plankton.

Hydrographic Data

Hydrographic data for the St. Andrew Bay System by station and season are presented in Tables 4 and 5 respectively. As Ichiye and Jones (1962) found in their study

TABLE 4

Physical data for the St. Andrew Bay System (1961–62 average values) according to station

Station	S3	S2	E4	S1	E3	W2	N2	W1	E2	N1	E1
Surface salinity (0/00)	32.2	29.2	26.7	26.3	24.0	23.9	22.8	23.2	21.4	16.8	14.9
Bottom salinity	33.3	33.0	32.6	32.4	29.3	28.4	30.4	26.0	25.9	26.0	24.0
Vertical gradient	1.1	3.8	5.9	6.1	5.3	4.5	7.5	2.8	4.5	9.2	9.1
Mean salinity	32.7	31.0	29.7	29.2	26.9	26.2	26.2	24.6	23.7	21.4	19.4
Mean temperature (°C)	22.8	22.7	22.7	22.8	22.4	22.9	23.5	23.1	22.4	23.8	22.5
Secchi depth (m)	6.5	4.6	3.8	3.7	3.4	2.9	2.9	2.1	2.5	1.9	1.6
Station depth (m)	11.5	11.8	12.9	15.5	6.1	4.7	5.8	5.0	3.2	2.9	4.5
Distance from Gulf (miles from S3)	0	3.0	7.0	6.4	11.7	10.4	11.0	14.7	15.5	15.0	20.4

TABLE 5

Seasonal data (average of all stations) on salinity, temperature, and transparency of the St. Andrew Bay System

Date	Mean salinity (ppt.)	Mean temperature (C)	Secchi depth (m)
Aug '59	21.4	28.4	----
Nov '59	23.6	20.6	----
Feb. '60	23.0	15.3	----
June '60	27.3	28.0	----
July '61	25.3	28.8	-
Aug '61	24.7	28.8	4.1
Sept '61	23.4	28.2	2.9
Oct '61	27.9	25.7	4.4
Nov '61	30.6	21.4	3.4
Dec '61	29.7	19.5	2.9
Jan. '62	26.0	11.5	3.2
Feb '62	26.8	17.3	3.7
Mar '62	26.8	18.1	2.9
Apr '62	21.3	21.3	2.1
May '62	25.3	26.0	3.0
June '62	28.7	27.7	3.2

of the bay complex, salinity increased with distance from the heads of the bays towards the Gulf with mean annual salinity ranging from 19.4 ppt at E1 to 32.7 ppt at S3. At all stations salinity at the surface was less than bottom salinity. Greatest differences between bottom and surface salinity occurred at the head of North Bay (N1: 9.2 ppt) and East Bay (E1: 9.1 ppt) while smallest differences occurred at the head of West Bay (W1: 2.8 ppt) and near the Gulf (S3: 1.1 ppt).

Though the overall trend was for vertical salinity difference to decrease towards the Gulf, the relationship was not nearly so linear with distance from the Gulf as was decrease in mean salinity. Variations in vertical differences in regions of comparable salinity are the result of the interaction of the effects of station distance from the source of fresh water, with the quantity of runoff, station depth, and degree of exposure to wind. The most important factor affecting vertical stability undoubtedly varies from one location in the bay complex to another and from time to time, depending on the amount of runoff and the wind velocity and direction. For example, the relatively large mean vertical differences at N1 and E1 may have resulted largely from the proximity of these stations to fresh water sources. Vertical stratification at these stations also was enhanced by the narrowness of East and North Bays at these points which effectively reduced wind fetch and attendant turbulence. The small vertical difference found at W1 probably resulted from a combination of factors such as comparatively small runoff into this region of West Bay and its exposure to wind which had considerable fetch from all quarters. The small mean vertical difference recorded for S3 was largely due to its remoteness from the major sources of runoff and its proximity to Gulf sea water.

Seasonally, mean salinity for the bay system was lowest in August and highest in June of the 1959–60 quarterly survey. In 1961–62 mean salinity values were smallest for September and April and largest for November, December, and June.

Temperature differences throughout the bay system at any one sampling were small and mean values for stations varied less than 2 C. Vertical temperature differences were also small and in only nine of 132 sets of surface and bottom samples did the vertical gradient exceed 2 C. Average temperature for the bay system ranged from 11.5 C in January 1962 to 28.8 C in July–August 1961.

Secchi disk readings showed an apparent strong positive relationship with salinity and increased from bay-head areas towards the Gulf. Seasonally transparency was greatest in the St. Andrew Bay System in October and January through March.

Phytoplankton Distribution by Season and Station

Records were kept on all genera of diatoms, thecate dinoflagellates, and silicoflagellates encountered in the 20 fields examined on each filter. Distribution by station of the principal genera of diatoms is presented in Fig. 2 A–H and in Table 6. In 1961–62 eight separate planktonic genera exceeded 1% of the total diatom volume in surface waters of St. Andrew Bay. In order of importance they were *Chaetoceros* (30.2%), *Rhizosolenia* (27.3%), *Skeletonema* (8.7%), *Cyclotella* (6.6%), *Thalassiothrix* (5.2%), *Coscinodiscus* (3.1%), *Bacteriastrum* (3.0%), and *Thalassionema* (1.0%). The remaining diatoms, averaging 14.9% of the total diatom volume, were predominantly of benthic genera. Of the eight genera mentioned above, *Chaetoceros*, *Rhizosolenia*, and *Thalassiothrix* were of greatest importance at stations of relatively high salinity near the Gulf.

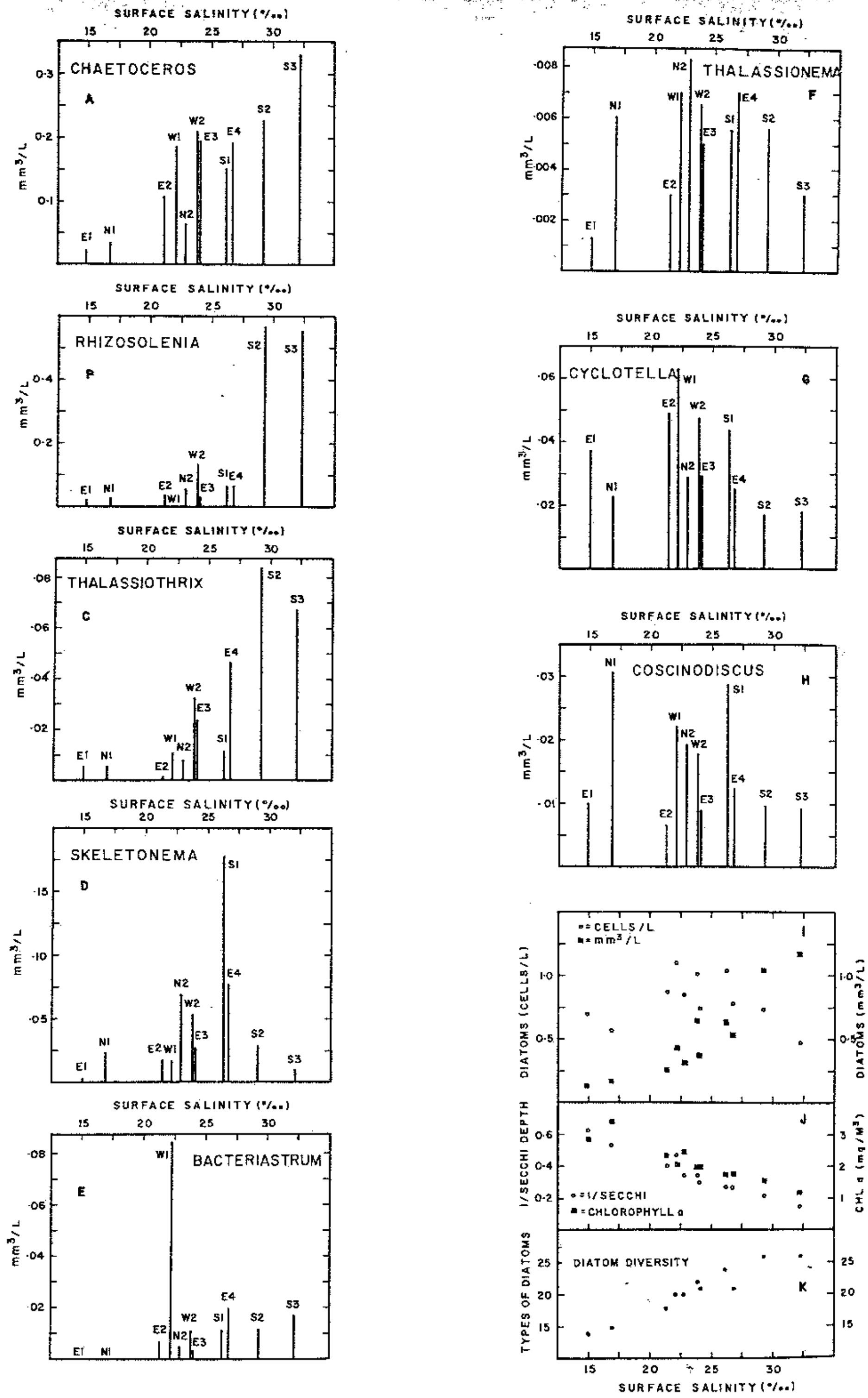

FIG. 2. Diatom and chlorophyll-a distribution (1961–62) in the St. Andrew Bay System with respect to Salinity. A—*Chaetoceros*; B—*Rhizosolenia*; C—*Thalassiothrix*; D—*Skeletonema*; E—*Bacteriastrum*; F—*Thalassionema*; G—*Cyclotella*; H—*Coscinodiscus*; I—Total diatom numbers and volume; J—Chlorophyll-a and 1/Secchi depth; K—Diatom variety.

TABLE 6

Distribution of diatoms and chlorophyll *a* by station in the St. Andrew Bay System (1961–62 average values)

	S3	S2	E4	S1	E3	W2	N2	W1	E2	N1	E1	Avg.	% Total
Chaetoceros	.3300	.2287	.1947	.1511	.1930	.2094	.0643	.1835	.1092	.0318	.0208	.1560	30.2
Rhizosolenia	.5585	.5737	.0648	.0639	.0244	.1328	.0581	0	.0336	.0231	.0187	.1411	27.3
Skeletonema	.0099	.0289	.0762	.1769	.0251	.0528	.0681	.0153	.0157	.0239	.0003	.0448	8.7
Cyclotella	.0180	.0169	.0249	.0433	.0282	.0447	.0282	.0625	.0484	.0225	.0375	.0341	6.6
Thalassiothrix	.0672	.0839	.0469	.0116	.0244	.0325	.0075	.0107	.0006	.0059	.0054	.0270	5.2
Coscinodiscus	.0092	.0096	.0123	.0287	.0089	.0176	.0194	.0221	.0063	.0306	.009	.0159	3.1
Bacteriastrum	.0163	.0108	.0191	.0119	.0033	.0114	.0046	.0848	.0061	0	0	.0153	3.0
Thalassionema	.0030	.0056	.0070	.0055	.0057	.0065	.0083	.0070	.0029	.0061	.0013	.0053	1.0
Rest	.1441	.0855	.0923	.1189	.0566	.1360	.0548	.0603	.0316	.0230	.0431	.0769	14.9
Total volume (mm³/1)	1.1543	1.0436	.5382	.6118	.3695	.6436	.3132	.4462	.2544	.1668	.1369	.5162	100.0
Total # (10⁶ cells/1)	.477	.736	.771	1.048	.749	1.008	.842	1.092	.860	.557	.681	.802	..
Types of diatoms	26	26	21	24	21	22	20	20	18	15	14	....	...
Chlorophyll *a* (mg/m³)	1.18	1.56	1.78	1.78	1.96	1.99	2.49	2.07	2.33	3.48	2.80	2.13	....
Surface sal (ppt)	32.2	29.2	26.7	26.3	24.0	23.9	22.8	22.1	21.4	16.8	14.9	....	....

Neglecting the unusually high average for W1, *Bacteriastrum* also showed a slight positive trend with increasing salinity. *Skeletonema* was most abundant at stations of intermediate salinity, its greatest volume average occurring at 26 ppt. *Coscinodiscus*, *Thalassionema*, and *Cyclotella* demonstrated less distinct distributional patterns, though the highest values for the latter two genera were recorded for stations intermediate in salinity. Total diatom biomass (Fig. 2 I), on the whole, increased with increasing salinity, the highest average being recorded for S3. Chlorophyll *a* (Fig. 2 J) demonstrated an opposite trend; highest pigment concentrations were found near the heads of bays. This suggests that the importance of the diatom contribution to total chlorophyll *a* in surface waters lessens with distance from the Gulf. Diatom volume and abundance trends were not strongly related since maximum numbers were found at intermediate stations instead of at stations near the Gulf. The mean number of diatoms per liter for the entire St. Andrew Bay System (1961–62) was 8×10^5.

Diatom variety generally increased with increasing salinity (Fig. 2 K). Greatest average diversity was recorded for S3 and S2, the two stations of highest salinity. Smallest diatom variety was encountered at N1 and E1, stations of lowest salinity.

Table 7 and Fig. 3 A–K contain seasonal data on diatoms, surface chlorophyll *a*, and water temperature. All eight of the principal genera (Fig. 3 A–H) had biomass peaks in summer or fall (*i.e.*, July–November). *Chaetoceros* and *Bacteriastrum* evidenced maxima in June, *Coscinodiscus* and *Skeletonema* in July, *Cyclotella* in August, *Thalassiothrix* and *Thalassionema* in October, and *Rhizosolenia* and *Coscinodiscus* in November. *Thalassiothrix* and *Skeletonema* also had peaks in winter (January and February respectively). No clearly defined maxima were recorded for any of the major genera in spring (March–May).

Seasonally, diatom number and volume and chlorophyll *a* maxima did not correspond well in time (Fig. 3 I–J) and these variables appeared to fluctuate independently of one another. Peaks in diatom numbers (Fig. 3 I) occurred in August, February, and May while diatom volume maxima appeared in November and June. Low values for diatom numbers were recorded for July, November, and January while minima for diatom volume were noted in September and April. The principal chlorophyll *a* peak (Fig. 3 J) was recorded for July and lesser peaks occurred in December and June. Concentrations of chlorophyll *a* were smallest in October and from January through March. Much of the chlorophyll *a* in the St. Andrew Bay System may be detrital, particularly towards the heads of the estuaries, and fluctuations in chlorophyll *a* possibly are related to the amount of detritus in suspension. This argument gains some support in the often inverse relationship between water transparency, as measured by Secchi disk, and chlorophyll *a* values (Figs. 2 J, 3 J). Diatom diversity minima for the bay complex (Fig. 3 K) occurred in September, February, and May while maxima were recorded for August, November, March, and June.

In regard to other thecate groups of phytoplankton, armored dinoflagellates and silicoflagellates were scarce compared to diatoms in the St. Andrew Bay System during 1961–62. *Ceratium* was included in counts of only seven of 132 filters while silicoflagellates (*Dichtyocha*) occurred in counts of 18 filters. When encountered, these cells generally numbered only one cell/20 fields, with three cells/20 fields (*Dichtyocha*) being the maximum. In one instance a chain forming blue-green alga was abundant and in June it constituted 52% of the volume of phytoplankton at station N1.

TABLE 7

Seasonal distribution (average of all stations) of diatoms and chlorophyll *a* in the St. Andrew Bay System in 1961-62

	1961 Jul	Aug	Sept	Oct	Nov	Dec	1962 Jan	Feb	Mar	Apr	May	June
Chaetoceros	.0594	.1657	.0654	.0815	.1022	.1158	.0973	.1510	.1733	.1250	.1812	.5628
Rhizosolenia	.0883	.1237	.0493	.3138	.4617	.0558	.1616	.0641	.0743	.0425	.0233	.2396
Skeletonema	.1620	.1201	.0003	.0023	.0058	.0124	.0119	.1604	.0274	.0016	.0025	.0331
Cyclotella	.0264	.1072	.0954	.0346	.0244	.0408	.0104	.0136	.0109	.0057	.0195	.0204
Thalassiothrix	.0091	.0362	.0016	.0735	.0659	.0312	.0740	.0205	.0021	.0035	.0109	.0210
Coscinodiscus	.0301	.0173	.0155	.0148	.0385	.0238	.0061	.0070	.0129	.0087	.0072	.0087
Bacteriastrum	.0100	.0063	0	.0034	.0100	.0301	.0022	0	0	.0012	.0028	.1153
Thalassionema	.0043	.0043	.0058	.0134	.0053	.0069	.0072	.0062	.0024	.0024	.0024	.0019
Rest	.1177	.0586	.0758	.0594	.1241	.0991	.0412	.0396	.1182	.0330	.0745	.1065
Total volume (mm^3/l)	.5073	.6401	.2436	.5966	.8378	.4157	.4119	.4624	.4215	.2237	.3243	1.1092
Total # (10^6 cells/l)	.487	1.436	.844	.687	.436	.617	.551	1.199	.822	.635	.957	.902
Types of diatoms	21	24	14	17	25	25	19	18	26	18	17	25
Chlorophyll *a* (mg/m^3)	4.18	3.21	2.10	.52	2.52	2.79	1.28	1.14	1.26	2.15	2.27	2.29
Surface temp (C)	28.8	28.8	28.1	25.3	21.4	19.6	10.9	17.2	18.2	22.2	27.1	27.9

