SEABROOK ECOLOGICAL STUDIES, JANUARY THROUGH DECEMBER 1978

PLANKTON

TECHNICAL REPORT X-5

Prepared for

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by

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SEABROOK ECOLOGICAL STUDIES,
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1.0 INTRODUCTION

Plankton studies designed to establish a preoperational data base of species occurrence, abundance and distribution have been conducted in the Hampton-Seabrook estuary and nearshore waters since 1969. A formal preoperational program was instituted in July 1975, resulting in two July-June annual reports (NAI, 1977a; 1978) and a six-month report (NAI, 1979a).

The plankton program includes phytoplankton, zooplankton, lobster larvae and ichthyoplankton studies in addition to chlorophyll *a*, primary productivity and nutrient measurements; ichthyoplankton results are presented with the finfish program (NAI, 1980). Beginning in July 1977, the phytoplankton sampling regime was expanded to include whole water samples in addition to 0.076 mm mesh pumped net samples. Whole water collections were initiated to sample small (<0.076 mm) species (= nanoplankton) not retained by the net. Phytoplankton and microzooplankton were enumerated from the pumped net samples. Macrozooplankton samples collected with 0.505 mm mesh meter nets replaced mesozooplankton samples (0.333 mm mesh bongo nets) in July 1977. Beginning in June 1978, separate neuston collections were made for lobster larvae.

The net phytoplankton assemblage in coastal New Hampshire waters is composed largely of diatoms and armored dinoflagellates (NAI, 1977a; 1978; 1979a). Diatoms typically reach peak abundance levels in spring and fall with minimal levels in winter and summer. Dinoflagellate densities tend to reach peak levels during the warmer months. Maximum concentrations of the critical plant nutrients, nitrogen and phosphorus,

often occur in winter, when low light levels tend to limit phytoplankton growth (NAI, 1977a; 1978).

The zooplankton assemblage in the Hampton-Seabrook area is composed principally of copepods; as holoplankters, these organisms spend their entire life cycle in the plankton. Seasonal distribution of copepods, which are mostly herbivores and omnivores, tends to follow phytoplankton abundance peaks. Among the more abundant meroplankton, which include floating developmental stages of the benthos and nekton, are bivalve veliger larvae, *Cancer* spp. zoeae and barnacle nauplii. Because meroplankton include the young of many economically important shellfish including clams, mussels and decapod crustaceans, as well as finfish eggs and larvae, it is given particular emphasis. Tychoplankton, principally benthic/epibenthic invertebrates which have temporarily migrated into the water column, are an important component in the diets of demersal finfish. Abundant tychoplankters in the area include *Neomysis americana*, *Mysis mixta* and *Crangon septemspinosa*.

Investigations of *Homarus americanus* (lobster) larvae distributions in coastal waters north of Cape Cod have shown larvae to be most abundant during July and August (Wilder, 1953; Sherman and Lewis, 1967; NAI, 1974a; Mass. Div. Mar. Fish., unpubl. data, 1978). Lobster larvae are most abundant in surface waters and during daylight hours (Templeman, 1937; Scarratt, 1973; Raytheon, 1977). Meteorological conditions (wind direction and velocity) may also be important in affecting larval distribution in neritic areas (Templeman, 1937; Smith, 1939). NAI (1974a) found that, during 1973, greatest numbers of larvae were collected following a 2-3 day period of onshore winds; similarly, the Massachusetts Division of Marine Fisheries (unpubl. data) found larvae to be more abundant in Cape Cod Bay when winds were either onshore or alongshore. Squires (1970) collected an unusually large number of larvae in Port au Port Bay, Newfoundland, following an onshore northeast gale.

This report presents results of plankton studies conducted from January through December 1978 and includes spatial and temporal comparisons with previous years of formal preoperational monitoring. Comparisons emphasize distributional patterns of the selected indicator species: the phytoplankters, *Skeletonema costatum, Chaetoceros debilis* and *Ceratium longipes*; and the zooplankters, *Pseudocalanus* spp., *Eurytemora herdmani, Oithona* spp., *Calanus finmarchicus, Neomysis americana, Crangon septemspinosa, Cancer* spp., and *Homarus americanus*.

2.0 METHODS

Plankton samples were collected from January through December 1978 at the station locations shown in Figure 2.1-1; field and laboratory methods are presented in the following sections. Plankton programs conducted from July 1975 through the present study are summarized in Figure 2.1-2.

2.1 FIELD COLLECTIONS

2.1.1 Pump Samples: Net Phytoplankton and Microzooplankton

Collections were made twice monthly from March through November and monthly in January, February and December. On each date four replicate submersible pump samples were collected during daylight hours at the intake site (Station 2), 1 m below surface and 2 m above bottom (Figure 2.1-1). Each pump discharged on deck into its own small, 0.076 mm mesh plankton net set into a specially designed stand that filled with seawater to within 15 cm of the top of the net. Each net was fitted with an 8-dram (33-ml) vial on its cod end. Pumping time was recorded in order to calculate volume filtered based on predetermined pumping rates. Volume filtered usually approximated 100 liters. Contents were thoroughly rinsed from the nets after pumping and fixed in borax-buffered 5% formalin.

2.1.2 Whole Water Samples: Phytoplankton, Chlorophyll *a*, Nutrients and Primary Productivity

Near-surface (1 m) and near-bottom (2 m above) water samples were collected during daylight hours with either a submersible pump or water sampler at the intake site (Station 2); at the discharge site (Station 5), only near-surface samples were collected. Collections were made in conjunction with pump samples (Section 2.1.1); two additional near-surface samples were obtained weekly at the intake site (phyto-