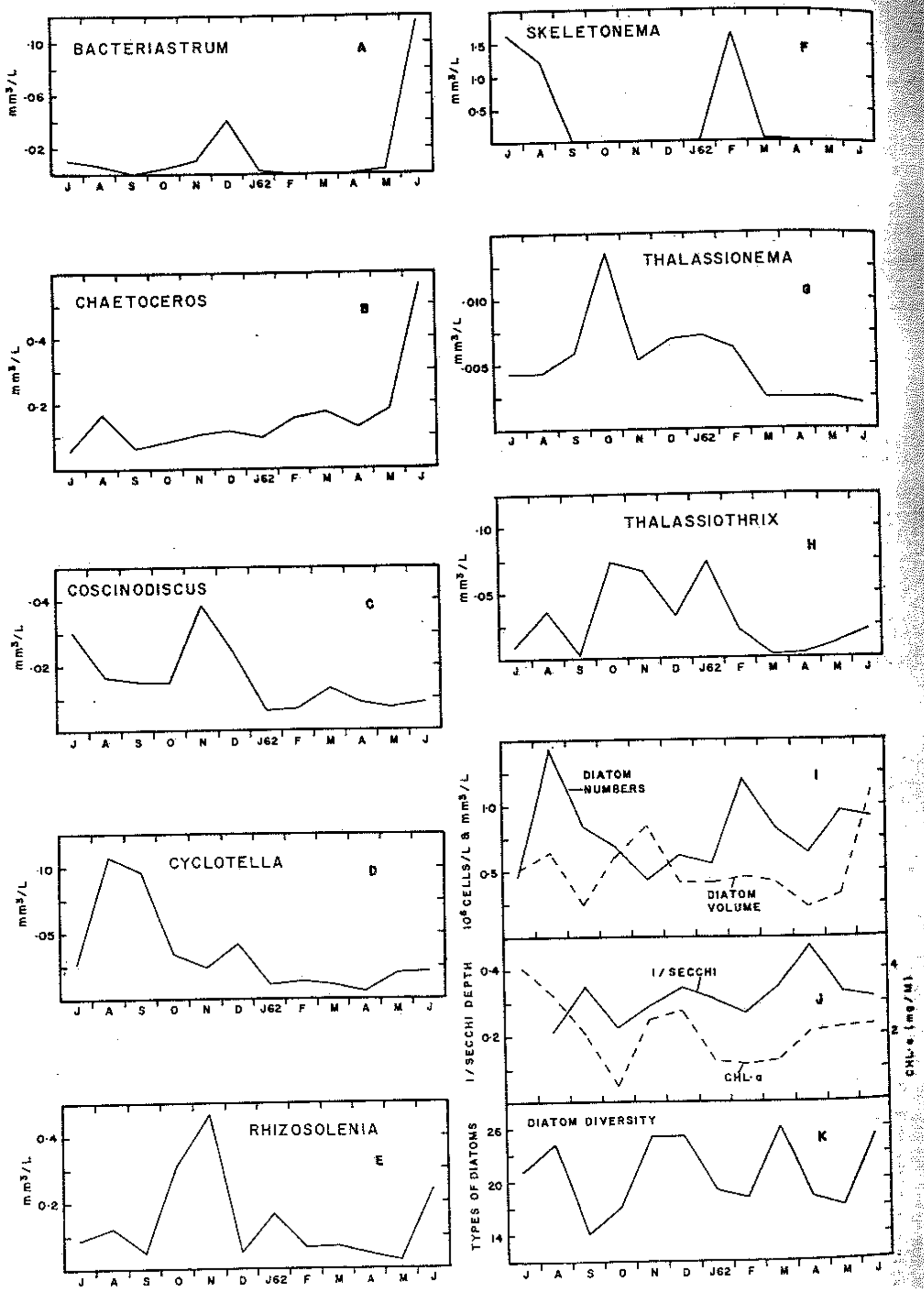

FIG. 3. Seasonal distribution of diatoms and chlorophyll-a in the St. Andrew Bay System in 1961–62. A—*Bacteriastrum*; B—*Chaetoceros*; C—*Coscinodiscus*; D—*Cyclotella*; E—*Rhizosolenia*; F—*Skeletonema*; G—*Thalassionema*; H—*Thalassiothrix*; I—Total diatom numbers and volume; J—Chlorophyll-a and 1/Secchi depth; K—Diatom variety.

Zooplankton Distribution by Season and Station

SPECIES ACCOUNT

The following account summarizes count and biomass data for individual species and types of zooplankton. Numerical and biomass contributions of each species of zooplankton by month are presented in Tables 8 and 9 and graphs of the seasonal biomass distribution of the major species in each plankton group are in Fig. 4 A–G. Tables 10 and 11 contain species count and biomass data according to salinity and station.

Dinoflagellates: The dinoflagellate *Noctiluca scintillans* (Macartney) is considered with zooplankton since it is holozoic in its mode of nutrition (Kofoid and Swezy, 1921). *Noctiluca* (Fig. 4 A) occurred first in 1961–62 in February and reached peak numbers (22,900/m³) in March. This organism became well distributed throughout the bay complex, though it was more abundant in North and West Bays than in the eastern arm of the complex. After March *Noctiluca* all but disappeared and only small numbers occurred in aliquots of samples taken from April–June 1962. In 1959–60 a few *Noctiluca* were recorded as early as November and it was still present in February, though not nearly in such numbers as in February of 1962. In 1961–62 *Noctiluca* averaged 6.9% of the total zooplankton number and 2.4% of the total biomass.

Tintinnids: Thirteen species of tintinnids were identified from aliquots of zooplankton collections. According to Borror's (1962) literature survey this is the first list of species from the Gulf of Mexico. On the basis of two years of sampling there is evidence for seasonal changes in relative abundance of various species in this group. Species found predominantly in cooler months were *Favella taraikaensis* Hada, *Tintinnopsis kofoidi* Hada, *Helicostomella subulata* (Ehrenberg), *Codonellopsis obesa* Balech, and *Tintinnidium mucicola* (Claparède and Lachmann). The most abundant winter form was *Tintinnidium mucicola,* though *Tintinnopsis kofoidi, Favella taraikaensis* and *Helicostomella subulata* were also numerous. Species more common in the warmer months were *Favella panamensis* Kofoid and Campbell, *Tintinnopsis radix* (Imhof[a]), *Tintinnopsis brandti* (Nordqvist), *Amphorides amphora* (Claparède and Lachmann), *Eutintinnus medius* Kofoid and Campbell, and *Eutintinnus pinguis* Kofoid and Campbell. The most prevalent tintinnid of the warmer months was *Tintinnopsis radix* with *Favella panamensis* and *Tintinnopsis brandti* being abundant on occasion. Seasonal fluctuations of *Stylicauda platensis* (Da Cunha and Fonseca) and *Tintinnopsis buetschlii* Daday were not apparent.

Tintinnids were found in every survey and noticeable peaks of total numbers occurred in January and June of 1962. They also were encountered at every station and, like *Noctiluca,* they were generally more abundant in West and North Bays than in East Bay. This group made up 4.3% of the total number of zooplankters but because of their diminutive size only constituted 0.11% of the zooplankton biomass. Since these plankters easily could have passed through the nets used in this survey, possibly only a small fraction of the tintinnid biomass was accounted for. Sampling the St. Andrew Bay System with a finer mesh net undoubtedly would disclose many additional species.

Hydromedusae: Hydromedusae were one of the more diverse groups (26 spp.) of the St. Andrew Bay plankton, though they made a comparatively insignificant contribu-

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[a] *T. radix, T. kofoidi,* and *S. platensis* were not accurately separated in initial counts, but after reexamining many samples it is reasonably safe to state that *T. radix* was more prevalent in the warmer months and that *T. kofoidi* was essentially a winter form.

Table 8

Seasonal numerical distribution of zooplankton in the St. Andrew Bay System (average of all stations)
+ indicates observed in sample but not in aliquot

	Aug. 59	Nov.	Feb. 60	June	July 61	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 62	Feb.	Mar.	April	May	June
DINOFLAGELLATA																
Noctiluca scintillans	....	9	4	....	....	....	....	....	....	....	....	10553	22882	6	2	2
TINTINNOINEA																
Tintinnopsis radix	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Stylicauda platensis	903	338	4	750	+	674	934	354	57	42	2547	24	603	154	57	13238
Tintinnopsis kofoidi	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Tintinnopsis beutschlii	....	....	+	+	....	....	+	....	....	....	95	+	101	....	....	323
Tintinnopsis brandti	41	14	....	....	....	489	43	....	....	....	....	....	6	....	5	833
Tintinnidium mucicola	....	....	13	....	....	....	....	....	....	....	7647	....	+	+	....	140
Eutintinnus medius	....	....	....	+	....	....	....	....	+	....	....	....	....	....	+	123
Eutintinnus pinguis	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+
Codonellopsis obesa	....	....	....	....	....	....	....	....	....	....	329	....	....	....	....	....
Helicostomella subulata	....	+	+	....	....	....	....	....	....	....	991	+	33	....	....	....
Amphorides amphora	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+
Favella panamensis	2	....	....	69	+	+	+	+	+	+	....	....	....	....	8	1652
Favella taraikaensis	....	....	43	....	....	....	....	....	....	....	1790	....	+	+	....	....
HYDROMEDUSAE																
Aglaura hemistoma	....	2	....	....	....	2	1	....	1	....	....	....	....	....	....	....
Bougainvillia carolinensis	1	+	1	....	....	....	8	....	....	1	+	1	+	1	....	2
Cunina octonaria	1	+	....	+	....	+	5	....	....	....	....	....	....	....	....	....
Dipurena ophiogaster	....	....	1	....	1	1	....	....	....	....	....	....	....	....	....	....
Dipurena strangulata	1	....	....	....	1	....	....	+	+	....	....	....	....	....	+	8
Ectopleura dumortieri	....	....	1	....	....	....	+	....	+	....	3	....	1	....	1	+
Eirene pyramidalis	+	+	....	....	....	....	+	+	....	....	....	....	....	....	....	....
Eucheilota duodecimalis	11	2	10	5	2	11	38	15	3	1	2	+	1	1	55	15
Eucheilota ventricularis	+	....	....	+	....	1	+	....	....	....	....	....	....	....	1	+
Euphysa aurata	....	....	....	....	....	....	....	....	....	....	....	....	1	2	+	....
Euphysora gracilis	+	+	1	+	....	....	....	....	1	....	....	....	....	....	+	1
Eutima variabilis	+	....	....	+	....	1	+	....	....	....	....	....	....	....	1	+
Halitiara formosa	+	+	....	....	....	....	+	....	....	....	....	....	....	....	....	....
Liriope tetraphylla	4	+	1	13	1	19	45	3	1	6	3	2	1	1	9	29
Nemopsis bachei	....	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....
Obelia spp.	1	2	+	....	2	2	1	....	....	....	....	+	....	....	+	1
Persa incolorata	....	1	22	....	....	....	....	3	2	7	8	1	1	7	+	+

Phialidium folleatum	8	....	....	18	3	10	24	7	3	1	....	....	....	....	41	17
Phialucium carolinae	....	....	....	....	....	....	+	....	....	....	....	....	....	....	....	....
Podocoryne minima	....	....	1	+	1	+	1	84	145	16	+	1	....	1	+	46
Podocoryne minuta	....	....	....	....	....	1	7	1	....	....	....	....	....	....	....	....
Poboscidactyla ornata	+	....	+	+	....	....	....	+	....	....	2	+	....	+	+	1
Rhopalonema velatum	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....
Sarsia sp.	....	....	....	....	....	....	....	....	2	....	....	....	....	....	1	....
Solmaris sp.	....	....	....	+	....	....	....	....	....	....	....	....	....	....	1	....
SIPHONOPHORA																
Agalma sp.	+	....	+	....	....	+	+	....	....	....	+	....	....	....	....	+
Bassia bassensis	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+
Diphyes dispar	+	....	+	....	+	....	....	....	....	....	....	+	....	....	....	....
Enneagonum hyalinum	....	....	....	....	....	....	....	....	....	....	....	+	....	....	....	....
Muggiaea kochi	18	....	4	+	+	2	1	2	2	1	1	+	1	+	2	2
ROTIFERA																
Synchaeta sp.	....	227	35	....	....	....	....	....	261	3280	19260	12	7	8	69	....
Trichocerca marina	....	27	5	....	....	....	....	5	....	....	198	....	....	....	47	780
Rotifer C	....	....	....	....	....	....	....	....	7	....	94	....	....	....	38	....
MOLLUSCA																
Creseis acicula	17	....	....	69	21	10	5	15	2	6	3	....	1	411	23	7
Desmopterus papilio	....	....	....	....	....	+	....	....	....	....	....	....	....	....	....	....
Pteropod A	....	....	....	+	....	+	+	....	....	....	....	....	....	....	....	....
Protatlanta souleyeti	....	....	+	+	....	+	....	....	....	....	....	....	....	....	....	+
POLYCHAETA																
Tomopteris mariana	....	....	....	....	....	....	+	+	....	....	....	....	....	....	2	+
COPEPODA																
Acartia tonsa	2487	5132	4994	2676	4349	5387	8162	7326	4114	3364	9138	1330	2049	2565	9989	4289
Anomalocera ornata	....	....	....	....	....	....	....	....	....	2	....	....	....	....	....	....
Calanopia americana	5	....	....	....	....	3	14	6	8	....	....	....	....	....	....	....
Candacia sp. (immatures)	....	....	....	....	....	....	....	....	....	....	3	....	....	....	....	....
Centropages furcatus	158	40	....	114	69	225	535	247	60	20	2	....	3	13	302	199
Centropages hamatus	....	6	439	....	....	....	....	....	20	106	1382	56	736	77	....	....
Clausocalanus furcatus	....	....	....	....	42	3	....	48	....	....	....	....	2	5	....	....
Clytemnestra rostrata	....	....	....	3	....	....	....	3	8	....	....	....	....	2	....	....
Corycaeus americanus	12	8	12	13	20	15	11	11	14	13	13	3	68	21	70	81
Corycaeus amazonicus	12	....	4	49	....	10	7	18	6	3	....	....	2	10	5	40

TABLE 8 (Continued)

Seasonal numerical distribution of zooplankton in the St. Andrew Bay System (average of all stations)
+ indicates observed in sample but not in aliquot

	Aug. 59	Nov.	Feb. 60	June	July 61	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 62	Feb.	Mar.	April	May	June
Corycaeus giesbrechti	5	8	....	5	....	3	....	21	6	3	....	....	....	....	....	2
Corycaeus latus	....	....	....	....	....	....	....	5	....	....	....	....	....	....	....	....
Corycaeus speciosus	....	....	....	....	....	+	....	....	....	....	....	....	....	....	....	....
Corycaeus spp. (immatures)	33	50	....	56	132	146	140	44	109	65	21	30	24	163	172	135
Corycella carinata	....	....	....	....	....	....	4	....	....	....	....	....	....	....	....	....
Eucalanus pileatus	26	6	20	3	30	13	62	20	13	5	12	3	5	5	59	28
Euterpina acutifrons	81	49	120	889	91	203	352	114	241	38	176	22	216	256	1114	340
Harpacticoids (benthic)	9	4	3	10	13	38	24	21	27	33	16	9	76	30	100	88
Hemicyclops type immatures	48	95	17	3	85	36	44	48	24	24	42	20	4	20	27	173
Kelleria sp.	54	13	4	13	....	....	15	....	20	....	7	2	....	....	4	119
Labidocera aestiva	34	....	8	108	124	65	86	121	177	25	22	6	39	5	66	110
Microsetella norvegica	....	....	....	3	....	17	4	....	....	....	....	....	....	....	....	....
Oithona brevicornis	944	2456	3896	6880	3544	10026	5548	5842	3755	3969	3794	785	2158	2020	2127	6633
Oithona nana	278	197	261	925	303	1528	1167	913	1283	248	547	146	1421	127	1968	1282
Oithona plumifera	....	8	40	....	....	27	....	5	4	....	3	....	....	....	2	....
Oithona simplex	57	7	10	....	46	320	378	794	935	70	46	....	2	....	....	4
Oncaea curta	16	161	12	189	96	192	23	25	380	183	24	9	25	15	57	23
Oncaea venusta	....	8	....	6	2	30	....	....	4	....	....	....	2	....	2	....
Paracalanus aculeatus	....	....	4	....	....	....	....	....	4	....	3	....	....	....	....	....
Paracalanus crassirostris	1813	4805	1216	10789	6910	15575	8936	8199	5254	2798	2046	266	1489	834	4069	20976
Paracalanus parvus	140	51	146	305	159	178	108	214	639	93	175	28	181	300	753	179
Pseudodiaptomus coronatus	79	70	16	48	24	84	458	233	277	73	146	10	8	39	171	50
Temora stylifera	....	....	....	....	2	....	....	2	....	....	2	....	....	....	....	....
Temora turbinata	84	126	....	2	4	10	348	46	156	22	31	2	5	2	52	7
Tortanus setacaudatus	4	13	....	17	65	59	52	47	4	2	....	....	....	....	4	14
Undinula vulgaris	....	....	....	....	....	+	....	10	2	....	....	....	....	....	....	....
Copepod nauplii	1054	7884	1626	4745	1944	6767	5094	5432	7189	2130	4727	719	2541	1603	7141	17909
CLADOCERA																
Evadne tergestina	408	46	....	768	649	2090	630	382	131	11	....	....	....	....	368	126
Penilia avirostris	19	2	....	72	11	121	241	89	88	9	....	....	....	....	67	82
Podon polyphemoides	....	....	340	+	....	....	1	....	2	81	1812	120	887	289	361	....
OSTRACODA																
Euconchoecia chierchiae	....	2	133	....	40	49	1	4	22	28	7	1	....	....	....	....