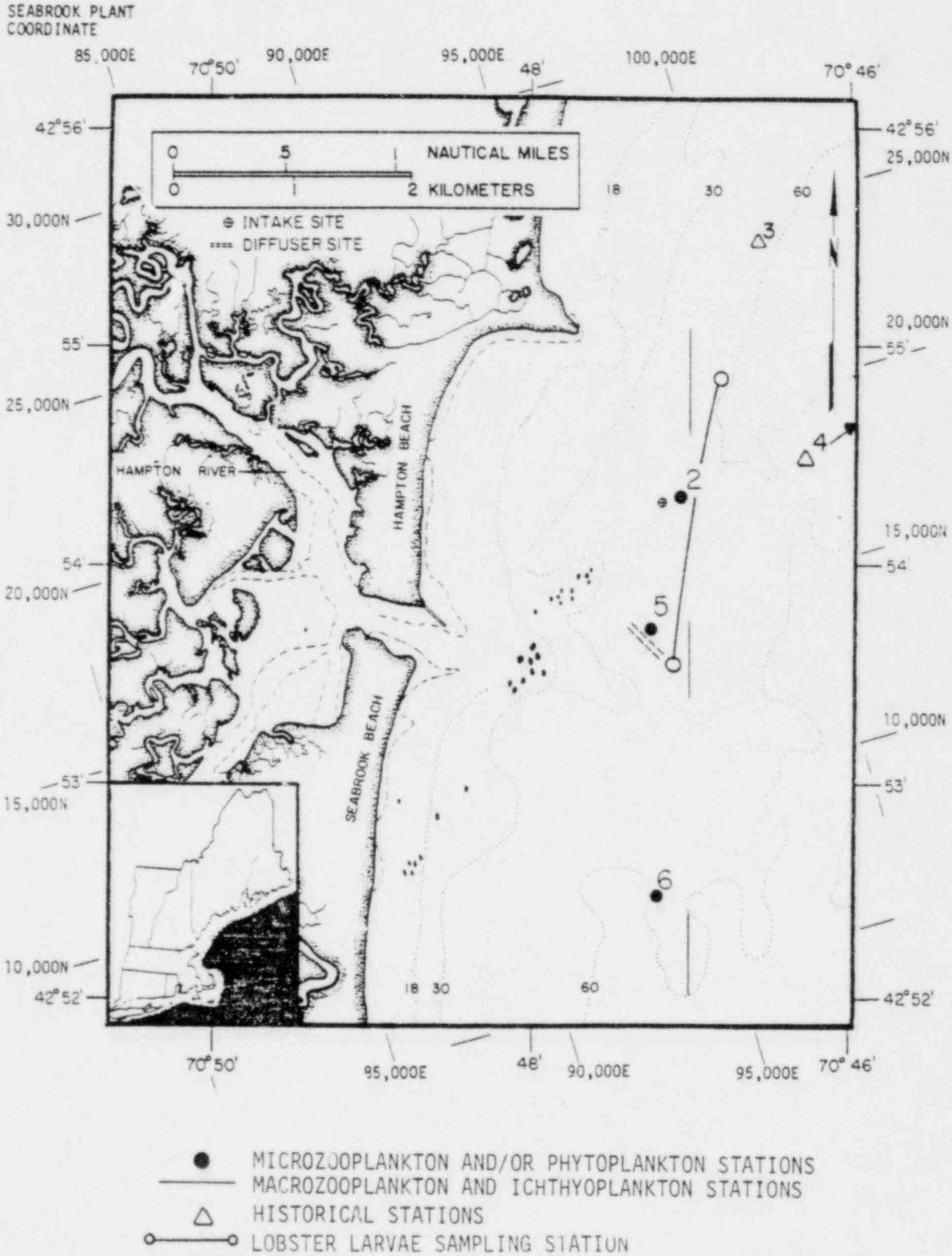

Figure 2.1-1. Plankton and lobster larvae sampling stations. Seabrook Ecological Studies, 1978.

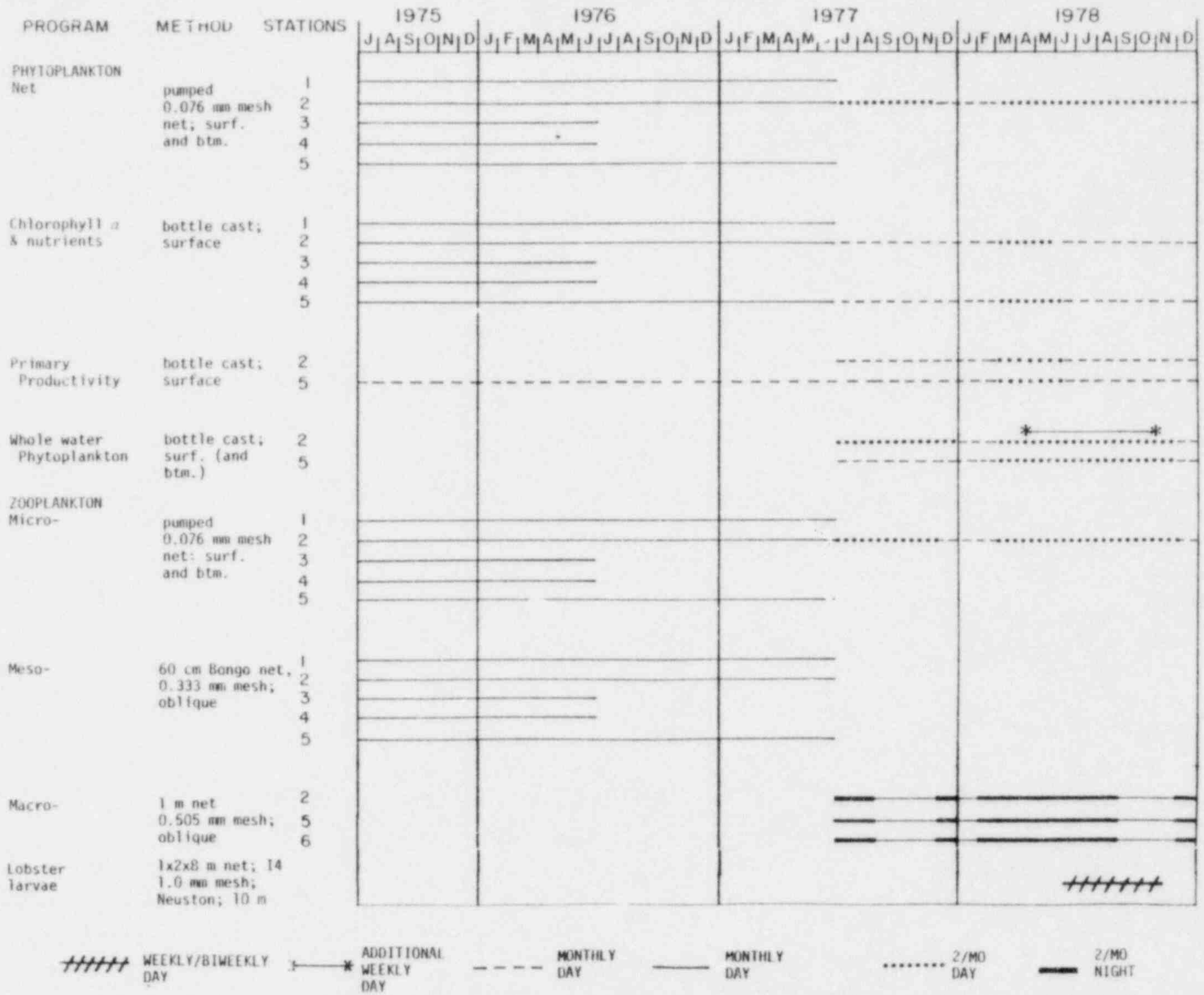

Figure 2.1-2. Summary of plankton programs conducted from July 1975 through December 1978. Seabrook Ecological Studies, 1978.

plankton contingency samples). From each whole water collection, 2 one-quart jars containing 50 ml of Lugol's iodine fixative were filled for phytoplankton taxonomic analysis. From monthly[1] near-surface collections at both stations, 1 gallon was reserved for chlorophyll *a* determinations, 250 ml frozen as soon as possible for nutrient analyses and 400 ml reserved for pH determinations; in addition, four 250 ml BOD bottles (2 light and 2 dark) were prepared for primary productivity experiments.

At both stations, temperature and conductivity profiles were made with a Beckman thermistor/salinometer (Model RS5-3). Duplicate dissolved oxygen samples and a salinity sample were also collected near surface and near bottom.

2.1.3 Net Tows: Macrozooplankton

Collections were made twice-monthly from March through August and in December, and monthly during the remaining months. Four replicate sequential oblique tows were made at night at the intake, discharge and south sites (Stations 2, 5 and 6, respectively; Figure 2.1-1) with 1 m diameter 0.505 mm mesh nets. Each tow was 5 or 10 minutes in duration, depending on plankton densities, and was taken from approximately 2 m off the bottom to the surface. Volume filtered, estimated with a General Oceanics digital flow meter, ranged from 196 to 724 m^3 and averaged 525 m^3. Upon retrieval, each net was thoroughly washed and the contents fixed in borax-buffered 5 to 10% (depending on plankton density) formalin.

2.1.4 Net Tows: *Homarus americanus* Larvae

Neuston and mid-depth tows were made along a north-south transect centered on the intake (Figure 2.1-1) twice weekly from 9 June

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[1] Twice monthly from March through May

through September and weekly through 18 October 1978. Collections were made with a rectangular, 1 mm mesh net (dimensions: 1m x 2m x 8m) fitted with a General Oceanics flowmeter; tow speeds of approximately 1 m/sec (2 kts) were maintained. Tow duration was 15 minutes from 9 June through 18 July, and was increased to 30 minutes from 21 July through 18 October.

Neuston tows were made from the side of the boat in water clear of the boat's wake; the bottom of the net mouth was 0.7 m below surface. For mid-depth tows, the net was lowered vertically from the side of the boat at rest, with the mouth opening facing up. Constant depth (10 m) was maintained with the aid of a surface buoy, a depressor (1 x 2m) and wire angle. At the end of the tow, a rope around the waist of the net was cinched to prevent further material from entering. Effective sampling area of the net was 1.0 m^2 (neuston) and 2.0 m^2 (mid-depth) through July. This was reduced to 0.4 m^2 and 1.0 m^2, respectively, from August through October as a consequence of reducing the wire and mouth angle to 60° from the vertical. Sample volumes averaged 1420 m^3 for neuston and 1941 m^3 for mid-depth tows. Areas sampled by the neuston averaged 1854 m^2 for a 15-minute tow and 3708 m^2 for a 30-minute tow.

Upon retrieval, the net was washed down from mouth to cod end and the contents emptied into five-gallon buckets. All debris was thoroughly rinsed before discarding. Larval Stages IV and older were returned to the ocean after recording both total length and carapace length (mm). Larval Stages I through III were retained in the sample.

2.2 LABORATORY ANALYSES

2.2.1 Net Phytoplankton and Microzooplankton

Net phytoplankton taxa from pump samples (2 field replicates from each depth) were enumerated from two independent, one-ml subsamples in a Sedgwick-Rafter counting cell. Each subsample was placed under a

compound microscope at 100X and three random passes across the width of the Sedgwick-Rafter cell examined. Net phytoplankton cells were identified to species as far as practical, and abundances (cells/liter) were computed.

Following net phytoplankton analysis, pump samples (four field replicates from each depth) were analyzed for microzooplankton. The sample volume was concentrated or diluted to a known volume, based upon the relative settled volume of the plankton and detritus, which provided an optimal working number of organisms (ca. 200 per one-ml subsample). The sample was agitated with a calibrated bulb pipette in an attempt to homogeneously distribute the contents. A one-ml subsample was quickly removed, placed in a Sedgwick-Rafter cell and examined under a compound microscope. Zooplankton taxa were identified using magnifications of 40X to 200X. Subsampling and enumeration continued until 300 to 400 organisms had been counted, and abundances (no./m^3) were computed.

2.2.2 Whole Water Phytoplankton

Each whole water sample was reduced to 33 ml by decanting the supernatent liquid (seawater and Lugols) after the plankton settled. The sample was placed in an 8-dram vial and mixed by inverting 30 times. Two 0.1-ml subsamples were withdrawn and each placed in a Palmer-Maloney counting cell. Each subsample was examined under a compound microscope at 200x, and the entire contents counted and identified to the lowest practical taxon. Abundances (cells/liter) were computed.

2.2.3 Chlorophyll *a* and Nutrients

Chlorophyll *a* water samples were divided into four 900-ml subsamples and filtered through a glass fiber filter. Near the end of filtration, 2 ml of saturated $MgCO_3$ solution was added to retard sample

degradation. Glass fiber filters were frozen pending laboratory extraction of pigment. Extraction of plant pigment consisted of macerating the filter in 90% aqueous acetone and centrifuging. Following extraction, fluorescence was determined before and after acidification (with 5% HCl) using a Turner fluorometer which had been calibrated spectrophotometrically (US EPA, 1973; Strickland and Parsons, 1972). Chlorophyll *a* and phaeophytin concentrations (mg/m^3) were computed.

Water samples were also analyzed for the following series of plant nutrients utilizing a Technicon Autoanalyzer system and EPA Methods (US EPA, 1973; 1974):

NUTRIENT	
total phosphorus	persulfate digestion in block digester followed by automated colorimetric ascorbic acid reduction
orthophosphate	automated colorimetric ascorbic acid reduction
nitrite	automated cadmium reduction, without cadmium column in place
nitrate	automated cadmium reduction
ammonia	automated idophenol blue

Concentrations were expressed as µg/l.