AMPHIPODA																
Hyperia atlantica	1	+	8	2	6	1	....	+	1	....	1	....	+	....	1	2
Simorhynchotus antennarius	....	....	....	....	....	....	....	....	....	....	....	....	....	....		+
MYSIDACEA																
Gastrosaccus dissimilis	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+
Metamysidopsis munda	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	....
Mysidopsis almyra	....	....	....	....	....	....	....	....	....	+	....	....	....	....	....	....
DECAPODA																
Lucifer faxoni	9	+	....	5	6	6	24	20	4	1	....	+	1	....	5	63
CHAETOGNATHA																
Sagitta enflata	5	19	3	5	1	6	1	3	3	2	5	....	....	....	....	....
Sagitta helenae	2	....	....	1	1	1	....	....	....	1	....	+	1	....	5	63
Sagitta hispida	7	2	8	3	6	....	9	8	1	....	....	....	....	....	2	....
Sagitta tenuis	28	5	8	29	7	9	19	21	18	7	10	....	14	4	49	64
Sagitta < 3 mm	119	128	24	143	177	250	117	226	120	51	40	25	26	67	249	508
APPENDICULARIA																
Appendicularia sicula	....	....	....	1012	17	24	....	....	....	7	5	4	....	12	20	....
Fritillaria borealis	....	....	....	....	12	....	....	....	....	....	....	....	....	....	19	9
Fritillaria formica	....	11	....	....	+	....	....	....	....	....	....	....	....	....	....	....
Fritillaria haplostoma	....	10	....	....	....	....	....	+	....	....	....	....	....	....	....	....
Oikopleura dioica	889	889	116	1770	1435	4688	3786	3156	3750	334	105	41	1383	1473	5326	4482
Oikopleura cornutogastra	....	....	....	....	....	....	....	11	....	....	....	....	....	....	....	....
Oikopleura fusiformis	31	47	6	+	74	179	52	243	75	+	1	2	72	458	41	14
Oikopleura longicauda	651	34	46	609	86	1640	521	235	103	7	80	14	77	192	358	445
Oikopleura rufescens	....	+	....	....	....	....	....	....	....	....	....	....	....	....	+	....
Kowalevskaia tenuis	....	+	....	....	....	....	....	....	....	....	....	....	....	....	....	....
THALIACEA																
Cyclosalpa floridana	....	....	....	....	....	+	....	....	....	....	....	....	....	....	....	....
Dolioletta gegenbauri	5	....	....	+	1	4	6	3	1	+	4	5	....	....	21	14
LARVAE																
Polychaete	155	153	143	269	141	373	288	450	355	507	836	80	410	311	1352	4283
Gastropod	619	58	338	725	979	2425	4072	553	384	66	93	17	209	143	1727	2816
Pelecypod	217	76	493	1955	596	2501	2485	759	1301	427	209	39	1078	868	2164	4335
Cirriped	29	56	586	186	151	60	61	166	406	330	162	98	323	179	303	441
Decapod	189	....	....	66	90	232	376	141	54	13	2	2	31	14	154	376
Echinoderm	51	4	19	58	24	191	161	74	16	13	22	....	67	173	217	9171
Other invertebrate	34	55	54	32	8	24	60	24	85	88	69	25	88	44	125	166
Cephalochordate	1	....	....	1	2	....	4	1	....	....	....	....	....	12	....	8
Fish eggs	22	....	....	18	5	66	4	9	....	9	....	....	3	....	95	41
Fish larvae	17	....	....	18	13	21	10	....	1	....	....	....	....	3	16	32

TABLE 9

Seasonal dry weight (mg/m^3) distribution of zooplankton in the St. Andrew Bay System (average of all stations)

	Aug. 59	Nov.	Feb. 60	June	July 61	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 62	Feb.	Mar.	April	May	June
DINOFLAGELLATA																
Noctiluca scintillans	....	....	....	....	....	....	....	....	....	....	....	3.91	8.47	....	....	....
TINTINNOINEA																
Tintinnopsis radix	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Stylicauda platensis	....	....	....	....	....	.01	.01	....	0.1	....	.03	....	.01	....	....	.16
Tintinnopsis kofoidi	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Tintinnopsis beutschlii	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Tintinnopsis brandti	....	....	....	....	....	.01	....	....	....	....	....	....	....	....	....	.02
Tintinnidium mucicola	....	....	....	....	....	....	....	....	....	....	.16	....	....	....	....	....
Eutintinnus medius	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Eutintinnus pinguis	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Codonellopsis obesa	....	....	....	....	....	....	....	....	....	....	.01	....	....	....	....	....
Helicostomella subulata	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Amphorides amphora	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Favella panamensis	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.20
Favella taraikaensis	....	....	....	....	....	....	....	....	....	....	.09	....	....	....	....	....
HYDROMEDUSAE																
Aglaura hemistoma	....	....	....	....	....	....	.01	....	.01	....	....	....	....	....	....	....
Bougainvillia carolinensis	....	....	....	....	....	....	.10	....	....	....	....	....	....	....	....	.03
Cunina octonaria	....	....	....	....	....	....	.14	....	....	....	....	....	....	....	....	....
Dipurena ophiogaster	....	....	....	....	....	.01	....	....	....	....	....	....	....	....	....	....
Dipurena strangulata	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.03
Ectopleura dumortieri	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Eirene pyramidalis	....	....	....	....	....	....	....	....	....	.01	....	....	....	....	....	....
Eucheilota duodecimalis	....	....	....	....	.02	.03	.12	.04	.01	....	.02	....	....	....	.16	.04
Eucheilota ventricularis	....	....	....	....	....	.01	....	....	....	....	....	....	....	....	.06	....
Euphysa aurata	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Euphysora gracilis	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Eutima variabilis	....	....	....	....	....	.01	....	....	....	....	....	....	....	....	.06	....
Halitiara formosa	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Liriope tetraphylla	....	....	....	....	.02	.05	.46	.07	.01	.03	....	.01	....	....	.04	.46
Nemopsis bachei	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Obelia spp.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Persa incolorata	....	....	....	....	....	....	....	.01	....	.02	.03	....	....	.01	....	....
Phialidium folleatum	....	....	....	....	.05	.08	.16	.02	.02	....	....	....	....	....	.38	.22

Phialucium carolinae	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Podocoryne minima	....	....	....	....	....	....	....	.13	.22	.02	....	....	....	....	....	.06
Podocoryne minuta	....	....	....	....	....	....	.01	....	....	....	....	....	....	....	....	....
Proboscidactyla ornata	....	....	....	....	....	....	....	....	....	....	.04	....	....	....	....	.01
Rhopalonema velatum	....	....	....	....	....	.03	....	....	....	....	....	....	....	....	....	....
Sarsia sp.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Solmaris sp.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
SIPHONOPHORA																
Agalma sp.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Bassia bassensis	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Diphyes dispar	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Enneagonum hyalinum	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Muggiaea kochi	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
ROTIFERA																
Synchaeta sp.	....	....	....	....	....	....	....	....	.06	.79	4.62	....	....	....	.02	....
Trichocerca marina	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Rotifer C	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
MOLLUSCA																
Creseis acicula	....	....	....	....	.03	.01	.01	.02	....	.01	....	....	....	.52	.03	.05
Desmopterus papilio	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Pteropod A	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Protatlanta souleyeti	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
POLYCHAETA																
Tomopteris mariana	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
COPEPODA																
Acartia tonsa	....	....	....	....	7.14	9.98	16.26	12.58	5.22	6.10	18.97	1.80	2.73	3.28	12.18	4.78
Anomalocera ornata	....	....	....	....	....	....	....	....	....	.01	....	....	....	....	....	....
Calanopia americana	....	....	....	....	....	.01	.04	.02	.04	....	....	....	....	....	....	....
Candacia sp. (immatures)	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Centropages furcatus	....	....	....	....	.21	.77	1.27	.64	.23	.03	....	....	.01	.07	1.19	.43
Centropages hamatus	....	....	....	....	....	....	....	....	.05	.24	3.51	.08	1.22	.17	....	....
Clausocalanus furcatus	....	....	....	....	.26	.01	....	.09	....	....	....	....	.02	.06	....	....
Clytemnestra rostrata	....	....	....	....	....	....	....	....	.01	....	....	....	....	.01	....	....
Corycaeus americanus	....	....	....	....	.01	.06	.04	.03	.05	.05	.05	.01	.30	.10	.23	.27
Corycaeus amazonicus	....	....	....	....	....	.05	.02	.05	.02	.01	....	....	.01	.03	.03	.17
Corycaeus giesbrechti	....	....	....	....	....	.02	....	.07	.01	.01	....	....	....	....	....	.02
Corycaeus latus	....	....	....	....	....	....	....	.04	....	....	....	....	....	....	....	....

TABLE 9 (Continued)

Seasonal dry weight (mg/m³) distribution of zooplankton in the St. Andrew Bay System (average of all stations)

	Aug. 59	Nov.	Feb. 60	June	July 61	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 62	Feb.	Mar.	April	May	June
Corycaeus speciosus	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Corycaeus spp. (immatures)	....	....	....	....	.10	.14	.10	.05	.13	.08	.02	.03	.05	.23	.16	.19
Corycella carinata	....	....	....	....	....	....	.01	....	....	....	....	....	....	....	....	....
Eucalanus pileatus	....	....	....	....	.23	.40	1.18	.15	.20	.09	.05	.01	.14	.12	1.37	.39
Euterpina acutifrons	....	....	....	....	.09	.19	.42	.12	.25	.06	.16	.02	.24	.26	1.53	.48
Harpacticoids (benthic)	....	....	....	....	.01	.03	.02	.02	.02	.03	.02	.01	.08	.03	.10	.07
Hemicyclops type immatures	....	....	....	....	.07	.03	.05	.05	.02	.02	.06	.02	.01	.02	.02	.13
Kelleria sp.	....	....	....	....	....	....	.03	....	.05	....	....	....	....	....	....	.27
Labidocera aestiva	....	....	....	....	.41	.24	.18	.53	.65	.07	.04	.01	.07	.01	.14	.34
Microsetella norvegica	....	....	....	....	....	.01	....	....	....	....	....	....	....	....	....	....
Oithona brevicornis	....	....	....	....	2.66	6.30	4.25	4.90	2.98	3.91	3.43	.73	1.87	1.83	1.78	4.72
Oithona nana	....	....	....	....	.22	1.14	.97	.65	1.46	.28	.48	.13	1.40	.11	1.68	.98
Oithona plumifera	....	....	....	....	....	.04	....	....	.01	....	....	....	....	....	....	....
Oithona simplex	....	....	....	....	.04	.24	.28	.59	.73	.06	.04	....	....	....	....	....
Oncaea curta	....	....	....	....	.07	.16	.02	.02	.36	.20	.02	.01	.02	.02	.05	.02
Oncaea venusta	....	....	....	....	....	.07	....	....	....	....	....	....	.01	....	.01	....
Paracalanus aculeatus	....	....	....	....	....	....	....	....	.04	....	.03	....	....	....	....	....
Paracalanus crassirostris	....	....	....	....	6.36	12.45	7.97	7.49	5.68	3.09	2.05	.27	2.06	.93	3.80	12.29
Paracalanus parvus	....	....	....	....	.27	.25	.15	.41	2.17	.23	.23	.03	.40	.83	1.71	.35
Pseudodiaptomus coronatus	....	....	....	....	.02	.10	.69	.22	.35	.10	.14	.01	.01	.04	.18	.05
Temora stylifera	....	....	....	....	.14	....	....	.03	....	....	....	....	....	....	....	....
Temora turbinata	....	....	....	....	.01	.02	.70	.24	.59	.17	.09	....	.01	....	.13	.04
Tortanus setacaudatus	....	....	....	....	.11	.19	.10	.10	.02	....	....	....	....	....	....	.03
Undinula vulgaris	....	....	....	....	....	....	....	1.59	....	....	....	....	....	....	....	....
Copepod nauplii	....	....	....	....	1.03	3.01	2.65	2.93	3.46	1.29	2.59	.44	1.58	.85	3.31	6.55
CLADOCERA																
Evadne tergestina	....	....	....	....	.79	2.51	.76	.46	.16	.01	....	....	....	....	.44	.15
Penilia avirostris	....	....	....	....	.02	.20	.40	.15	.15	.01	....	....	....	....	.11	.14
Podon polyphemoides	....	....	....	....	....	....	....	....	....	.07	1.67	.11	.82	.27	.33	....
OSTRACODA																
Euconchoecia chierchiae	....	....	....	....	.09	.47	....	.01	.05	.08	.01	....	....	....	....	....
AMPHIPODA																
Hyperia atlantica	....	....	....	....	.16	.02	....	....	.04	....	.02	....	....	....	.01	.05
Simorhynchotus antennarius	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

MYSIDACEA																
Gastrosaccus dissimilis	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Metamysidopsis munda	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Mysidopsis almyra	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
DECAPODA																
Lucifer faxoni	....	....	....	....	.07	.30	.35	.24	.04	.01	....	....	.02	....	.04	.59
CHAETOGNATHA																
Sagitta enflata	....	....	....	....	.18	.11	.06	.06	.02	.02	.14	....	....	....	....	.21
Sagitta helenae	....	....	....	....	.01	.01	....	....	....	....	....	....	....	....	.04	....
Sagitta hispida	....	....	....	....	.11	....	.18	.18	.03	.04	.20	.01	.19	....	.09	.11
Sagitta tenuis	....	....	....	....	.12	.15	.27	.29	.28	.09	.22		.20	.05	.73	.80
Sagitta < 3mm	....	....	....	....	.22	.64	.20	.30	.15	.08	.06	.04	.05	.08	.68	.69
APPENDICULARIA																
Appendicularia sicula	....	....	....	....	.01	.03	....	....	....	.01	.01	....	....	.01	.01	....
Fritillaria borealis	....	....	....	....	.01	....	....	....	....	....	....	....	....	....	.05	.02
Fritillaria formica	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Fritillaria haplostoma	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Oikopleura dioica	....	....	....	....	1.40	6.25	5.42	4.15	5.14	4.99	.20	.05	2.65	1.89	6.40	3.53
Oikopleura cornutogastra	....	....	....	....	....	....	....	.03	....	....	....	....	....	....	....	....
Oikopleura fusiformis	....	....	....	....	.08	.24	.10	.47	.12	....	....	....	.12	.81	.09	.02
Oikopleura longicauda	....	....	....	....	.09	1.79	1.04	.36	.18	.01	.20	.02	.15	.35	.62	.43
Oikopleura rufescens	....	....	....	....	....	....	....	....	....	....	....	....	.03	....	....	....
Kowalevskaia tenuis	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
THALIACEA																
Cyclosalpa floridana	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Dolioletta gegenbauri	....	....	....	....	.02	.02	.05	.02	.01	....	.07	.21	....	....	.18	.09
LARVAE																
Polychaete	....	....	....	....	.52	1.38	1.07	1.67	1.31	1.88	3.09	.30	1.52	1.15	5.00	15.85
Gastropod	....	....	....	....	2.60	6.45	10.83	1.39	1.02	.18	.25	.04	.56	.38	4.59	7.49
Pelecypod	....	....	....	....	1.58	6.65	6.61	1.02	3.46	1.14	.55	.10	2.80	2.31	5.76	11.53
Cirriped	....	....	....	....	.18	.07	.15	.20	.38	.31	.17	.13	.61	.45	.52	.59
Decapod	....	....	....	....	.49	1.26	2.04	.76	.29	.07	.01	.01	.17	.08	.84	2.04
Echinoderm	....	....	....	....	.01	.06	.06	.03	....	....	....	....	.02	.06	.07	2.39
Other invertebrate	....	....	....	....	....	....	.01	.01	....	....	....	....	.01	....	.04	....
Cephalochordate	....	....	....	....	.01	....	.02	.01	....	....	....	....	....	.05	....	.03
Fish eggs	....	....	....	....	.04	.58	.03	.06	....	.08	....	....	.02	....	.83	.36
Fish larvae	....	....	....	....	.08	.14	.06	....	.01	....	....	....	....	.02	.11	.21

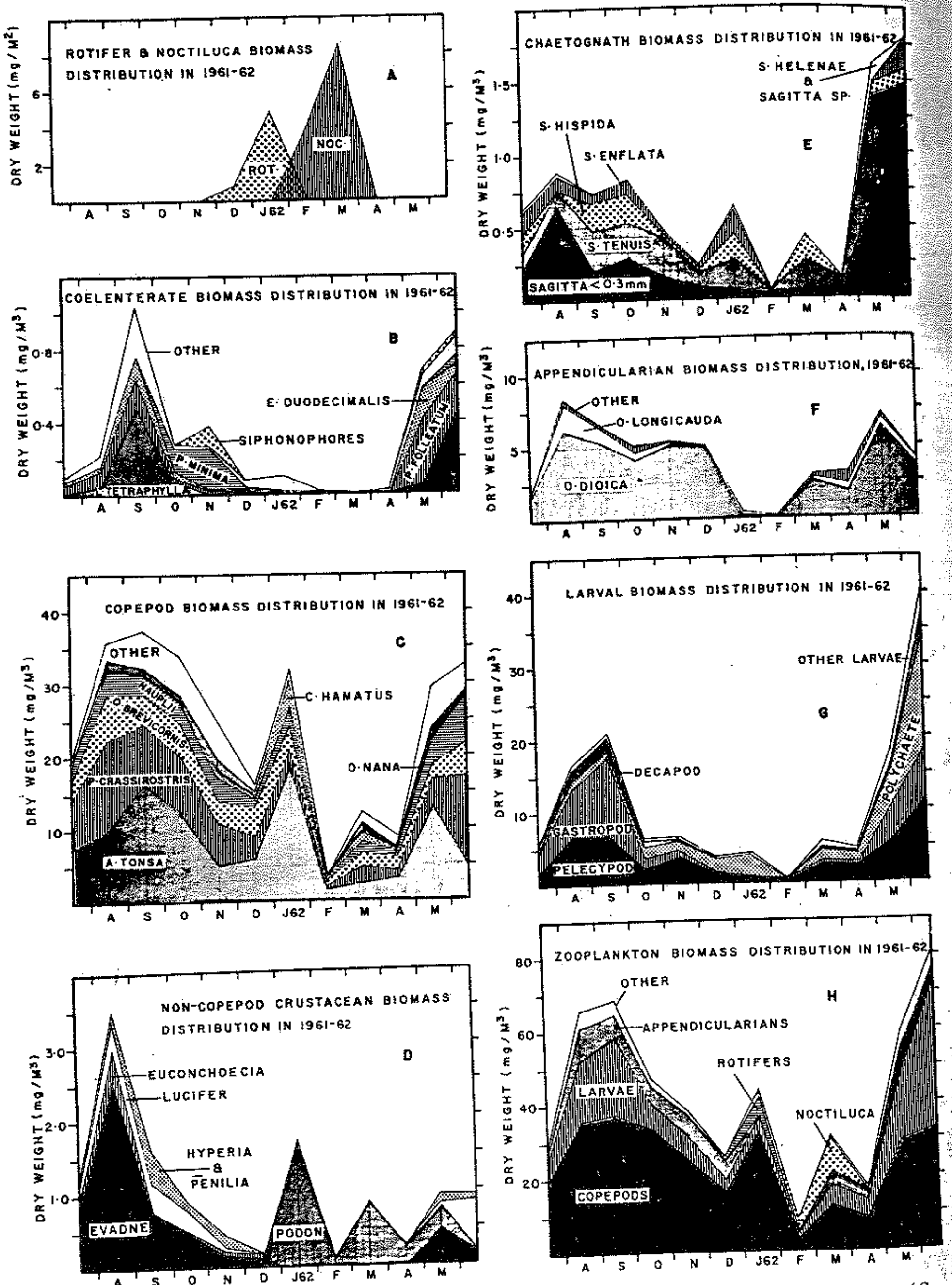

FIG. 4. Zooplankton distribution in the St. Andrew Bay System in 1961–62. A—Rotifers (*Synchaeta*) and *Noctiluca*; B—*Coelenterates*; C—Copepods; D—Non-copepod crustaceans; E—Chaetognaths; F—Appendicularians; G—Larvae; H—Total Zooplankton.