2.2.4 Primary Productivity

Samples were inoculated with five microcuries of ^{14}C as sodium bicarbonate as soon as they arrived at the laboratory and incubated for four hours at ambient seawater temperature in a flow-through box with 1000-1100 lux fluorescent illumination. Samples were then fixed with 2 ml of 40% formalin, filtered through a 25 mm Millipore membrane filter (0.45 µm pore size) at about 15 psi, dried on a planchet in a desiccator and counted using a Nuclear Chicago Model 186 gas flow scintillometer. Primary productivity was calculated as mg $C/m^3/hr$ (Strickland and Parsons, 1972). Assimilation efficiency was computed as mg $C/m^3/hr$ divided by mg chl a/m^3.

2.2.5 Macrozooplankton

Each sample to be analyzed[2] was split, using a Folsom Plankton Splitter, into fractions which provided counts of at least 30 individuals of the selected species (see below); generally, no more than 1/4 of the original sample was analyzed. Zooplankton taxa were enumerated by species, and general life stage when practical, using a dissecting microscope at magnifications between 6x and 150x. Selected taxa (*Crangon septemspinosa, Cancer* spp., *Neomysis americana* and Euphausiacea) were identified to detailed developmental stage. *Neomysis americana* only were identified as immature, male, female (ovigerous or larvigerous); carapace length was measured to the nearest 0.1 mm and brood pouch contents, if intact, were counted. If copepod taxa were considered rare, they were sorted and counted (at least 30 of each indicator species) from an appropriate split; if abundant, up to 3 one- or two-ml aliquots were removed with a Stempel pipette from the recombined sample of known volume. Abundances (individuals/1000 m^3) were computed.

2.2.6 *Homarus americanus* Larvae

Stage IV lobster larvae were sorted from the samples in the field; total length and carapace length were measured (± 0.1 mm) and the larvae were released. In the laboratory, samples were completely sorted for lobster larvae either by scanning the contents of the sample in a white enamel pan or by examination under a stereoscopic dissecting microscope at a magnification of 40X. All lobster larvae were staged and any living Stage IV larvae missed during the field sorting were measured and released.

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2 Three of the four field replicates from each station were randomly selected for analysis [all four were previously sorted and analyzed for ichthyoplankton, see Finfish Report (NAI, 1980)]. March 29, April 26, May 24, June 22, July 26, August 23 and December 26 were selected as "contingency" dates and only samples from the intake site were analyzed.

An areal estimate of weekly production of lobster larvae was calculated after Scarratt (1964):

$$\text{Production} = \frac{c}{f} \times \frac{t}{L} \qquad \text{Equation (1)}$$

where:

c = total week's catch (no./1000 m^2)

f = number of tows/week (2)

t = number of days (7)

L = time between molts at a given mean weekly temperature (from Templeman, 1936)

Equation 1 recognizes that stage duration increases with succeeding stages and is dependent upon temperature (Templeman, 1936). Areal estimates were calculated to permit comparison with Scarratt's (1964; 1973) data.

Survivorship between stages was calculated as:

$$\frac{\text{Production}_{(\text{stage } x)}}{\text{Production}_{(\text{stage } x+1)}} \times 100 \qquad \text{Equation (2)}$$

Percent composition by stage of lobster larvae in the Hampton-Seabrook area was compared with data from other areas by calculating percent similarity and presenting the results as a dendrogram using group average clustering (Boesch, 1977).

3.0 RESULTS AND DISCUSSION

3.1 PHYTOPLANKTON

3.1.1 Results 1978

3.1.1.1 Numerical Abundance and Species Composition

One hundred and five phytoplankton taxa were enumerated during the 1978 program (Appendix 6.1). Of these, 22 taxa were collected only in 0.076 mm mesh net samples, 33 in whole water samples, and 50 in both net and whole water samples. Total phytoplankton densities estimated by whole water collections were, on the average, two orders of magnitude higher than densities estimated by pumped net collections (Table 3.1-1). Overall, whole water phytoplankton densities during 1978 averaged 7.7 x 10^5 cells/liter in comparison to 7.0 x 10^3 cells/liter for net phytoplankton collections.

Diatoms of the genus *Chaetoceros* were the most prominent net phytoplankton taxa, comprising 18 species (including the undifferentiated category, *Chaetoceros* sp.) and approximately 88% of the total mean annual cell count. Of the ten top-ranked taxa, *Chaetoceros* was represented by seven species and comprised 86% of the mean cell count (Table 3.1-1). Other taxa within the top-ten category were *Thalassiosira nordenskioldii* (8.1%), *Skeletonema costatum* (1.4%) and *Peridinium depressum* (0.8%).

Whole water phytoplankton collections contained a larger diversity of generic groups within the top-ten category (Table 3.1-1). *Skeletonema costatum* ranked first, comprising 49% of the total mean annual cell count. *Rhizosolenia delicatula*, several pennate diatoms, the haptophyte, *Phaeocystis poucheti*, and the chrysophyte, *Olisthodiscus luteus*, were among the dominant taxa. *Chaetoceros debilis* also ranked among the top ten, although *Chaetoceros* species collectively comprised less than 5% of the total phytoplankton count.

TABLE 3.1-1. OVERALL PERCENT COMPOSITION OF NET AND WHOLE WATER PHYTOPLANKTON COLLECTED AT STATION 2 (SURFACE AND NEAR-BOTTOM) FROM JANUARY THROUGH DECEMBER 1978. SEABROOK ECOLOGICAL STUDIES, 1978.

NET PHYTOPLANKTON				WHOLE WATER PHYTOPLANKTON			
SPECIES	MEAN CELLS/ℓ	PERCENT COMP.	PERCENT OCCURRENCE	SPECIES	MEAN CELLS/ℓ	PERCENT COMP.	PERCENT OCCURRENCE
Chaetoceros debilis	4,461	63.9	52.4	*Skeletonema costatum*	379,793	49.0	81.3
Thalassiosira nordenskioldii	562	8.1	19.0	*Rhizosolenia delicatula*	122,074	15.8	51.6
Chaetoceros laciniosus	553	7.9	61.9	*Nitzschia delicatissima*	68,038	8.8	58.1
Chaetoceros decipiens	328	4.7	71.4	*Thalassionema nitzschioides*	51,917	6.7	35.5
Chaetoceros diadema	328	4.7	19.0	*Phaeocystis poucheti*	51,723	6.7	22.5
Chaetoceros sp.	172	2.5	66.7	Pennales	36,535	4.7	90.3
Chaetoceros lorenzianus	113	1.6	9.5	*Chaetoceros debilis*	26,818	3.5	12.9
Skeletonema costatum	95	1.4	52.4	*Nitzschia longissima*	7,784	1.0	80.7
Chaetoceros teres	67	1.0	19.0	*Chaetoceros laciniosus*	4,855	0.6	22.6
Peridinium depressum	58	0.8	38.1	*Olisthodiscus luteus*	4,606	0.6	22.5
Rhizosolenia hebetata	51	0.7	66.7	*Chaetoceros socialis*	3,795	0.5	19.4
Chaetoceros concavicornis	47	0.7	52.4	*Gyrosigma/Pleurosigma* spp.	3,685	0.5	22.6
Thalassionema nitzschioides	35	0.5	42.9	*Thalassiosira nordenskioldii*	3,512	0.5	16.1
Chaetoceros affinis	29	0.4	42.9	*Nitzschia seriata*	1,502	0.2	22.6
Biddulphia aurita	16	0.2	33.3	*Chaetoceros diadema*	1,289	0.2	6.5
Coscinodiscus sp.	12	0.2	61.9	*Chroomonas* sp.	974	0.1	51.6
Thalassiosira rotula	10	0.1	9.5	*Guinardia flaccida*	816	0.1	22.6
Chaetoceros compressus	9	0.1	23.8	*Asterionella glacialis*	751	0.1	19.5
Ceratium longipes	7	0.09	61.9	*Cylindrotheca closterium*	533	0.07	67.7
Rhizosolenia delicatula	6	0.08	14.3	*Rhizosolenia hebetata*	510	0.07	45.2
Pennales	4	0.06	66.7	*Prorocentrum micans*	470	0.06	38.7
Asterionella glacialis	4	0.05	14.3	*Chaetoceros* sp.	416	0.05	3.9
Coscinosira polychorda	2	0.03	9.5	*Thalassiosira* sp.	380	0.05	6.5
Nitzschia seriata	2	0.02	14.3	*Paralia sulcata*	337	0.04	35.5
Chaetoceros socialis	2	0.02	9.5	*Chaetoceros decipiens*	319	0.04	41.9
Fragilaria sp.	2	0.02	19.0	*Gyrodinium* sp.	319	0.04	38.7
Thalassiosira sp.	1	0.02	14.3	*Chaetoceros teres*	307	0.04	6.5
Asterionella formosa	1	0.02	19.0	*Cerataulina bergoni*	293	0.04	51.6
Ceratium tripos	1	0.02	47.6	Unidentified unicellular	287	0.04	12.9
				Gonyaulax sp.	249	0.03	12.9
TOTAL	6,980			TOTAL	774,887		

3.1.1.2 Seasonal and Spatial Distribution

Net and whole water phytoplankton collections at Stations 2 and 5 revealed a bimodal spring density peak. mid-March through mid-April and late May through mid-June (Table 3.1-2). During fall (early October through mid-November), a major bloom was apparent from whole water samples. Density estimates from net samples, however, suggested only a minor fall density resurgence.

Despite the parallel pattern between net and whole water phytoplankton density peaks during spring, species composition differed notably. Net phytoplankton were comprised largely of various *Chaetoceros* species which, along with *Thalassiosira nordenskioldii* and *Peridinium depressum*, showed a fairly well-defined seasonal succession from February through June (Appendix 6.2). During the remaining six months, densities of *Chaetoceros* species were low. Whole water samples, on the other hand, were primarily dominated by smaller-celled phytoplankters during spring: *Skeletonema costatum* (March and late June), *Phaeocystis poucheti* (April-June), and *Nitzschia delicatissima* (late June), in addition to the dominant net phytoplankter, *Chaetoceros debilis* (May) (Appendix 6.3).

The fall bloom, shown in whole water collections, was dominated by *Skeletonema costatum, Rhizosolenia delicatula, Nitzschia delicatissima* and *Thalassionema nitzschioides*. Although no major density peak was detected in net samples during this period, species composition of dominant taxa was similar to whole water samples; as expected net samples largely underestimated densities of these smaller-celled taxa.

Phytoplankton densities were higher in surface waters than near-bottom waters during 15 of 21 sample periods for both net and whole water phytoplankton (Table 3.1-2). Overall, the difference in density between surface and bottom was minimal for whole water phytoplankton; however, net phytoplankton were overall an order of magnitude more dense

TABLE 3.1-2. ABUNDANCE (CELLS/ℓ) OF NET AND WHOLE WATER PHYTOPLANKTON COLLECTED AT STATIONS 2 AND 5 (SURFACE AND NEAR-BOTTOM) FROM JANUARY THROUGH DECEMBER 1978. SEABROOK ECOLOGICAL STUDIES, 1978.

	STATION 2						STATION 5
SAMPLE DATE	NET			WHOLE WATER			WHOLE WATER
	SURF.	BOT.	$\bar{X}$	SURF.	BOT.	$\bar{X}$	SURF.
Jan 16	85	107	96	3,820	5,670	4,740	4,230
Feb 15	63	255	159	10,500	12,000	11,200	5,670
Mar 17	5,680	4,440	5,060	124,000	75,100	100,000	74,400
30	26,200	9,680	18,000	574,000	83,000	328,000	103,000
Apr 12	31,500	5,050	18,300	1,390,000	391,000	891,000	2,460,000
26	23	71	47	6,390	8,350	7,370	7,013
May 10	75	60	68	4,540	1,860	3,200	4,130
24	195,000	70	97,500	1,010,000	162,000	587,000	510,000
Jun 7	2,600	62	1,330	194,000	43,000	118,000	285,000
21	6,240	125	3,184	651,000	555,000	603,000	-
Jul 13	54	39	47	2,580	5,360	3,970	*
26	61	88	75	17,700	5,780	11,800	-
Aug 9	35	13	24	3,710	2,580	3,150	*
23	27	15	21	5,780	3,090	4,440	-
Sep 6	82	32	57	6,810	4,020	5,410	*
20	315	101	208	55,300	36,400	45,800	-
Oct 4	640	279	459	3,790,000	4,790,000	4,290,000	*
18	486	668	577	2,980,000	3,980,000	3,480,000	-
Nov 2	991	310	650	3,110,000	2,990,000	3,050,000	3,830,000
15	1,170	208	689	1,540,000	852,000	1,200,000	-
Dec 6	253	266	259	28,700	25,400	27,000	*

* Not analyzed (contingency samples)
- Not sampled.

in surface waters than in near-bottom waters. Higher surface densities of net phytoplankton were attributed largely to *Chaetoceros* species.