TABLE 10

Zooplankton numbers/m³ by station in the St. Andrew Bay System (1961–62 average values) Stations arranged in order of decreasing mean annual salinity + indicates observed in sample but not in aliquot

	S3	S2	E4	S1	E3	W2	N2	W1	E2	N1	E1	Avg. 1961–62
DINOFLAGELLATA												
Noctiluca scintillans	4768	5486	877	3127	2515	6347	1638	2632	85	3209	20	2787
TINTINNOINEA												
Tintinnopsis radix	....	....	....	....	....	....						
Stylicauda platensis	207	521	1705	5605	1184	1286	3406	1237	1915	428	291	1557
Tintinnopsis kofoidi	....	....	....	....	....	....	....	....	....	....	....	....
Tintinnopsis beutschlii	....	....	126	203	75	61	12	....	....	....	....	43
Tintinnopsis brandti	....	....	+	....	....	112	647	247	34	29	192	115
Tintinnidium mucicola	....	....	7	152	29	754	2172	974	....	3050	....	649
Eutintinnus medius	....	....	+	....	....	....	....	....	....	....	....	10
Eutintinnus pinguis	....	....	113	....	....	....	....	....	....	....	....	....
Codonellopsis obesa	....	....	....	....	....	75	124	....	....	102	....	27
Helicostomella subulata	....	....	13	....	....	17	124	....	....	610	....	85
Amphorides amphora	....	....	+	....	....	....	....	....	....	....	....	....
Favella panamensis	....	....	120	....	243	27	....	....	1131	....	....	138
Favella taraikaensis	....	83	28	76	....	377	871	104	....	102	....	....
HYDROMEDUSAE												
Aglaura hemistoma	1	2	+	....	+	....	....	....	....	....	....	....
Bougainvillia carolinensis	3	2	3	1	+	1	....	....	....	....	....	1
Cunina octonaria	3	+	1	+	+	....	....	....	....	....	....	....
Dipurena ophiogaster	....	....	....	....	....	1	1	+	....	....	....	....
Dipurena strangulata	....	2	1	+	+	....	....	4	+	....	....	1
Ectopleura dumortieri	3	+	+	2	+	....	....	....	....	....	....	....
Eirene pyramidalis	+	....	....	....	....	....	....	....	....	....	....	....
Eucheilota duodecimalis	15	10	23	6	24	14	12	11	9	2	5	12
Eucheilota ventricularis	1	+	....	....	....	+	....	....	....	....	....	....
Euphysa aurata	....	+	+	1	+	....	+	+	....	....	....	....
Euphysora gracilis	1	+	....	....	....	....	....	....	....	....	....	....
Eutima tariabilis	+	....	+	....	....	....	1	....	1	....	....	....
Halitiara formosa	....	....	+	....	....	....	....	....	....	....	....	....
Liriope tetraphylla	42	24	26	3	4	5	1	5	1	....	....	10
Nemopsis bachei	....	....	....	....	....	....	....	....	....	....	....	....
Obelia spp.	+	+	+	1	....	1	....	+	....	1	2	4
Persa incolorata	11	6	1	1	+	+	+	....	....	....	....	2

TABLE 10—Continued

Zooplankton numbers/m³ by station in the St. Andrew Bay System (1961–62 average values) Stations arranged in order of decreasing mean annual salinity + indicates observed in sample but not in aliquot

	S3	S2	E4	S1	E3	W2	N2	W1	E2	N1	E1	Avg. 1961–62
Phialidium folleatum	10	8	21	15	10	5	12	3	5	....	2	9
Phialucium carolinae	....	....	+	+	+	....	....	....	+	....	....	....
Podocoryne minima	2	3	32	4	53	....	3	25	84	3	59	25
Podocoryne minuta	4	2	1	+	1	....	+	....	....	....	+	1
Proboscidactyla ornata	2	+	+	+	....	....	....	....	....	....	....	....
Rhopalonema velatum	1	+	....	+	....	....	....	....	....	....	....	....
Sarsia sp.	+	....	....	....	1	+	+	....	....	....	....	....
Solmaris sp.	1	....	+	....	....	....	....	....	....	....	....	....
SIPHONOPHORA												
Agalma sp.	+	+	+	+	....	....	....	....	....	....	....	....
Bassia bassensis	....	+	....	....	....	....	....	....	....	....	....	....
Diphyes dispar	+	+	....	....	....	....	....	....	....	....	....	....
Enneagonum hyalinum	+	....	....	....	....	....	....	....	....	....	....	1
Muggiaea kochi	6	2	2	2	....	....	+	....	....	....	....	4
ROTIFERA												
Synchaeta sp.	....	17	188	129	3605	2139	1681	1579	3153	4109	4387	1908
Trichocerca marina	....	15	....	58	317	292	44	25	39	154	....	86
Rotifer C	....	....	5	....	....	1	98	4	....	19	....	12
MOLLUSCA												
Creseis acicula	402	54	2	1	+	....	....	....	+	....	....	42
Desmopterus papilio	+	....	....	....	....	....	....	....	....	....	....	....
Pteropod A	1	+	3	....	....	....	....	....	....	....	....	....
Protatlanta souleyeti	+	+	+	....	....	....	....	....	....	....	....	....
POLYCHAETA												
Tomopteris mariana	+	1	5	+	+	....	....	....	....	....	....	....
COPEPODA												
Acartia tonsa	415	1520	4276	3590	5433	5823	6317	9350	8525	3489	8142	5172
Anomalocera ornata	....	....	....	+	....	....	....	....	....	....	....	....
Calanopia americana	16	3	2	3	2	....	....	....	3	....	....	3
Candacia sp. (immatures)	3	....	2	....	....	....	....	....	....	....	....	....
Centropages furcatus	443	185	243	183	315	23	47	28	105	2	1	140
Centropages hamatus	131	495	365	431	146	214	180	138	69	3	6	198
Clausocalanus furcatus	48	2	....	....	....	....	....	....	....	....	1	8

Clytemnestra rostrata	5	4	....	2	....	....	....	....	....	....	....	1
Corycaeus americanus	178	65	49	13	5	....	....	....	2	....	....	28
Corycaeus amazonicus	62	20	5	5	....	....	....	....	....	....	....	8
Corycaeus giesbrechti	25	....	....	4	....	....			3	....	....	3
Corycaeus latus	....	5	....	....	....	....		....	....	....	....	....
Corycaeus speciosus	....	+	....	....	....	....	....	....	....	....	....	....
Corycaeus spp. (immatures)	586	235	80	114	32	24	6	....	....	....	....	98
Corycella carinata	....	3	....	....	....	....	....	....	....	....	....	....
Eucalanus pileatus	107	59	37	9	2	....	....	....	19	....	....	21
Euterpina acutifrons	658	593	567	509	215	41	63	60	161	6	26	263
Harpacticoids (benthic)	55	46	56	59	32	53	17	63	31	7	17	40
Hemicyclops type immatures	7	16	24	19	36	136	9	146	29	....	33	45
Kelleria sp.	97	2	8	2	1	....	....	36	4	....	....	14
Labidocera aestiva	59	173	98	110	52	92	98	36	53	2	2	70
Microsetella norvegica	8	11	....	....	....	....	....	....	....	....	....	2
Oithona brevicornis	930	5557	6678	5760	6631	3609	2974	5523	5097	450	2715	4183
Oithona nana	3219	2857	1358	1774	216	139	188	20	190	6	54	911
Oithona plumifera	20	13	....	2	....	....	2	....	....	....	....	3
Oithona simplex	400	836	547	349	149	37	34	1	19	2	6	216
Oncaea curta	418	355	62	72	42	3	6	....	4	2	5	88
Oncaea venusta	15	22	....	....	....	....	....	....	....	....	....	3
Paracalanus aculeatus	7	....	....	....	....	....	....	....	....	....	....	1
Paracalanus crassirostris	5619	8161	8352	7992	7597	6396	5248	14096	5319	479	1635	6445
Paracalanus parvus	1126	612	383	287	130	41	24	6	110	17	17	251
Pseudodiaptomus coronatus	....	7	26	17	87	82	114	446	299	123	241	131
Temora stylifera	4	2	....	....	....	....	....	....	....	....	....	1
Temora turbinata	224	83	173	46	43	2	21	4	22	4	4	57
Tortanus setacaudatus	3	3	23	5	25	19	37	6	41	1	62	21
Undinula vulgaris	4	5	....	....	1	....	....	....	....	....	....	1
Copepod nauplii	2498	4543	6119	6067	6626	5508	4198	9616	5367	2361	5027	5266
CLADOCERA												
Evadne tergestina	321	296	213	294	476	528	925	208	456	48	255	366
Penilia avirostris	120	105	177	35	87	12	10	+	82	4	16	59
Podon polyphemoides	31	88	617	318	404	468	522	119	420	214	57	296
OSTRACODA												
Euconchoecia chierchiae	87	41	6	2	+	....	1	....	1	....	1	13
AMPHIPODA												
Hyperia atlantica	6	2	1	....	....	2	....	....	....	....	....	1
Simorhynchotus antennarius	+	....	....	....	....	....	....	....	....	....	....	....
MYSIDACEA												
Gastrosaccus dissimilis	+	....	....	....	....	....	....	....	....	....	....	....

TABLE 10—Continued

Zooplankton numbers/m³ by station in the St. Andrew Bay System (1961–62 average values) Stations arranged in order of decreasing mean annual salinity + indicates observed in sample but not in aliquot

	S3	S2	E4	S1	E3	W2	N2	W1	E2	N1	E1	Avg. 1961–62
Metamysidopsis munda	....	....	+	....	....	....	....	....	....	....	....	....
Mysidopsis almyra	....	+	....	....	....	....	....	....	....	....	....	....
DECAPODA												
Lucifer faxoni	56	20	26	6	7	4	1	....	+	....	+	11
CHAETOGNATHA												
Sagitta enflata	18	5	4	2	1	....	+	....	....	....	....	3
Sagitta helenae	1	....	1	....	....	....	....	....	....	....	....	....
Sagitta hispida	8	4	+	3	2	2	2	9	5	....	+	3
Sagitta tenuis	56	42	39	27	12	13	12	3	5	....	1	19
Sagitta < 3 mm	458	364	222	196	88	123	52	112	52	2	16	155
APPENDICULARIA												
Appendicularia sicula	+	28	32	20	+	2	+	....	+	....	....	7
Fritillaria borealis	25	+	....	11	....	....	....	....	....	....	....	3
Fritillaria formica	+	....	....	....	....	....	....	....	....	....	....	....
Fritillaria haplostoma	+	+	+	+	+	....	+	....	....	....	....	....
Oikopleura dioica	774	1107	2580	2729	2795	3420	3649	3782	3801	1933	3631	2746
Oikopleura cornutogastra	1	....	....	....	....	....	....	....	9	....	....	1
Oikopleura fusiformis	452	176	168	109	126	6	30	....	24	....	42	101
Oikopleura longicauda	886	624	372	456	786	108	49	....	164	....	....	313
Oikopleura rufescens	+	....	....	....	....	....	....	....	....	....	....	....
Kowalevskaia tenuis	+	....	....	....	....	....	....	....	....	....	....	....
THALIACEA												
Cyclosalpa floridana	+	....	....	....	....	....	....	....	....	....	....	....
Doliolletta gegenbauri	23	15	9	1	3	....	....	....	....	....	....	5
LARVAE												
Polychaete	797	578	594	798	744	1150	593	1995	979	118	258	782
Gastropod	683	606	2912	643	2218	1721	1228	1597	525	120	79	1124
Pelecypod	2420	1408	2369	1277	894	2067	582	3905	257	113	71	1397
Cirriped	117	166	107	288	89	86	230	56	331	576	411	223
Decapod	318	254	137	128	163	144	60	74	60	5	17	124
Echinoderm	450	372	718	672	886	1163	278	4326	392	26	....	834
Other invertebrate	58	86	72	78	66	59	64	211	28	12	9	67
Cephalochordate	21	5	1	3	1	1	1	....	4	....	....	2
Fish eggs	2	8	5	15	58	18	5	17	35	3	32	19
Fish larvae	5	3	7	5	7	7	11	26	12	3	13	8

Table 11

Zooplankton dry weight (mg/m³) distribution by station in the St. Andrew Bay System (1961–62 average values)
Stations arranged in order of decreasing mean annual salinity

	S3	S2	E4	S1	E3	W2	N2	W1	E2	N1	E1	Avg. 1961–62
DINOFLAGELLATA												
Noctiluca scintillans	1.74	2.03	.33	1.16	.93	2.35	.61	.97	.03	1.19	.01	1.03
TINTINNOINEA												
Tintinnopsis radix	....	....	....	....	....	....	....	....	....	....	....	....
Stylicauda platensis	....	.01	.02	.07	.02	.02	.04	.02	.02	.01	....	.02
Tintinnopsis kofoidi	....	....	....	....	....	....	....	....	....	....	....	....
Tintinnopsis beutschlii	....	....	....	....	....	....	....	....	....	....	....	....
Tintinnopsis brandti	....	....	....	....	....	....	.01	.01	....	....	....	....
Tintinnidium mucicola	....	....	....	....	....	.02	.05	.01	....	.06	....	.01
Eutintinnus medius	....	....	....	....	....	....	....	....	....	....	....	....
Eutintinnus pinguis	....	....	....	....	....	....	....	....	....	....	....	....
Codonellopsis obesa	....	....	....	....	....	....	....	....	....	....	....	....
Helicostomella subulata	....	....	....	....	....	....	....	....	....	....	....	....
Amphorides amphora	....	....	....	....	....	....	....	....	....	....	....	....
Favella panamensis	....	....	.02	....	.03	....	....	....	.14		....	.02
Favella taraikaensis	....	....	....	....	....	.02	.04	.01	....	.01	....	....
HYDROMEDUSAE												
Aglaura hemistoma	.01	....	....	....	....	....						
Bougainvillia carolinensis	.03	.02	.03	.01	.01	.02	....	....	....	....	....	.01
Cunina octonaria	.10	.01	.02	....	....	....	....	....	....	....	....	.01
Dipurena ophiogaster	....	....	....	....	....	....	....	....	....	....	....	....
Dipurena strangulata	....	.01	.01	....	....	....	....	.02	....	....	....	....
Ectopleura dumortieri	.01	....	....	....	....	....	....	....	....	....	....	....
Eirene pyramidalis	....	....	....	....	....	....	....	....	....	....	....	....
Eucheilota duodecimalis	.07	.03	.08	.02	.06	.05	.03	.03	.02	....	.02	.04
Eucheilota ventricularis	.01	....	....	....	....	....	....	....	....	....	....	....
Euphysa aurata	....	....	....	....	....	....	....	....	....	....	....	....
Euphysora gracilis	....	....	....	....	....	....	....	....	....	....	....	....
Eutima variabilis	....	....	....	....	....	....	.01	....	.06	....	....	.01
Halitiara formosa	....	....	....	....	....	....	....	....	....	....	....	....
Liriope tetraphylla	.23	.14	.34	.01	.02	.04	....	.28	.01	....	....	.10
Nemopsis bachei	....	....	....	....	....	....	....	....	....	....	....	....
Obelia spp.	....	....	....	....	....	....	....	....	....	....	....	....
Persa incolorata	.03	.02	....	....	....	....	....	....	....	....	....	.01

TABLE 11 (Continued)

Zooplankton dry weight (mg/m³) distribution by station in the St. Andrew Bay System (1961–62 average values)
Stations arranged in order of decreasing mean annual salinity

	S3	S2	E4	S1	E3	W2	N2	W1	E2	N1	E1	Avg. 1961–62
Phialidium folleatum	.09	.04	.33	.08	.10	.03	.12	.03	.02	....	.02	.08
Phialucium carolinae	....	....	....	....	....	....	....	....	....	....	....	....
Podocoryne minima	....	.01	.04	.01	.08	....	....	.03	.13	.01	.09	.04
Podocoryne minuta	.01	....	....	....	....	....	....	....	....	....	....	....
Proboscidactyla ornata	.04	.01	....	....	....	....	....	....	....	....	....	....
Rhopalonema velatum	.03	....	....	....	....	....	....	....	....	....	....	....
Sarsia sp.	....	....	....	....	....	....	....	....	....	....	....	....
Solmaris sp.	....	....	....	....	....	....	....	....	....	....	....	....
SIPHONOPHORA												
Agalma sp.	....	....	....	....	....	....	....	....	....	....	....	....
Bassia bassensis	....	....	....	....	....	....	....	....	....	....	....	....
Diphyes dispar	....	....	....	....	....	....	....	....	....	....	....	....
Enneagonum hyalinum	....	....	....	....	....	....	....	....	....	....	....	....
Muggiaea kochi	....	....	....	....	....	....	....	....	....	....	....	....
ROTIFERA												
Synchaeta sp.	....	....	.05	.03	.87	.51	.40	.38	.76	.99	1.05	.46
Trichocerca marina	....	....	....	....	....	....	....	....	....	....	....	....
Rotifer C	....	....	....	....	....	....	....	....	....	....	....	....
MOLLUSCA												
Creseis acicula	.65	.07	....	....	....	....	....	....	....	....	....	.06
Desmopterus papilio	....	....	....	....	....	....	....	....	....	....	....	....
Pteropod A	....	....	....	....	....	....	....	....	....	....	....	....
Protatlanta souleyeti	....	....	....	....	....	....	....	....	....	....	....	....
POLYCHAETA												
Tomopteris mariana	....	....	....	....	....	....	....	....	....	....	....	....
COPEPODA												
Acartia tonsa	.65	2.32	7.38	4.98	7.75	9.93	9.66	14.42	16.40	6.10	13.01	8.42
Anomalocera ornata	....	....	....	....	....	....	....	....	....	....	....	....
Calanopia americana	.05	.02	....	.01	....	....	....	....	.01	....	....	.01
Candacia sp. (immatures)	....	....	.01	....	....	....	....	....	....	....	....	....
Centrophages furcatus	2.19	.58	.39	.36	.65	.08	.07	.04	.15	....	.01	.41
Centrophages hamatus	.23	1.10	.83	.96	.34	.41	.29	.52	.12	....	.03	.44
Clausocalanus furcatus	.32	.01	....	....	....	....	....	....	....	....	....	.04

Clytemnestra rostrata	.01	.01	....	....	....	....	....	....	....	....	....	....
Corycaeus americanus	.63	.22	.17	.05	.02	....	....	....	....	....	....	.10
Corycaeus amazonicus	.24	.06	.02	.02	....	....	....	....	....	....	....	.03
Corycaeus giesbrechti	.11	....	....	.02	....	....	....	....	.01	....	....	.10
Corycaeus latus	....	.04	....	....	....	....	....	....	....	....	....	....
Corycaeus speciosus	....	....	....	....	....	....	....	....	....	....	....	....
Corycaeus spp. (immatures)	.73	.20	.08	.10	.02	.02	.01	....	....	....	....	.11
Corycella carinata	....	....	....	....	....	....	....	....	....	....	....	....
Eucalanus pileatus	1.09	1.28	.86	.36	.01	....	....	....	.43	....	....	.36
Euterpina acutifrons	1.00	.70	.77	.46	.24	.04	.05	.07	.13	.01	.02	.32
Harpacticoids (benthic)	.08	.03	.06	.04	.04	.04	.01	.04	.03	.01	.01	.04
Hemicyclops type immatures	.01	.02	.03	.02	.03	.12	.01	.12	.04	....	.03	.04
Kèlleria sp.	.23	....	.03	....	....	....	....	.05	....	....	....	.03
Labidocera aestiva	.49	.48	.34	.28	.08	.24	.25	.21	.08	....	....	.22
Microsetella norvegica	.01	.01	....	....	....	....	....	....	....	....	....	....
Oithona brevicornis	.70	4.17	5.32	4.40	5.12	2.81	2.33	4.43	4.24	.34	2.33	3.28
Oithona nana	2.81	2.43	1.21	1.60	.17	.13	.15	.01	.14	.01	.04	.79
Oithona plumifera	.02	.02	....	....	....	....	.01	....	....	....	....	....
Oithona simplex	.30	.63	.43	.28	.11	.03	.03	....	.02	....	.01	.17
Oncaea curta	.39	.33	.07	.06	.03	....	.01	....	....	....	....	.08
Oncaea venusta	.05	.05	....	....	....	....	....	....	....	....	....	.01
Paracalanus aculeatus	.07	....	....	....	....	....	....	....	....	....	....	.01
Paracalanus crassirostris	5.33	7.28	7.18	6.51	6.87	5.28	4.89	8.68	4.90	.51	1.66	5.37
Paracalanus parvus	2.95	1.49	.78	.70	.13	.10	.02	.01	.17	.02	.04	.59
Pseudodiaptomus coronatus	....	.01	.04	.03	.11	.12	.14	.59	.37	.11	.25	.16
Temora stylifera	.16	....	....	....	....	....	....	....	....	....	....	.02
Temora turbinata	.69	.39	.34	.17	.13	....	.03	.01	.05	....	.01	.17
Tortanus setacaudatus	.02	.01	.03	.03	.04	.04	.12	.02	.06	....	.15	.05
Undinula vulgaris	.86	.60	....	....	....	....	....	....	....	....	....	.13
Copepod nauplii	1.38	2.39	2.83	2.98	2.90	2.49	2.15	3.83	2.53	1.29	2.45	2.47
CLADOCERA												
Evadne tergestina	.39	.36	.26	.36	.57	.63	1.11	.25	.55	.06	.31	.44
Penilia avirostris	.20	.18	.30	.06	.15	.02	.02	....	.14	.01	.03	.10
Podon polyphemoides	.03	.08	.57	.29	.37	.43	.48	.11	.39	.20	.05	.27
OSTRACODA												
Euconchoecia chierchiae	.47	.17	.01	....	....	....	....	....	....	....	....	.06
AMPHIPODA												
Hyperia atlantica	.15	.04	.03	....	....	.05	....	....	....	....	....	.02
Simorhynchotus antennarias	....	....	....	....	....	....	....	....	....	....	....	....
MYSIDACEA												
Gastrosaccus dissimilis	....	....	....	....	....	....	....	....	....	....	....	....

TABLE 11 (Continued)

Zooplankton dry weight (mg/m³) distribution by station in the St. Andrew Bay System (1961–62 average values)
Stations arranged in order of decreasing mean annual salinity

	S3	S2	E4	S1	E3	W2	N2	W1	E2	N1	E1	Avg. 1961–62
Metamysidopsis munda	....	....	....	....	....	....	....	....	....	....	....	....
Mysidopsis almyra	....	....	....	....	....	....	....	....	....	....	....	....
DECAPODA												
Lucifer faxoni	.79	.30	.26	.07	.06	.04	.01	....	....	....	....	.14
CHAETOGNATHA												
Sagitta enflata	.48	.09	.06	.02	.07	....	....	....	....	....	....	.07
Sagitta helenae	.04	....	.01	....	....	....	....	....	....	....	....	.01
Sagitta hispida	.30	.10	.01	.06	.07	.11	.03	.26	.07	....	....	.10
Sagitta tenuis	.80	.66	.60	.29	.16	.21	.08	.04	.09	....	.01	.27
Sagitta <3mm	1.05	.51	.37	.30	.12	.20	.11	.16	.07	....	.02	.27
APPENDICULARIA												
Appendicularia sicula	....	.02	.03	.01	....	....	....	....	....	....	....	.01
Fritillaria borealis	.06	....	....	.01	....	....	....	....	....	....	....	.01
Fritillaria formica	....	....	....	....	....	....	....	....	....	....	....	....
Fritillaria haplostoma	....	....	....	....	....	....	....	....	....	....	....	....
Oikopleura dioica	1.49	1.72	3.83	4.20	3.55	4.39	4.57	3.70	4.13	2.25	4.72	3.51
Oikopleura cornutogastra	.01	....	....	....	....	....	....	....	.02	....	....	....
Oikopleura fusiformis	.88	.28	.20	.14	.21	.01	.05	....	.03	....	.13	.17
Oikopleura longicauda	1.38	.87	.53	.50	1.13	.10	.08	....	.22	....	....	.44
Oikopleura rufescens	....	....	....	....	....	....	....	....	....	....	....	....
Kowalevskaia tenuis	....	....	....	....	....	....	....	....	....	....	....	....
THALIACEA												
Cyclosalpa floridana	....	....	....	....	....	....	....	....	....	....	....	....
Dolioletta gegenbauri	.35	.11	.10	....	.02	....	....	....	....	....	....	.05
LARVAE												
Polychaete	2.95	2.14	2.20	2.95	2.75	4.25	2.19	7.38	3.62	.44	.96	2.89
Gastropod	1.82	1.62	7.75	1.71	5.90	4.58	3.27	4.25	1.40	.32	.21	2.98
Pelecypod	6.44	3.68	6.30	3.40	2.38	5.50	1.55	10.39	.68	.28	.19	3.71
Cirriped	.33	.42	.20	.39	.21	.18	.23	.09	.41	.58	.41	.31
Decapod	1.72	1.38	.74	.70	.89	.78	.31	.40	.32	.03	.09	.67
Echinoderm	.14	.11	.19	.18	.23	.30	.08	1.13	.10	.01		.23
Other invertebrate	.05	.06	....	.01	....	....	....	.06	.01	....	.01	.01
Cephalochordate	.09	.02	....	.01	.01	.01	....	....	.02			.01
Fish eggs	.02	.07	.04	.13	.51	.16	.05	.15	.30	.03	.28	.17
Fish larvae	.03	.02	.05	.04	.04	.05	.08	.17	.08	.02	.08	.05

tion to total zooplankton number (0.16%) and biomass (0.71%). The four most important species which together composed 82% of the hydromedusae biomass were *Liriope tetraphylla* (Chamisso and Eysenhardt) (32.2%), *Phialidium folleatum* (McCrady) (25.3%), *Eucheilota duodecimalis* A. Agassiz (12.2%), and *Podocoryne minima* (Trinci) (11.8%).

Seasonally, total hydromedusae numbers were largest in February 1960 and in November 1961. The biomass peak (Fig. 4 B) occurred in September of 1961. In 1961–62, 18 species were either seen more frequently or gave higher counts in aliquots of samples taken during the warmer months (25–29 C). These species were *Aglaura hemistoma* Péron and Lesueur, *Bougainvillia carolinensis* (McCrady), *Cunina octonaria* McCrady, *Dipurena ophiogaster* Haeckel, *Dipurena strangulata* McCrady, *Eirene pyramidalis* (L. Agassiz), *Eucheilota duodecimalis, Eucheilota ventricularis* McCrady, *Euphysora gracilis* (Brooks), *Eutima variabilis* McCrady, *Halitiara formosa* Fewkes, *Liriope tetraphylla, Obelia* sp. (spp.?), *Phialidium folleatum, Phialucium carolinea* (Mayer), *Podocoryne minuta* (Mayer), *Rhopalonema velatum* Gegenbaur, and *Solmaris* sp. The remaining species (*Ectopleura dumortieri* (van Beneden), *Euphysa aurata* Forbes, *Persa incolorata* McCrady, *Podocoryne minima, Proboscidactyla ornata* (McCrady), *Sarsia* sp.) appeared more frequently in the cooler half of 1961–62 (11–22 C).

Eighteen of the 25 species seen in 1961–62 appeared previously in 1959–60 samples. Only a single species, *Nemopsis bachei* L. Agassiz, was taken in 1959–60 but not in 1961–62. Though data for 1959–60 are less complete, it is clear that the seasonal picture for this year does not correspond well with that of 1961–62. The greatest variety of hydromedusae in 1959–60 was recorded for February whereas in 1961–62 the greatest diversity occurred in the warmer months. Species which were more prevalent in the cooler months of both years were *E. dumortieri, P. incolorata,* and *P. minima.*

Geographically, greatest variety was found at station S3, the sampling point nearest the Gulf. Twelve species (*B. carolinensis, C. octonaria, E. dumortieri, E. pyramidalis, E. ventricularis, E. gracilis, L. tetraphylla, P. incolorata, P. minuta, P. ornata, R. velatum, Solmaris* sp.) were more prevalent at this station than at any other. These species along with *E. aurata, H. formosa,* and *P. folleatum* were more abundant at the four stations nearest the Gulf (29–33 ppt) than at all other stations combined. The remaining species (*E. duodecimalis, E. variabilis, D. ophiogaster, D. strangulata, N. bachei, Obelia* sp. (spp.?), *P. carolinae, P. minima, Sarsia* sp.) were taken more often at stations farther into the estuaries (19–27 ppt). One species, *Aequorea macrodactyla* (Brandt), while not collected in the bay system, was seen in a sample taken near station S3 on the Gulf side of West Pass.

According to Kramp's (1961) synopsis and to Sears (1954) all but three species (*E. dumortieri, E. aurata, P. minima*) have previously been reported from the Tortugas and coastal waters of the southeastern United States.

Siphonophores: Siphonophores were not conspicuously abundant. This group comprised only 0.01% of total zooplankton number and 0.04% of the dry weight. Nectophores of *Muggiaea kochi* (Will) constituted 23.4% of the total number of bracts, eudoxids, and nectophores found in aliquots. The remainder was largely unidentified because of their small size and poor state of preservation. Three other siphonophores, *Bassia bassensis* Quoy and Gaimard, *Diphyes dispar* Chamisso and Eysenhardt, and *Enneagonum hyalinum* Quoy and Gaimard, were seen in several collections but did not occur in aliquots. Dr. Mary Sears (personal communication) also found two bracts of *Diphyes bojani* (Eschscholtz) among specimens picked from aliquots. Agalmid persons were occasionally enountered but were not identified.

No seasonal trend for total numbers of siphonophores was evident though it is worth noting that *Muggiaea kochi* was more abundant in warmer months. Siphonophores generally did not penetrate far into the bay and were rarely seen at stations beyond S1 and E4. An exception occurred in November 1959 when bracts were carried as far into the bay as E2.

Rotifers: The three kinds of rotifers caught with #10 nets were *Synchaeta* sp., *Trichocerca marina* (Daday), and an unidentified rotifer. *Synchaeta* sp. was the most abundant species and was large enough for dry weight estimates. *Synchaeta* appeared in the winter (Fig. 4 A), making its first appearance in 1961–62 in November. Maximum abundance occurred in January (19,300/m^3). The number dropped sharply in February (12/m^3) and *Synchaeta* disappeared completely by June. Counts of this rotifer in quarterly survey samples suggest that a similar cycle occurred in 1959–60. *Trichocerca marina,* appeared sporadically throughout 1961–62 and was found in November and February samples of 1959–60. The unidentified rotifer occurred in November, January, and May samples of 1961–62 and in November and February samples of 1959–60.

Synchaeta was most abundant at stations near the heads of East and North Bays and least abundant at the four stations nearest the Gulf. This rotifer, then, may be a true estuarine species. Although the other two species were taken less frequently, it appears that they, too, were least abundant at high salinity stations.

Rotifers made a significant contribution to zooplankton numbers and in 1961–62, with an average of almost 5% of the total catch. The numerical importance of rotifers undoubtedly has been underestimated since both *Trichocerca* and the unidentified rotifer easily can pass through the meshes of #10 nets. The biomass contribution of *Synchaeta* to total zooplankton biomass alone was 1.07%. Weights of the other two species were not determined.

Molluscs and polychaetes: Molluscs were represented by the pteropods *Creseis acicula* Rang, *Desmopterus papilio* Chun, and an unidentified gymnosomatous form and by the heteropod *Protatlanta souleyeti* (E.A. Smith). Of the three pteropods only *Creseis acicula* appeared commonly in aliquots. *Creseis* was taken in August and June of 1959–60 and appeared in every month of 1961–62 except February. It was generally more prevalent in the warmer months (April–October 1961) and showed maxima in June 1960 and April 1962. *Creseis* was most abundant at S3, the station nearest the Gulf, and its numbers declined sharply with decreasing mean salinity. In one instance it was collected as far into East Bay as E2 (September 1961). *Desmopterus papilio* was taken at S3 in August 1961 and the gymnosomatous pteropod was collected at S2 in August 1961, and at S3 and E4 in September 1961. *Protatlanta* was seen in February and June samples of 1960 and was encountered again in August and June samples of 1961–62. This species was taken only at S3, S2, and E4. Because of the eroded condition of the specimens the identification of this atlantid must remain tentative (Mr. Norman Tebble, personal communication).

Only one species of holoplanktonic polychaete, *Tomopteris mariana* Greeff, was found in St. Andrew Bay. It was an uncommon plankter and never exceeded five individuals/m^3. This polychaete was not recorded at all for 1959–60, and was seen only a few times in samples collected in September, October, and May-June of 1961–62. *T. mariana* was taken at sampling points no farther into the bay complex than E3 and S1.

The contribution of holoplanktonic molluscs and polychaetes together was small and constituted only 0.1% of the total zooplankton count. Specimens of *Tomopteris* were too scarce to weigh and all that were sorted were used for identification purposes. *Creseis* on the other hand, was abundant enough to permit dry weight analysis and this species averaged 0.13% of the total zooplankton dry weight (inorganic shell weight included).

Copepods: Copepods, as in many other surveys, constituted the most important zooplankton group, averaging 59.0% of the total number and 55.8% of the total dry weight in 1961–62. Peak numbers of copepods and nauplii occurred in November and June of 1959–60 and in June and August of 1961–62. Minima were recorded for August of 1959 and February of 1962. Copepod biomass maxima in 1961–62 (Fig. 4 C) appeared in September and August while the minimum, which corresponded with the numerical low, occurred in February. Populations were largest at W1 near the head of West Bay and smallest at N1 in North Bay.

Thirty species of copepods were identified from aliquots. These species check well with those previously listed by Grice (1957) for St. Andrew Bay. Thirteen of the thirty individually averaged more than 1% of both the copepod number and weight at one station or another. Seven of these thirteen, *Centropages furcatus* (Dana), *Corycaeus americanus* M. S. Wilson, *Euterpina acutifrons* (Dana), *Oithona nana* Giesbrecht, *Oncaea curta* Sars, *Paracalanus parvus* (Claus), and *Temora turbinata* (Dana), were most numerous at S3, the sampling point nearest the Gulf. Two, *Oithona simplex* Farran and *Centropages hamatus* (Lilljeborg), were most abundant at S2 which is three miles farther into the bay than S3. Three more of the thirteen, *Paracalanus crassirostris* Dahl, *Pseudodiaptomus coronatus* Williams, and *Acartia tonsa* Dana were most abundant in the upper reaches of West Bay (W1), though populations of *Acartia* were almost as large near the head of East Bay (E1, E2). Finally, *Oithona brevicornis* Giesbrecht was taken in greatest quantities in East Bay (E3, E4). The latter species seems to thrive best in estuarine conditions as do *Acartia tonsa, Paracalanus crassirostris, Pseudodiaptomas coronatus,* and *Tortanus setacaudatus* Williams (a species of lesser importance).