During the ten sample periods in which samples from both Stations 2 and 5 were analyzed, surface phytoplankton densities were approximately two to five times higher at Station 2 on four dates but higher (on the same order) at Station 5 on one date; on the remaining dates densities were usually slightly higher at Station 5 (Table 3.1-2). Station differences during the two spring peaks can be attributed to the distribution of *Phaeocystis poucheti*, which was more abundant at Station 5 on April 12 (the first spring peak) and absent from Station 5 on May 24 (the second spring peak) (Appendix 6.3).

3.1.1.3 Indicator Species

Skeletonema costatum exhibited a spring bloom (March/early April), an early summer bloom (June) and a major fall bloom (October through early November) (Figure 3.1-1). In whole water samples, spring and early summer bloom densities were 10^4 to 10^5 cells/liter whereas densities during the fall bloom exceeded 10^6 cells/liter. Densities of *S. costatum* in surface and near-bottom waters were generally comparable.

Chaetoceros debilis was primarily a spring-blooming diatom with a minor pulse in November (Figure 3.1-2). The spring density pattern was bimodal with the second and largest density peak occurring in late May, just prior to the second spring density peak of *S. costatum*. Densities during the first spring peak generally ranged between 10^3 and 10^4 cells/liter, whereas densities approached 10^6 cells/liter during the second spring peak, *Chaetoceros debilis* was consistently more dense in surface waters.

Ceratium longipes was collected in relatively low numbers throughout much of the year; highest and most consistent density estimates occurred in both whole water and net collections from July through

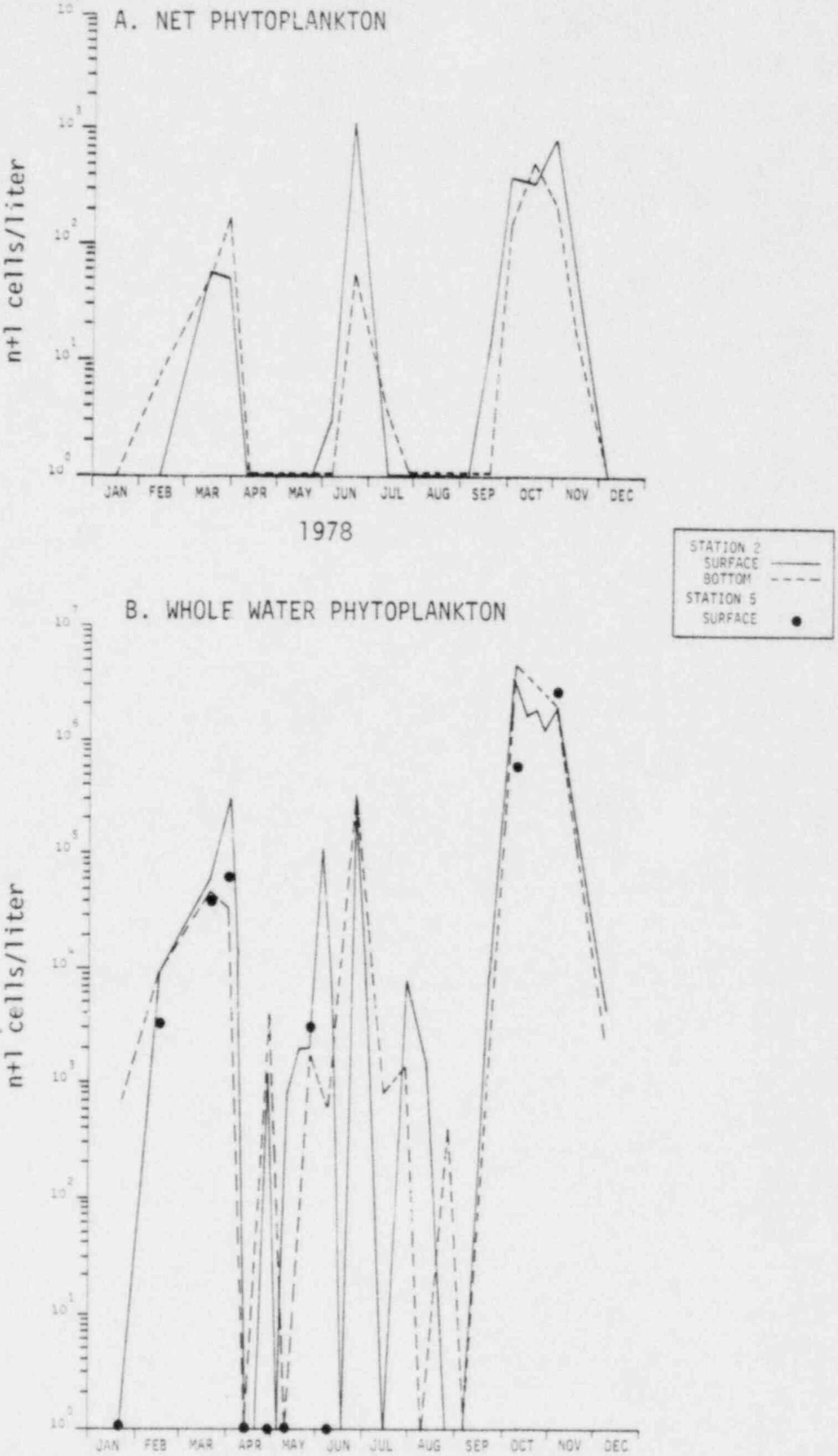


Figure 3.1-1. Densities of *Skeletonema costatum* at Stations 2 and 5 during 1978. Seabrook Ecological Studies, 1978.