Data on seasonal distribution of copepods in 1961–62 reveal that annual maxima for ten of the 13 most abundant species occurred during the warmest months of the year, *i.e.,* May–September (25–29 C). Four species, *E. acutifrons, P. parvus, O. nana,* and *A. tonsa* were numerically most abundant in late spring. Four other species, *P. crassirostris, O. brevicornis, C. americanus,* and *C. furcatus,* were most abundant in the summer and two species, *T. turbinata* and *P. coronatus* were taken in greatest numbers in early fall. Maxima during the warmer months were also observed in populations of three less prominent species, *Eucalanus pileatus* Giesbrecht, *Tortanus setacaudatus,* and *Labidocera aestiva* Wheeler. Only *O. simplex* and *O. curta* were most abundant in late fall and *C. hamatus* alone achieved a maximum in mid-winter. Of the copepods which were most abundant in the warmer months, *T. turbinata, C. americanus, P. parvus, O. nana, L. aestiva,* and *A. tonsa* also had peaks in the cooler months of the year, *i.e.,* November–March (11–22 C). *Acartia,* in fact, was nearly as abundant in January as in May. Peaks in warmer months, at least, for *C. furcatus* and *T. setacaudatus* and in the cooler months for *C. hamatus* would be expected since a rather distinct seasonal pattern of abundance in northern Gulf waters has already been reported (Grice, 1957) for these species. The principal maxima for the total copepod population appeared in August and June, though a lesser peak was noted in January. The minimum for the year was recorded for February. The decline of the copepod population in this month was apparently the result of a sharp drop in the numbers of *A. tonsa*. Of the thirteen most abundant species, eleven were found at their annual minimum in February.

Quarterly survey data reveal a different copepod seasonal picture for 1959–60. Seven of the 13 species mentioned above were less abundant in the summer collections than in the late fall and winter surveys. Also, smallest catches of copepods were obtained in August instead of in February.

Considering overall averages for the entire bay complex, *Acartia tonsa* was the most abundant copepod averaging 39.4% of the copepod biomass (exclusive of nauplii). Dominance of *A. tonsa* in St. Andrew Bay estuaries is not surprising since the importance of this species in brackish waters from southern New England to southern Florida and to Texas has been well documented (Sutcliffe, 1948; Deevey, 1948, 1956, 1960; Grice, 1953, 1957; Breuer, 1962; Cronin *et al.*, 1962; Cuzon du Rest, 1963). The two next most important species were *Paracalanus crassirostris* (25.1%) and *Oithona brevicornis* (15.3%). These species together with *Acartia* composed the bulk (80%) of the copepod stock. Of the remaining species only *Oithona nana* (3.7%), *Paracalanus parvus* (2.7%), *Centropages hamatus* (2.1%), *Centropages furcatus* (1.9%), *Eucalanus pileatus* (1.9%), and *Euterpina acutifrons* (1.5%) exceeded 1% of the dry weight of the copepod standing crop.

Other crustaceans: Cladocerans were often abundant in the plankton of the St. Andrew Bay System. These crustaceans in 1961–62 averaged 1.8% of the total number and 1.9% of the total zooplankton biomass. Population maxima occurred in June of the 1959–60 quarterly investigation and in August and January of the monthly 1961–62 survey. Minima were recorded for November of 1959 and for December and February of 1961–62. Biomass peaks for 1961–62 (Fig. 4 D) corresponded with numerical peaks for this sampling year and occurred in August and January. Biomass minima in 1961–62 were recorded for December and February.

Three species of cladocerans, *Evadne tergestina* Claus, *Penilia avirostris* Dana, and *Podon polyphemoides* (Leuckart), were taken in the plankton hauls. *Evadne* and *Penilia* were collected in the warmer months and were scarce or absent from December through April. A similar distribution for *Evadne* and *Penilia* was observed at Alligator Harbor, Florida by Grice (1953). Peak numbers of *Evadne* appeared in June 1960 and in August 1961. During the warmer months *Evadne* became well established throughout the bay system and was especially abundant at N2 close to the mouth of North Bay. *Evadne* was least abundant in the bay system at N1 near the head of North Bay. *Penilia* populations were largest in June 1960 and in September 1961. This cladoceran was most abundant at stations nearest the Gulf and was better represented in East Bay than in North or West Bays. *Podon polyphemoides*, a cool water species according to Baker (1938), was taken in numbers from December through May. *Podon* was found in greatest quantities in the June survey of 1960 and in January and March of 1962. As was true for many species of copepods, there was a significant drop in counts of this cladoceran in February 1962. Largest populations of *Podon* were at stations of mean salinities between 23–30 ppt with heaviest concentrations occurring at E4 (29.7 ppt). *Podon* was taken in fewest numbers at E1 (19.4 ppt) and S3 (32.7 ppt), stations with mean salinities on either side of the above salinity range.

Only one holoplanktonic ostracod, *Euconchoecia chierchiae* Müller, was taken in St. Andrew Bay. It is a coastal form which has been reported from the coasts of Brazil and North Carolina and from Delaware Bay and Block Island Sound (Deevey, 1952, 1960). This species appeared in November and February hauls of 1959–60 and was collected July through February in 1961–62. Maximum averages for *Euconchoecia* were recorded for February 1960 and August 1961. It was encountered most often at S2 and S3, stations closest to the Gulf. *Euconchoecia* was scarce at all other stations in the bay and was not taken at all at the head of North Bay (N1) and in West Bay. Benthic ostracods occasionally appeared in sample aliquots but their identifications were not pursued.

Three species of mysids were encountered in tows made from 1959–62. *Metamysidopsis munda* (Zimmer) appeared in a January (1962) sample collected in East Bay (E4), *Gastrosaccus dissimilis* Coifmann was taken in St. Andrew Bay (S1) in December 1961, and *Mysidopsis almyra* Bowman was collected at S2 in December 1961 and at S3 in June 1962. Three other species were identified from tows made near S3 prior to 1959. These species, *Promysis atlantica* Tattersall, *Taphromysis bowmani* Bacescu, and *Anchialina typica* (Krøyer), were represented, as were those taken in 1959–62, by only a few specimens per tow. *Taphromysis bowmani, M. munda, G. dissimilis* and *M. almyra* have been found previously in northern Gulf of Mexico waters (Tattersall, 1951; Bacescu, 1961; Bowman, 1964).

Since all of the tows in the 1959–62 investigations were made during daylight hours it is possible that the mysid contribution to the plankton has been underestimated. Hopkins (1958) and Herman (1963) have noted that mysids are far more abundant in the water column during periods of darkness. Herman (1963) has shown that *Neomysis americana* (S. I. Smith), an abundant mysid in coastal waters of the northern Atlantic states, is either on or just above the bottom during the day. Mysids in the St. Andrew Bay System with a behavior pattern similar to that of *Neomysis* could well have avoided capture in this investigation. This is so because the Clarke-Bumpus device was towed no closer than a foot or so above the bottom as a precaution against filling the sampler with sediment.

Amphipods constituted only a small portion of the zooplankton number and biomass. Of the two planktonic species encountered, *Hyperia atlantica* Vosseler and *Simorhynchotus antennarius* Claus, only the former appeared in sample aliquots. *Hyperia atlantica* was taken in small numbers in every season particularly at stations near the Gulf. *Simorhynchotus* was observed in a sample taken at S3 in June 1961. Gammarid amphipods were seen on occasion, though they were even less abundant than planktonic forms.

Isopods were collected throughout the year and were found at every station but N1. There was little variety in the catch and the species encountered were almost invariably Bopyridae or *Munna*. Branchiurans were captured in several East Bay tows made at E1 and E4 and a single cumacean specimen appeared in the aliquot of the June 1962 sample from S3.

The planktonic shrimp *Lucifer faxoni* Borradaile was present in St. Andrew Bay in every season, though in 1961–62 it was relatively scarce from December through April and was not seen at all in winter (February, 1960) samples of the quarterly survey.

Lucifer was taken most often at S3 near the Gulf and became increasingly scarce towards the heads of estuaries.

Lucifer along with the amphipod *Hyperia* and the ostracod *Euconchoecia* only represented 0.52% of the zooplankton biomass. Except for copepods and cladocerans these were the only planktonic crustaceans for which dry weight estimates were obtained. The combined number of all crustaceans other than copepods and cladocerans was only 0.08% of the total zooplankton number.

Chaetognaths: Chaetognaths were represented in the St. Andrew complex by four species, *Sagitta enflata* Grassi, *Sagitta helenae* Ritter-Zahony, *Sagitta hispida* Conant, and *Sagitta tenuis* Conant. All of these species have been recorded previously in coastal waters of the Gulf of Mexico (Pierce, 1951, 1962). Chaetognaths were most abundant during the warmer months while the population was smallest from December through April. Maxima (Fig. 4 E) were recorded for August and June of the monthly investigations while the minimum appeared in February. The average number of chaetognaths in the quarterly 1959–60 survey was about the same in August, November, and June while the population in February was comparatively small. This group totalled 0.45% of the zooplankton number and 1.66% of the zooplankton biomass.

Most of the chaetognath biomass was composed of immature forms under 3 mm in length. These immatures were not positively identified but in most instances they appeared to be the young of *S. tenuis*. The most important species of those chaetognaths larger than 3 mm was also *S. tenuis*, with *S. hispida*, *S. enflata*, and *S. helenae* following in order of importance. *Sagitta enflata*, *S. helenae*, and *S. tenuis* were most abundant at stations near the Gulf, though the latter species penetrated far into the estuaries. *Sagitta hispida* was taken throughout the bay complex and its distribution was not obviously related to distance from the Gulf. Largest averages for *S. hispida* were obtained for S3 and W1, two widely separated stations.

An earlier study of the chaetognath fauna of St. Andrew Bay was reported by Smith (1955), who sampled two stations located near S2 and S3. Smith encountered the same four species and averages for both Smith's two stations and S2 and S3 are in Table 12 below:

In both investigations, *S. tenuis* was the most abundant chaetognath, though this species was more abundant in 1961–62 than in 1954. *Sagitta enflata*, the next most important species, and *S. hispida* were found in approximately the same numbers in both years. *Sagitta helenae*, on the other hand, was noticeably more abundant in 1954 than in 1961–62. Smith found *S. helenae* to be more common at his offshore stations; perhaps the higher average for this species in 1954 is partially related to the fact that the

TABLE 12

Chaetognath abundance in 1954 and 1961–62

	1954 (Smith) #/m³	1961–62 (Hopkins) #/m³
S. hispida	5.4	5.2
S. helenae	6.3	0.5
S. tenuis	16.4	49.0
S. enflata	8.6	11.1
Mean salinity	34 ppt	32 ppt

mean salinity in the lower reaches of St. Andrew Bay was higher in 1954 (34 ppt) than in 1961–62 (32 ppt).

Considering Smith's 1954 data and those for 1959–60 and 1961–62, *Sagitta enflata* maxima appeared in one year or another in fall, winter, and summer. *Sagitta tenuis* maxima occurred only in summer and fall. *Sagitta hispida* peaks occurred in every season and maxima for *S. helenae* were recorded for every season but fall. In summary, *S. tenuis* was most abundant in the warmer months while seasonal patterns of the other three species were less well defined.

Appendicularians: Considering holoplankters alone, appendicularians were outranked in abundance only by copepods. This group in 1961–62 constituted 7.9% of the number and 9.7% of the biomass of the zooplankton. Of the ten species identified *Oikopleura dioica* Fol was by far the most common, averaging 86.5% of the appendicularian dry weight. The bulk of the remaining biomass was composed of *Oikopleura longicauda* Vogt (9.9%) and *Oikopleura fusiformis* Fol (3.2%), though *Appendicularia sicula* Fol was abundant on occasion (July 1960). Species of lesser importance were *Fritillaria borealis* f. *sargassi* Lohmann, *Fritillaria formica* Fol, *Fritillaria haplostoma* Fol, *Kowalevskaia tenuis* Fol, *Oikopleura rufescens* Fol, and *Oikopleura cornutogastra* Aida. The latter species, according to Tokioka (1940), may be a form of *O. fusiformis* and forms intermediate between these two species were encountered among St. Andrew Bay specimens (Dr. Takasi Tokioka, personal communication).

All species with the exception of *O. dioica* were taken in greatest numbers at stations in the more saline regions of the bay system (S3, S2, S1, E4, E3). *Oikopleura dioica*, a temperate-tropical species often reported from estuaries (Essenberg, 1926; Percival, 1929; Thompson, 1948; Barlow, 1955; Deevey, 1960) was collected throughout the bay complex and its numbers increased towards the heads of the estuaries. A conspicuous deviation from this trend is the low average number of *O. dioica* recorded for N1 which is far below the mean for stations of similar brackishness. *Appendicularia sicula*, while usually most abundant near the Gulf, appeared in numbers far into the bay complex in June 1960, reaching a density of 6600/m^3 at W2 in West Bay.

Though the appendicularian species found in the St. Andrew Bay System are reportedly most abundant in tropical and subtropical seas (Thompson, 1948), half of the species were encountered so infrequently and in such small numbers that little can be said of their local seasonal distribution. *Fritillaria borealis* f. *sargassi* was taken in only three months, *F. formica, F. haplostoma,* and *O. rufescens* in only two months, and *K. tenuis* and *O. cornutogastra* in but one month. *Appendicularia sicula* appeared in every season but its distribution in time may not have been continuous. The maximum count for this species was obtained in July 1960.

In regard to the more prevalent species, *O. fusiformis* was most abundant in November of the 1959–60 quarterly survey and in August, October, and April of the 1961–62 monthly investigation. This species was scarce in the February and June surveys of 1960 and from December through February in 1961–62. *Oikopleura longicauda*, perhaps the most frequently encountered appendicularian in tropical waters (Thompson, 1948), was prevalent in the warmer months and appeared in greatest densities in August and June of 1959–60 and again in August and June of 1961–62. This appendicularian was quite abundant at S3 near the Gulf where it approximated *O. dioica* in number. Minimum counts of *O. longicauda* were recorded for November and February of 1959–60 and in

December and February of 1961–62. The dominant appendicularian, *O. dioica*, like *O. longicauda*, was most abundant during the warmer months. *O. dioica* showed peaks in August and June of 1959–60 and in August and May of 1961–62. Smallest catches of *O. dioica* were obtained in February of both 1960 and 1962. Because of the relative importance of this species, total appendicularian number and biomass essentially followed the same seasonal pattern as that of *O. dioica* (Fig. 4 F).

Thaliaceans: The contribution of Thaliacea to zooplankton biomass was insignificant and in 1961–62 accounted for only 0.13% of the total dry weight. One doliolid, *Dolioletta gegenbauri* (Uljanin), and a single species of salp, *Cyclosalpa floridana* Apstein, were seen in 1959–62 collections. Two other salps, *Salpa cylindrica* Cuvier and *Thalia democratica* Forskal were taken near S3 in 1958. *Dolioletta gegenbauri* occurred at the five stations with the highest salinity averages and was most abundant at S3, the station nearest the Gulf. This doliolid, reportedly a eurythermal species (Thompson, 1948), was taken in every month in 1961–62 except March and April and reached peak abundance in May. In 1959–60 it was found in only August and June. A fourth thaliacean *Cyclosalpa floridana* was seen in a single sample collected in August 1961 at station S3.

Larvae: On the basis of dry weight, the biomass of the larvae exceeded one-fifth the zooplankton biomass caught with #10 nets. The most important contributors were mollusc veligers, which averaged 60.7%[a] of the larvae dry weight and polychaete larvae which accounted for 26.2% of the larvae biomass. Predominance of veligers and polychaete immatures in larval plankton also has been observed in Long Island Sound by Deevey (1956). The remaining invertebrate larval biomass was composed principally of decapod immatures (6.1%) cirriped larvae (2.8%), and echinoderm larvae (2.0%). Cephalochordate larvae, small fish larvae, and fish eggs totaled 2.1% of the larvae weight. Larvae for which no dry weight data are available were either scarce or, if occasionally abundant, were quite small and therefore of little consequence in biomass considerations.

Mollusc larvae were abundant throughout the entire bay complex with gastropod veliger populations being greatest in East Bay (E3, E4) and with pelecypod veligers reaching maximum concentrations in West Bay (W1). Lowest average counts for both pelecypod and gastropod larvae were obtained near the heads of East and North Bays. Larval polychaete populations were greatest in West Bay and comparatively small catches were obtained, as with veligers, in the upper reaches of North and East Bays. Decapod larvae were in greatest numbers near the Gulf (S3) and there was a general decrease in abundance with decreasing mean salinity. Smallest averages for these larvae were obtained, again, for the heads of North and East Bays. Cirriped larvae, on the other hand, were most abundant at the three stations of lowest salinity (E2, N1, E1) and least abundant at three stations of intermediate salinity. Peak values for echinoderm larvae (chiefly brachiolarians) were recorded for West Bay station W1, where counts averaged 4300/m^3 in 1961–62. The high mean for W1 can be attributed to the unusually high densities (49,500/m^3) of brachiolarians which were found at this station in June 1962. Echinoderm larvae were scarce in North Bay and were absent from E1 at the head of

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[a] This value can lead to an overestimate of the relative importance of veligers in the plankton food chain since veliger dry weight also includes inorganic shell weight.

East Bay. Cephalochordates were taken most frequently near the Gulf whereas highest values for fish eggs and larvae were found for stations well into the bay system.

Seasonal maxima for mollusc, polychaete, decapod, and echinoderm larvae occurred during the warmer months (Fig. 4 G) which corresponds with the seasonal distribution of these larvae in Long Island Sound (Deevey, 1956). Cirriped larvae maxima were in the cooler months as well and were particularly abundant in February 1960.

In the 1959–60 survey gastropod veligers were most common in August and June and in the 1961–62 survey they were most abundant in September and June. Comparatively few gastropods were taken in the November survey of 1959 and from December through April in 1961–62. The principal maxima for pelecypod larvae were recorded for June of 1959 and for August and June of 1961–62. Lowest count averages were obtained from November 1959 and February 1962 samples. Polychaete larvae were taken in greatest quantities in June of both 1960 and 1962. A cool weather peak was also recorded in January of 1962. A winter (February) minimum for polychaete larvae was noted for 1962 but there was no apparent minimum in 1959–60. Decapod larvae were most numerous in August of 1959–60 and in September and June of 1961–62. They were entirely absent from samples taken in November and February of 1959–60 and were least abundant in 1961–62 from November through April. Echinoderm larvae, brachiolarians in the main, were extremely abundant in June 1962 but did not show a corresponding peak in June of 1960. A minimum occurred in November 1959, and echinoderm larvae were not seen in samples taken in February 1962. Maximum numbers of fish eggs were recorded for August and June of 1959–60 and small peaks appeared in August and May of 1961–62. Small fish larvae were taken only in August and June of 1959–60 and were most prevalent in August and June of 1961–62. The maximum total count for all larvae occurred in June of both 1959 ($3300/m^3$) and 1962 ($21{,}700/m^3$) while minima were recorded in November 1959 ($400/m^3$) and in February 1962 ($260/m^3$).

TOTAL ZOOPLANKTON STANDING CROP

Contributions of the principal groups of plankters to total zooplankton standing crop are summed in Tables 13 and 14. Groups exceeding 1% of both zooplankton number and dry weight were copepods, larvae of benthic invertebrates, appendicularians, dinoflagellates, rotifers, and cladocerans. The most important of these were copepods, larvae of benthic invertebrates, and appendicularians. Together these three categories constituted 79% of the zooplankton number and 92% of the dry weight. The dominant plankters as in many other studies were the copepods. They alone accounted for 60% and 56% of the zooplankton number and dry weight respectively.

Over 50% of zooplankton numbers and 53% of the dry weight were contributed by seven species of plankton: *Acartia tonsa*, *Paracalanus crassirostris*, *Oikoplura dioica*, *Oithona brevicornis*, *Noctiluca scintillans*, *Oithona nana*, and *Synchaeta* sp. .The most important plankter in terms of dry weight was *Acartia tonsa* which accounted for 20% of the total zooplankton standing crop while the greatest numerical contribution was that of *Paracalanus crassirostris* which composed 16% of the zooplankton catch. The contributions of these copepods are underestimated since nauplii counts were not taken to species.

TABLE 13

Distribution of the major zooplanton groups by station in the St. Andrew Bay System (average 1961–62 values). Upper numbers in each row represent individuals/m³; lower numbers in parentheses represent dry weight (mg/m³). Stations arranged in order of decreasing mean annual salinity.

	S3	S2	E4	S1	E3	W2	N2	W1	E2	N1	E1
Dinoflagellates	4768 (1.74)	5486 (2.03)	877 (.33)	3127 (1.16)	2515 (.93)	6347 (2.35)	1638 (.61)	2632 (.97)	85 (.03)	3209 (1.19)	20 (.01)
Tintinnids	207 (<.01)	604 (.01)	2111 (.04)	6036 (.08)	1530 (.05)	2711 (.06)	7356 (.13)	2568 (.04)	3081 (.16)	4320 (.08)	483 (.01)
Hydromedusae	100 (.66)	62 (.28)	116 (.86)	35 (.14)	94 (.28)	27 (.14)	31 (.17)	52 (.41)	103 (.24)	5 (.01)	68 (.13)
Siphonophores	24 (.14)	16 (.04)	5 (.01)	6 (.01)	....	....	....	....	....	....	....
Rotifers	....	32 (<.01)	193 (.05)	188 (.03)	3922 (.87)	2433 (.51)	1823 (.40)	1608 (.38)	3192 (.76)	4281 (.99)	4387 (1.05)
Molluscs & Polychaetes	402 (.65)	55 (.07)	11 (<.01)	1 (<.01)	1 (<.01)	....	....	....	....	....	....
Copepods	17392 (23.77)	26494 (26.84)	29540 (29.20)	27429 (24.43)	27853 (24.80)	22253 (21.89)	19586 (20.21)	39594 (33.07)	25469 (29.88)	6953 (8.41)	17998 (19.96)
Cladocerans	472 (.62)	489 (.61)	1007 (1.12)	648 (.71)	967 (1.09)	1008 (1.08)	1457 (1.60)	327 (.36)	958 (1.07)	266 (.26)	327 (.38)
Other Crustaceans	161 (1.40)	78 (.50)	44 (.30)	15 (.07)	19 (.06)	6 (.09)	13 (.01)	5 (<.01)	11 (<.01)	....	4 (<.01)
Chaetognaths	541 (2.66)	418 (1.42)	267 (1.05)	229 (.68)	103 (.43)	139 (.53)	66 (.23)	124 (.45)	62 (.23)	2 (<.01)	17 (.03)
Appendicularians	2138 (3.81)	1935 (2.89)	3170 (4.62)	3325 (4.87)	3708 (4.88)	3537 (4.51)	3729 (4.70)	3782 (3.70)	3999 (4.40)	1933 (2.25)	3673 (4.85)
Thaliaceans	23 (.35)	15 (.11)	9 (.10)	1 (<.01)	3 (.02)	....	....	....	....	....	....
Larvae	4871 (13.59)	3486 (9.52)	6922 (17.46)	3907 (9.51)	5127 (12.92)	6416 (15.81)	3048 (7.75)	12205 (24.01)	2623 (6.94)	975 (1.69)	890 (2.23)
Total Zoop. no./m³	31099	39170	44272	44947	45841	44877	38747	62897	39583	21944	27867
Total Zoop. dry wt(mg/m³)	(49.40)	(44.33)	(55.15)	(41.69)	(46.31)	(46.96)	(35.81)	(63.39)	(43.71)	(14.88)	(28.65)

TABLE 14

Seasonal distribution of the major zooplankton groups in the St. Andrew Bay System (averages of all stations). Upper numbers in each row represent individuals/m³; lower numbers in parentheses represent dry weight mg/m³).

	Aug. 59	Nov.	Feb. 60	June	July 61	Aug.	Sept.	Oct.	Nov.	Dec.	Jan. 62	Feb.	Mar.	April	May	June	Avg. 1961-62	Percent Total Zoop.
Dinoflagellates	....	9	4	....	....	....	....	....	....	....	....	10553	22882	6	2	2	2787	6.94
	....	....	....	....	....	....	....	....	....	....	....	(3.91)	(8.47)	(<.01)	(<.01)	(<.01)	(1.03)	(2.41)
Tintinnids	708	352	60	819	790	1163	977	354	57	42	13399	24	743	154	70	16309	2840	7.08
	....	....	....	....	(.01)	(.02)	(.01)	(<.01)	(.01)	(<.01)	(.29)	(<.01)	(.01)	(<.01)	(<.01)	(.39)	(.06)	(.15)
Hydromedusae	27	8	39	36	11	58	131	115	160	30	17	7	5	11	109	122	65	.16
	....	....	....	....	(.10)	(.22)	(1.02)	(.28)	(.28)	(.07)	(.11)	(.03)	(.01)	(.03)	(.65)	(.86)	(.30)	(.71)
Siphonophores	18	....	4	....	....	5	3	3	5	4	5	2	1	2	16	12	5	.01
	....	....	....	....	....	(.01)	(.01)	(.01)	(.01)	(.01)	(.01)	(<.01)	(<.01)	(.01)	(.04)	(.03)	(.02)	(.04)
Rotifers	....	254	39	....	....	....	....	5	267	3280	19551	12	7	8	154	780	2005	4.99
	....	....	....	....	....	....	....	....	(.06)	(.79)	(4.62)	(<.01)	(<.01)	(<.01)	(.02)	....	(.46)	(1.07)
Molluscs & Polychaetes	17	....	....	69	21	10	5	15	2	6	3	....	1	411	25	7	42	.10
	....	....	....	....	(.03)	(.01)	(.01)	(.02)	(<.01)	(.01)	(<.01)	....	(<.01)	(.52)	(.03)	(.05)	(.06)	(.13)
Copepods	7440	21194	12848	27851	18053	40959	31574	29811	24719	13287	22377	3444	11054	8111	28254	52726	23697	59.03
	....	....	....	....	(19.47)	(35.87)	(37.39)	(33.60)	(24.79)	(16.15)	(31.98)	(3.62)	(12.21)	(8.99)	(29.59)	(32.58)	(23.85)	(55.82)
Cladocerans	427	48	340	840	660	2210	872	471	221	100	1812	120	887	289	796	207	720	1.79
	....	....	....	....	(.80)	(2.71)	(1.16)	(.61)	(.31)	(.10)	(1.67)	(.11)	(.82)	(.27)	(.88)	(.29)	(.81)	(1.89)
Other Crustaceans	16	2	131	7	5	64	29	42	40	40	10	1	4	2	22	84	32	.08
	....	....	....	....	(.32)	(.79)	(.35)	(.25)	(.12)	(.09)	(.03)	(<.01)	(.02)	(<.01)	(.05)	(.63)	(.22)	(.52)
Chaetognaths	160	154	43	185	192	265	147	256	142	61	57	25	42	71	308	591	180	.45
	....	....	....	....	(.63)	(.90)	(.74)	(.83)	(.49)	(.23)	(.64)	(.06)	(.44)	(.13)	(1.61)	(1.80)	(.71)	(1.66)
Appendicularians	1571	991	168	3390	1623	6531	4359	3654	3928	3338	190	61	1553	2135	5764	4949	3173	7.90
	....	....	....	....	(1.60)	(8.30)	(6.56)	(5.01)	(5.44)	(5.00)	(.41)	(.07)	(2.95)	(3.06)	(7.17)	(4.00)	(4.13)	(9.67)
Thaliaceans	5	....	....	....	1	4	6	3	1	....	4	5	....	....	21	14	5	.01
	....	....	....	....	(.02)	(.02)	(.05)	(.02)	(.01)	....	(.07)	(.21)	....	....	(.18)	(.09)	(.05)	(.13)
Larvae	1351	402	1633	3329	2007	5897	7521	2175	2603	1452	1393	261	2207	1746	6153	21668	4590	11.43
	....	....	....	....	(5.52)	(16.58)	(20.88)	(6.13)	(6.48)	(3.64)	(4.08)	(.59)	(5.69)	(4.49)	(17.75)	(40.49)	(11.03)	(25.80)
Total Zoop. no./m³	12740	23414	15319	36526	23363	57166	45624	36895	32145	21640	58818	14515	39386	12694	41694	97471	40141	
Total Zoop. dry wt (mg/m³)	....	....	....	....	(28.51)	(65.42)	(68.16)	(46.74)	(38.08)	(26.08)	(43.90)	(8.60)	(30.62)	(17.50)	(57.96)	(81.20)	(42.73)	

The variety of organisms seen in plankton sample aliquots decreased with decreasing salinity in a fairly linear manner (Fig. 5). Greatest plankton variety occurred at S3 (43 types/aliquot) and S2 (41 types/aliquot), stations with the highest mean salinities, and the least variety occurred at N1 (14 types/aliquot) and E1 (18 types/aliquot), stations with the lowest salinity averages. At E1 only five species exceeded 1% of both the zooplankton number and dry weight and the dominance of *Acartia* was pronounced. At this station *Acartia* accounted for 63% and 46% of the zooplankton number and dry weight respectively. At S3, where plankton diversity was greatest, 12 species averaged greater than 1% of the population number and weight with the most abundant species, *Paracalanus crassirostris*, accounting for only 18% of the zooplankton number and 11% of the weight.

Without regard to species composition, both total numbers and biomass were rather evenly distributed throughout the bay complex, though unusually high averages were obtained for W1 at the head of West Bay (62,900/m^3; 63.4 mg/m^3) and comparatively low mean values were recorded for N1 (21,900/m^3; 14.9 mg/m^3) and E1 (27,900/m^3; 28.6 mg/m^3) in the upper reaches of North and East Bays. The average for all stations for 1961–62 was 40,100 plankters/m^3 and 42.7 mg of zooplankton dry weight/m^3.

Zooplankton seasonal data reveal that in 1961–62 biomass and numerical fluctuations were rather closely associated. In late summer of 1961 a zooplankton numerical maximum appeared in August and a biomass peak occurred a month later in September.

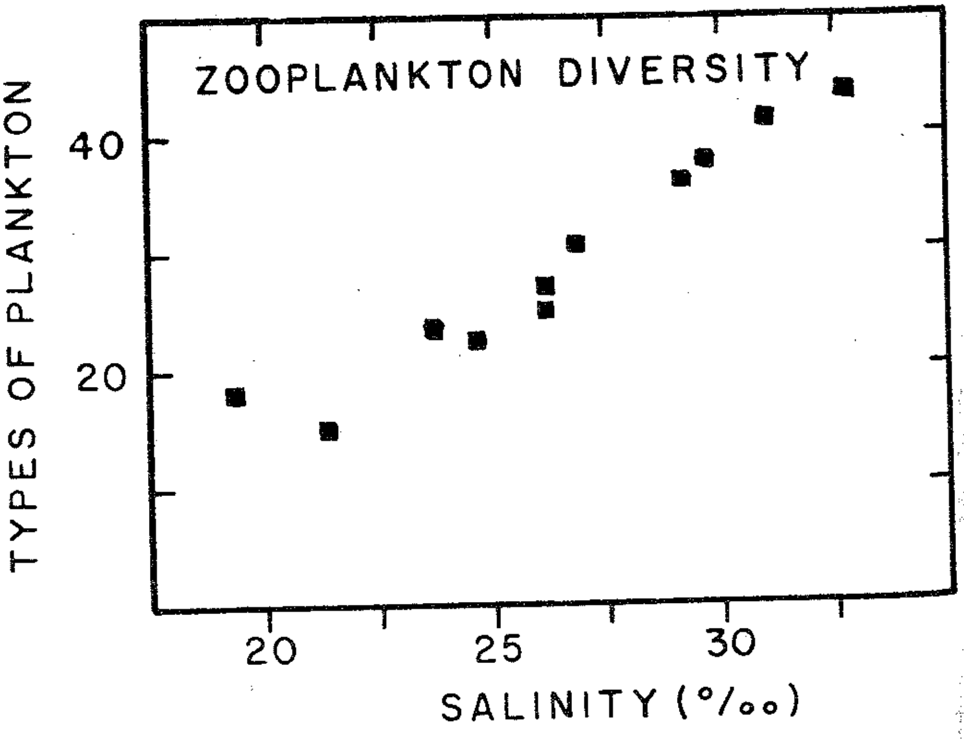

Fig. 5. Distribution (1961–62) of zooplankton species diversity in the St. Andrew Bay System with respect to salinity.

Biomass and numerical fluctuations for the remainder of the year corresponded in time. There was a moderate peak in January, a smaller one in March, and the annual maximum in June. Minima were recorded for July, December, February, and April. In 1959–60 zooplankton counts were largest in November and June while lowest counts were obtained for August and February.

Zooplankton variety (Fig. 6) was greatest during the warmer months and maxima were recorded for September 1961 (34 types/aliquot) and June 1962 (37 types/aliquot). Faunal variety was comparatively low from February through April with the minimum occurring in February 1962 (16 types/aliquot).

Peaks in zooplankton numbers in the warmer months of 1961–62 (Table 14) can be attributed to copepods and to a lesser extent to larvae, appendicularians and tintinnids. In January, tintinnids and rotifers as well as copepods contributed significantly to the winter numerical peak. The minimum in December resulted primarily from a drop in the copepod population and that for February, the minimum of the year, was due to the comparative scarcity of nearly all types of plankton except *Noctiluca*. Virtual disappearance of *Noctiluca* along with continued scarcity of other plankters accounts for the small standing crop of April.

Biomass peaks (Fig. 4 H) in the warmer months were formed predominantly by copepods and invertebrate larvae. Copepods, again, were largely responsible for the January biomass pulse while a small increase in copepods and a doubling of the *Noctiluca* population caused the much smaller peak which followed in March. Though tintinnids and rotifers were abundant in January, they did not contribute a proportional amount to the zooplankton biomass.

Even though data for the 1959–60 quarterly survey are not as complete as are those for the 1961–62 monthly investigation, it is probably safe to state on the basis of these two surveys, that standing crop level varies from year to year (Fig. 7) and that peaks do not necessarily correspond in time from one year to the next. Poor agreement of yearly plankton cycles also has been noted in other estuaries (e.g. Sheepscot estuary: Stickney, 1959; Delaware Bay: Deevey, 1960) and in coastal waters (Cape Cod to Chesapeake Bay: Bigelow and Sears, 1939).

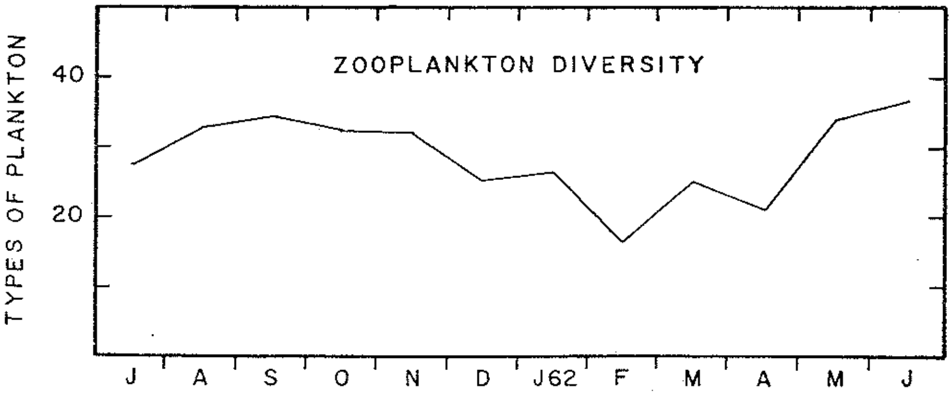

FIG. 6. Seasonal (1961–62) distribution of zooplankton species diversity in the St. Andrew Bay System.