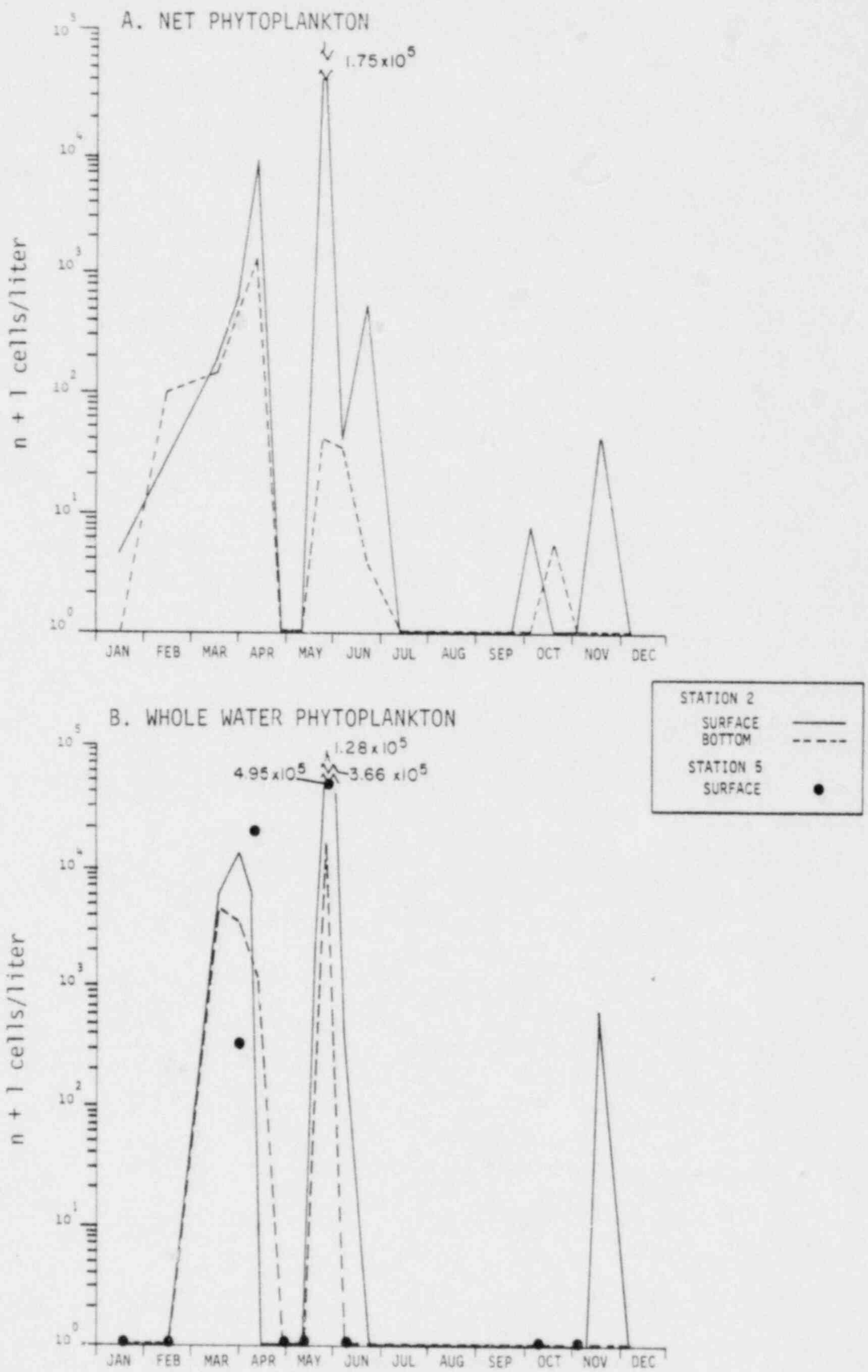


Figure 3.1-2. Densities of *Chaetoceros debilis* at Stations 2 and 5 during 1978. Seabrook Ecological Studies, 1978.

September (Figure 3.1-3). Due to the smaller volume collected and examined by the whole water method as compared to the pumped net method, densities of this relatively large phytoplankter less than approximately 100/liter were usually undetected by whole water samples. Density distribution of *Ceratium longipes* between surface and near-bottom waters was inconsistent.

3.1.1.4 Primary Productivity, Phytoplankton Biomass and Plant Nutrients

Seasonal patterns of primary productivity (carbon-14 uptake) and biomass (chlorophyll *a*) (Appendix 6.4) closely correspond to seasonal density patterns of total phytoplankton (whole water) (Table 3.1-2). Primary productivity ranged from <1 to 15 mg $C/m^3/hr$ and chlorophyll *a* concentrations ranged from <1 to 9 mg/m^3. Both productivity and biomass showed spring peaks from late March through mid-April and in late May, and a fall peak from early October through early November. On the average, values reported at Stations 2 and 5 were similar. Highest assimilation efficiency corresponded to periods of moderate productivity and low biomass: late April through mid-May and early June through mid-July. During these periods, small-celled taxa such as the flagellates, *Chroomonas* sp. and *Phaeocystis poucheti*, and pennate diatoms such as *Cylindrotheca closterium* and *Nitzschia delicatissima* were among the dominant species (Appendix 6.3). Phaeophytin followed a pattern similar to that of productivity and biomass.

Concentrations of nitrogen and phosphorous, both essential for phytoplankton growth, were generally highest during winter and lowest during the principal growing seasons (Appendix 6.4). Nitrate exhibited the largest and clearest seasonal variation, dropping from a high of approximately 150-170 μg/liter during January and February to 10 μg/liter from April through early November, and increasing again during December. Although nitrite showed little seasonal variability, concentrations dropped below detectable limits (<1.0 μg/l) during fall, coincident with peak whole water phytoplankton densities. Concentrations of ammonia