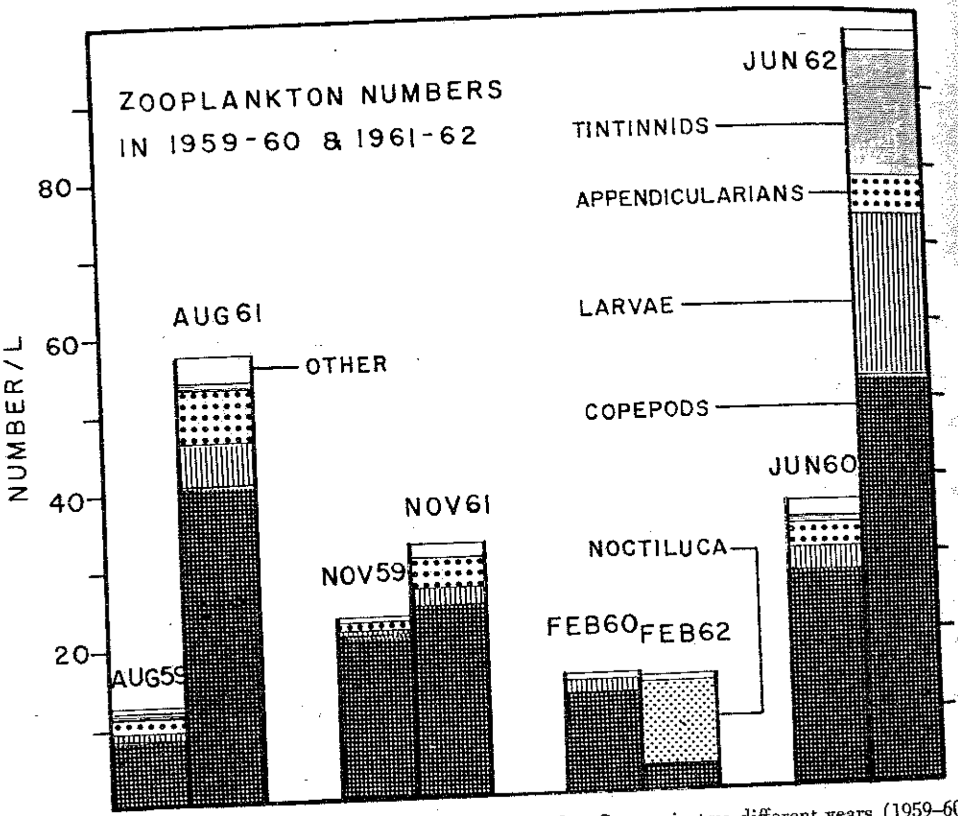

Fig. 7. Zooplankton standing crop in the St. Andrew Bay System in two different years (1959–60, 1961–62).

Discussion of Results

FACTORS INFLUENCING THE DISTRIBUTION OF PLANKTON BIOMASS

Multiple linear regression analyses have been used to evaluate relationships between diatom standing crop and salinity and temperature. Possible delayed effects (one month) of salinity and temperature on diatom biomass have been included in the analyses. Results of these regression analyses are in Table 15.

Table 15

Multiple linear regression analyses of diatom volume, surface salinity, and temperature data (dependent variable: diatom volume; independent variables: temperature, salinity)

Independent variable	Degrees of freedom	T-value of regression coefficient	Cumulated proportion of variance (R^2)
	Diatom data offset (lag) by one month		
Temperature	118	2.08[a]	0.023
Salinity	118	3.15[b]	0.076
	No time lag of diatom data		
Temperature	129	1.81	0.012
Salinity	129	5.57[b]	0.192

[a] Significant at t.05.
[b] Significant at t.01.

In both the month-lag and non-lag analyses salinity accounts for a significant portion (at t.01) of the diatom biomass variance. The strongest t-test is obtained for the non-lag regression which may indicate that salinity lag effects are better measured by a time interval other than one month. The temperature-diatom biomass relationship is not strong and is significant only at t.05 in the month-lag analysis. Cumulated proportion of variance figures indicate that at best about 20% of the diatom biomass variability can be attributed to the combined effects of salinity and temperature. While it may be that more intensive sampling would ultimately reveal lag intervals which would yield stronger statistical relationships between diatom biomass and the two hydrographic parameters, it is also probable that a good portion of the unaccounted diatom volume variance was caused by variables not assayed. To date there is no information on primary production, grazing rates, dissolved nutrients, or the effects of circulation patterns on the diatom population in the St. Andrew Bay System. This information is necessary before the most important regulators of the diatom population can be determined.

Multiple linear regression analyses also have been used to investigate the extent that diatom biomass, salinity, and temperature influenced variations in zooplankton biomass (Table 16). As in the previous analyses, delayed effects of the independent variables were studied. The temperature-zooplankton biomass regression coefficient is significant (t.01) in both the time-lag and non-lag studies with the t-test being strongest in the lag analysis. Salinity, on the other hand, is not linearly related to zooplankton biomass to a statistically significant degree.

Diatom biomass accounts for a significant portion of zooplankton biomass variance only in the non-lag analysis. Cumulated proportion of variance figures show that diatom standing crop fluctuations account for only 11.5% of the zooplankton biomass variance. Perhaps a stronger relationship would be expected if other possible sources of zooplankton food, such as detritus, flagellates, micro-organisms, and even organically rich bottom sediments, were not available.

The food value of detritus to higher forms of zooplankton has been questioned in the past (Riley, 1959), but Riley (1963) recently suggested that detritus formed by the adsorption of dissolved organic matter on particle or bubble surface forms a rich supply of supplementary food in coastal waters. In fact, Baylor and Sutcliffe (1963) have successfully reared *Artemia* on detritus formed by bubbling air through a medium rich in dissolved organic substances. Also Cowey and Corner (1963) have demonstrated that total

TABLE 16

Multiple linear regression analyses of zooplankton biomass (dry weight) and diatom volume, temperature, and salinity data (dependent variable: zooplankton biomass—dry weight; independent variables: diatom volume, temperature, and salinity)

Independent variable	Degrees of freedom	T-value of regression coefficient	Cumulated proportion of variance (R^2)
Zooplankton biomas data offset (lag) by one month			
Diatom volume	117	—0.35	0.004
Temperature	117	5.91[a]	0.210
Salinity	117	1.91	0.024
No time lag of zooplankton data			
Diatom volume	128	3.09[a]	0.115
Temperature	128	3.46[a]	0.071
Salinity	128	0.97	0.006

[a] Significant at t.01

particulate matter in waters off Plymouth is little different from the diatom *Skeletonema costatum* in the variety and quantiy of its amino acids. Flagellates are a likely source of nutrition since copepods and various invertebrate larvae thrive on this diet in the laboratory (Loosanoff *et al.*, 1957). Too, Manuilova (1957, 1958) has found that some species of fresh water cladocerans, at least, can grow and reproduce using bacteria as the sole constituent of the diet. Although there are little data on the significance of organically rich bottom sediments as zooplankton food, this possibility cannot be discounted. If any of the above alternate food sources are utilized by zooplankton it might have the effect of reducing grazing on the diatom population.

Cumulated proportion of variance values in Table 16 indicate that temperature, salinity, and diatom biomass together account for only a small portion of the total variance of zooplankton biomass, even when lag effects are considered. This suggests, as in the case of diatom variation, that parameters not included in the statistical analyses were responsible for most of the observed variations. It is unfortunate that accurate quantitative records were not maintained on large plankters such as scyphomedusae and ctenophores for there is some evidence that they play an important role in the population dynamics of the St. Andrew estuaries. A rough estimate of their abundance is available, however, in the form of records of presence or absence of scyphomedusae and ctenophore fragments in sample aliquots. As shown in Table 17, fragments were found in samples collected at eight of the 11 stations during January and February 1962. It is surmised that by February a considerable quantity of the zooplankton crop had been consumed, thus accounting for the February drop in biomass. By March scyphomedusae, primarily *Cyanea capillata* (Linnaeus), and ctenophores had almost disappeared. Zooplankton standing crop remained low through March and April which may be considered the lag time required for the microplankton population to attain pre-February levels.

Table 17 also shows that scyphomedusae (*Chrysaora quinquecirrha* [Desor]) and ctenophores were numerous in August 1959 and that ctenophores were again prevalent in February 1960. They occurred during the time when the least plankton was collected. It may be, as numerous authors have suggested (Nelson, 1925; Barlow, 1955; Conover,

TABLE 17

Occurrence of ctenophore and scyphomedusa fragments in sample aliquots

Date	Fragment occurrence (fraction of samples examined)
Aug '59	6/8
Nov '59	0/8
Feb '60	6/8
Jun '60	0/8
Jul '61	3/11
Aug '61	3/11
Sept '61	1/11
Oct '61	0/11
Nov '61	1/11
Dec '61	1/11
Jan '62	8/11
Feb '62	8/11
Mar '62	1/11
Apr '62	1/11
May '62	1/11
Jun '62	1/11

1961; Cronin *et al.*, 1962), that these large predators, which feed indiscriminately (Lebour, 1922; Mikhailov, 1962; Zenkevitch, 1963) on the rest of the community, make vast inroads on the microzooplankton of this bay complex. These predators, in fact, must be considered along with physical parameters such as salinity and temperature in interpreting seasonal fluctuations of estuarine zooplankton.

COMPARISON OF STANDING CROP WITH THAT OF OTHER AREAS

A comparison of phytoplankton counts for the St. Andrew Bay complex with those for other areas in the Gulf of Mexico and along the Atlantic coast of North America is shown in Table 18. It appears that mean numbers of diatoms in St. Andrew Bay are somewhat smaller than the averages listed for other estuaries whereas they are considerably higher than the coastal and offshore means. Patten *et al.*'s (1963) value approaches the St. Andrew Bay figures, but since they recorded chains of cells as single units, their counts would tend to underestimate total cell numbers.

Dissolved nutrients in the St. Andrew Bay System were not investigated in the period of this survey but phytoplankton standing crop suggests that nutrient levels in the bay complex were not high compared to the other estuaries considered. The relatively low St. Andrew Bay cell densities are not typical of a nutrient rich domestically polluted environment and though primary and secondary treated domestic wastes enter the bay system in three places, stations nearest the outfalls (N1, N2, S1, E4) did not yield unusually high cell counts. Also, the St. Andrew Bay System does not receive extensive fresh water runoff. The principal sources, the Econfina River and the local bayous, drain nutrient poor soils which supports mostly scrub oak, pine, and palmetto. Conversely, phytoplankton inhibition by industrial wastes seems unlikely since the St. Andrew Bay area is not heavily industrialized. One of the largest possible sources of toxic effluent would be the International Paper Company on the north shore of East Bay, but station E4 which is directly opposite the plant demonstrated no anomalously low cell densities nor did other stations adjacent to E4. Perhaps the major source of phytoplankton nutrients

TABLE 18

A comparison of phytoplankton abundance in St. Andrew Bay with abundance in other areas in the Gulf of Mexico and the northwestern Atlantic

Area	Source	Diatoms[a] (10^5 cells/l)	Sampling period
ESTUARIES			
St. Andrew Bay	Hopkins, 1964	8.46-s[b]	All seasons
Mississippi Delta	Thomas & Simmons, 1960	10.60	Jan, Apr
		35.67-s	Fall, Feb, May
Lower Chesapeake Bay	Patten *et al.*, 1963	9.38-s	All seasons
Long Island Sound	Conover, 1956	24.30	All seasons
Tisbury Pond	Hulburt, 1956	3.44-63.30	All seasons
Narragansett Bay	Pratt, 1959	53.06	All seasons
COASTAL AND OFFSHORE WATERS			
Georges Bank	Sears, 1941	2.10	Mar, Jun
Vineyard Sound	Lillick, 1937	.25	All seasons
Block Island Sound	Riley, 1952	3.25	All seasons
Continental shelf	Hulburt, 1963	.92-10m	All seasons
Bermuda to shelf	Hulburt, 1963	.27-10m	May-Aug, Dec-Mar
Sargasso Sea	Riley, 1957	.01-.03	All seasons

[a] Some averages include thecate dinoflagellates and silicoflagellates, however, diatoms constitute the bulk of the mean.
[b] Averages followed by s (surface) or 10m indicate that samples were taken only from these depths.

is the indrafted coastal water which composes the deeper layers of the bay system. If this indeed proves to be the case, it might explain why St. Andrew Bay cell counts fall between usual estuarine and offshore oceanic values.

The annual chlorophyll *a* average for St. Andrew Bay (Table 19) is also well below that of the other listed estuaries. It is greater, however, than the offshore values with the exception of those of Marshall (1956) and Riley (1941) for the West Coast of Florida and for Georges Bank respectively. Riley's figure represents total chlorophyll and Marshall's value is for November only.

An important factor to consider in these chlorophyll comparisons is that the St. Andrew Bay annual average was determined from surface samples whereas three of the five averages for other estuaries were derived from samples taken at more than one level in the water column.

Zooplankton standing crop data for Gulf of Mexico and Western Atlantic waters expressed in terms of numbers and dry organic weight per cubic meter of water are shown in Table 20. Dry weights in most cases have been computed from displacement volumes with the following conversion factor (Deevey, 1952):

$$\text{dry organic weight} = 0.089 \times \text{cc displacement volume.}$$

In regard to plankton numbers, the St. Andrew Bay average is less than the mean for Tisbury Pond (40,100 vs 52,200) and considerably less than the Long Island Sound average (40,100 vs 62,000). On the other hand the St. Andrew Bay average is significantly larger than the means for the five coastal and offshore areas listed (Tortugas, slope waters off Georgia, Sargasso Sea, slope waters off New Jersey, Block Island Sound). While the Grice and Hart (1962) values for Sargasso and slope waters off New Jersey perhaps would have been larger had they used nets finer than #6 mesh, it is unlikely that these averages would have approached those for St. Andrew Bay.

TABLE 19

A camparison of the chlorophyll a content of St. Andrew Bay waters with plant pigment concentrations in other areas of the Gulf of Mexico and the western Atlantic

Area	Source	Chl. a (mg/m^3)	Sampling period	Vertical salinity gradient ppt
ESTUARIES				
St. Andrew Bay	Hopkins, 1964	2.13-s[b] 4.87	All seasons Jan, Apr	1.0–9.2 2.9–8.5
Alligator Harbor	Marshall, 1956	4.3-s	All seasons	~1.0
Tampa Bay	Marshall, 1956	6.6-s	Sept, Jan Apr-May	
Sapelo & Doboy Sounds	Ragotzkie, 1959	11.7	Feb-May, Jul	Well mixed
Lower Chesapeake Bay	Patten *et al.*, 1963	6.15	All seasons	1.1–4.5
Long Island Sound	Conover, 1956	6.14	All seasons	~1.0
COASTAL AND OFFSHORE WATERS				
Sargasso Sea	Ryther *et al.*, 1961	.18	Apr	
Florida Straits	Alexander & Corcoran, 1963	.1-.3	Jun	
Florida west coast[a]	Marshall, 1956	2.3-s	Nov	
Florida Keys	Marshall, 1956	1.2-s	Nov	
Dry Tortugas	Riley, 1939	.33-s	Jul-Aug	
N.W. Atlantic slope waters	Riley, 1939	2.1-s[c]	May Jun	
Georges Bank	Riley, 1941	3.6-s	?	

[a] Red tide values not included

[b] Surface samples

[c] All of Riley's values are for total plant pigments

TABLE 20

A comparison of zooplankton standing crop in St. Andrew Bay with abundance in other Gulf of Mexico and northwestern Atlantic waters

Area	Source	#/m³	Dry organic weight (mg/m³)	Net mesh	Comments
ESTUARIES					
St. Andrew Bay	Hopkins, 1964	40,100	33.1	#10	
Biscayne Bay	Woodmansee, 1958	....	53.4	#6	Surface
Lower Delaware Bay	Cronin *et al.*, 1962	....	31.2	#2	
Long Island Sound	Deevey, 1956	62,000	85.2	#10	
Tisbury Pond	Deevey, 1948	52,200	----	#10	
Charlestown and Greenhill Ponds	Conover, 1961	....	59.6	#12	
Sheepscot Estuary	Stickney, 1959	....	36.5	#2	Jun-Nov
COASTAL AND OFFSHORE WATERS					
Tortugas	Riley, 1938	1,500	----	#20	Surface Jul-Aug
Continental shelf off North Carolina	St. John, 1958	....	24.6	#2	Jan, Jun
Shelf waters—Cape Cod to Chesapeake Bay	Bigelow & Sears, 1939	....	35.6	#2	
Block Island Sound	Deevey, 1952	16,600	60.5	#10	
Vineyard Sound	(Clarke & Zinn, 1937) Deevey, 1952	....	26.6	#2	
Gulf of Maine	(Redfield, 1941) Deevey, 1952	....	26–47	#0	
Georges Bank	(Riley & Bumpus, 1946) Deevey, 1952	....	64.0	#2	
Slope waters off New Jersey	Grice & Hart, 1962	310	24.0	#6	Upper 200 m
Slope waters off Georgia	Riley, 1939	900	4.0	#10	May-Jun, upper 300 m
Sargasso Sea	Grice & Hart, 1962	71	1.8	#6	Upper 200 m

The dry organic weight figure for St. Andrew Bay is substantially smaller than averages of the other listed estuaries with the exception of lower Delaware Bay and the Sheepscot estuary. Sampling in the Sheepscot and Delaware estuaries was with nets of #2 mesh, a mesh shown by Deevey (1952) to fish poorly for the small plankters which predominate in estuaries. It is possible, then, biomass averages for these two estuaries also would have exceeded the St. Andrew Bay mean had finer nets been employed.

St. Andrew Bay biomass, instead of approximating standing crop of the estuaries, falls more within the range of the values listed for coastal and offshore waters. Georges Bank and Block Island Sound averages, however, are noticeably higher than the St. Andrew Bay dry weight average, whereas Sargasso Sea and Georgia slope water biomass levels are significantly lower. Comparison here, as above, is of catches made with nets of various meshes.

Zooplankton population density and biomass values for St. Andrew Bay were based on the 12 month 1961–62 survey. During this year it appears that scyphomedusa and ctenophore predation was heavy. The effects of this predation were apparent from February through April, a period when the reproductive potential of the community is probably at its lowest level of the year. Had predation been less severe perhaps St. Andrew Bay annual standing crop averages would have approached more closely those of the other estuaries considered. Whether or not 1961–62 was anomalous with regard to scyphomedusa and ctenophore consumption of microzooplankton can be determined only with a long term sampling program.

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