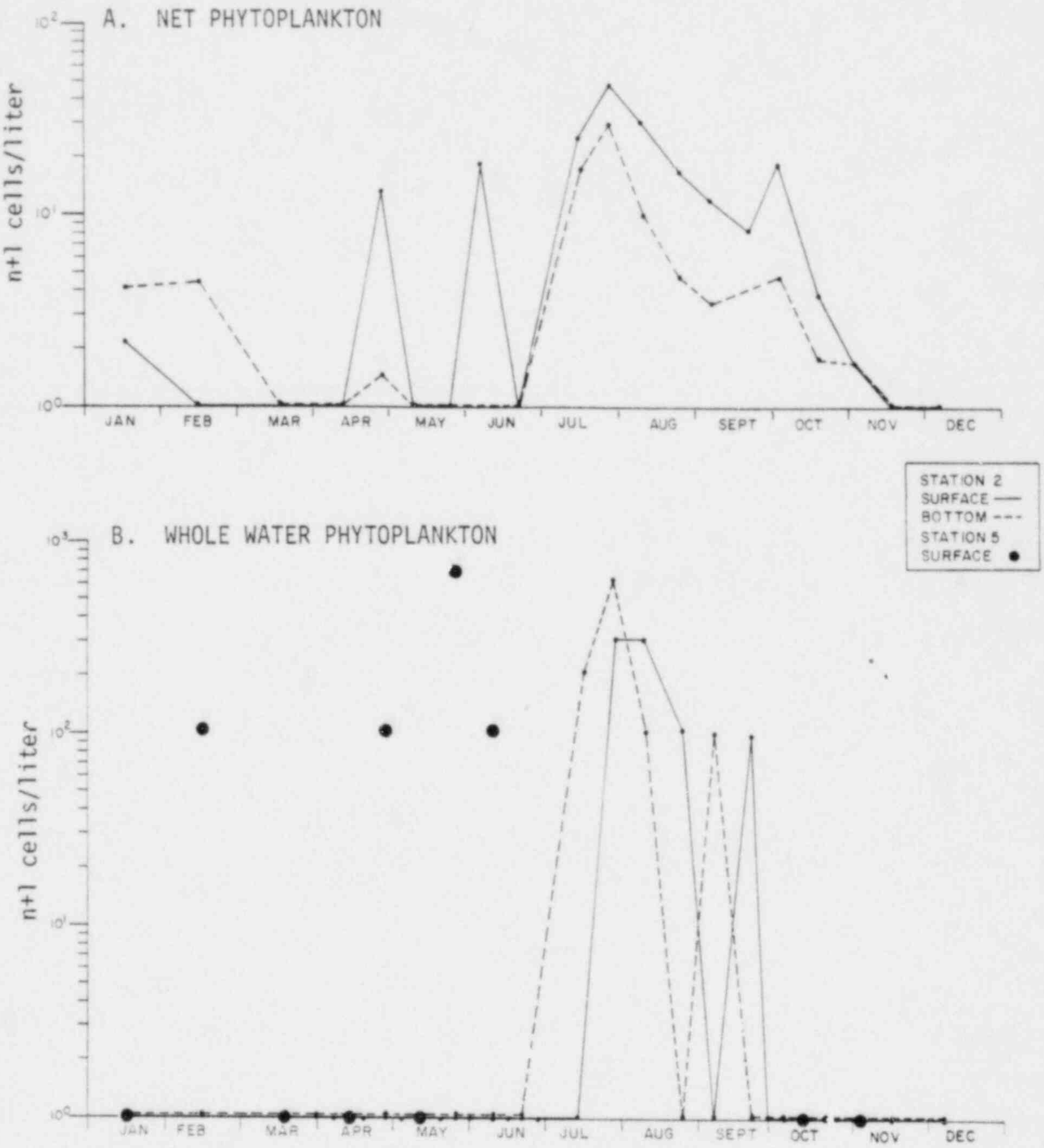


Figure 3.1-3. Densities of *Ceratium longipes* at Stations 2 and 5 during 1978. Seabrook Ecological Studies, 1978.

reached maximum levels during September at Station 2 and December at Station 5. Ammonia concentrations were generally high at both stations during fall, in early winter and to a lesser degree in late winter, and low from late March through August. Total phosphate showed a similar trend of high winter and low summer concentrations, although less pronounced than nitrate and ammonia. Orthophosphate fluctuated considerably throughout the year, with lowest concentrations at both stations during September and October and highest concentrations during December.

3.1.2 Discussion, 1975-1978

3.1.2.1 General

Net phytoplankton cell densities during 1978 were higher than levels recorded during the 1976-1977 program (2.0 x 10^3 cells/liter or less) and more closely approched the high levels recorded during the 1975-1976 sampling (NAI, 1977a; 1978). Maximum 1978 cell densities (May) reached 2.0 x 10^5 cells/liter in comparison to maximum 1976 cell densities (May) of 3.1 x 10^5 cells/liter. Total phytoplankton (whole water) densities were generally two orders of magnitude greater than net phytoplankton densities. Maximum whole water densities recorded from July through December 1978 (average of 1.2 -4.3 x 10^6 cells/liter) were comparable to densities recorded during the same period in 1977 (2.9-3.8 x 10^6 cells/liter) when whole water sampling was initiated.

As in previous years, *Chaetoceros* species were the most well-represented of the net phytoplankton taxa--up to 18 differentiated species plus the undifferentiated category, *Chaetoceros* sp., were enumerated annually since 1975. Collectively, these taxa comprised 50 to 90% of the mean annual cell count. As reported in previous years, *Chaetoceros* species were most abundant in net phytoplankton samples from February through June; a seasonal succession of individual species was evident during this period.

The whole water phytoplankton method, initiated in July 1977, collected larger numbers of smaller-celled species not effectively sampled by the 0.076 mm mesh net and gave a better estimate of total phytoplankton including *Chaetoceros* species. The dominant whole water phytoplankter, *Skeletonema costatum*, represented only 1.4% of the mean 1978 annual net phytoplankton cell count; net density estimates were nearly five orders of magnitude less than whole water estimates. Other dominant whole water species, such as *Rhizosolenia delicatula* (2nd-ranked), *Nitzschia delicatissima* (3rd-ranked) and *Thalassionema nitzschioides* (4th ranked), comprised far less than 1% of the mean annual cell count in pumped net samples, and the fifth-ranked whole water species, *Phaeocystis poucheti*, was undetected in net samples. The most dense bloom during 1978 (i.e., October/November), dominated by *S. costatum, R. delicatula, T. nitzschioides,* and *N. delicatissima*, was only partially detected by net samples.

3.1.2.2 Seasonal and Spatial Distribution: Total Phytoplankton

Seasonal patterns of total (whole water) phytoplankton densities and chlorophyll *a* have corresponded closely and have indicated annual cycles of spring and fall maxima (Figure 3.1-4). Major phytoplankton blooms were recorded during fall 1977 and 1978 and a secondary bimodal bloom during spring 1978. Dominant species during the 1978 spring bloom were *Skeletonema costatum, Chaetoceros debilis* and *Phaeocystis poucheti*. The largest chlorophyll *a* peak during spring occurred in late March, when *Skeletonema costatum* was dominant; highest primary production rates were also noted at this time.

During fall 1977, a succession of phytoplankton taxa was evident: *Peridinium trochoideum* dominated during September, followed by *Skeletonema costatum* for a brief period in early October, and by a major bloom of *Olisthodiscus luteus* through mid-November (NAI, 1979a). During fall 1978, *Skeletonema costatum* dominated from early October through early November and was succeeded by *Rhizosolenia delicatula* during the

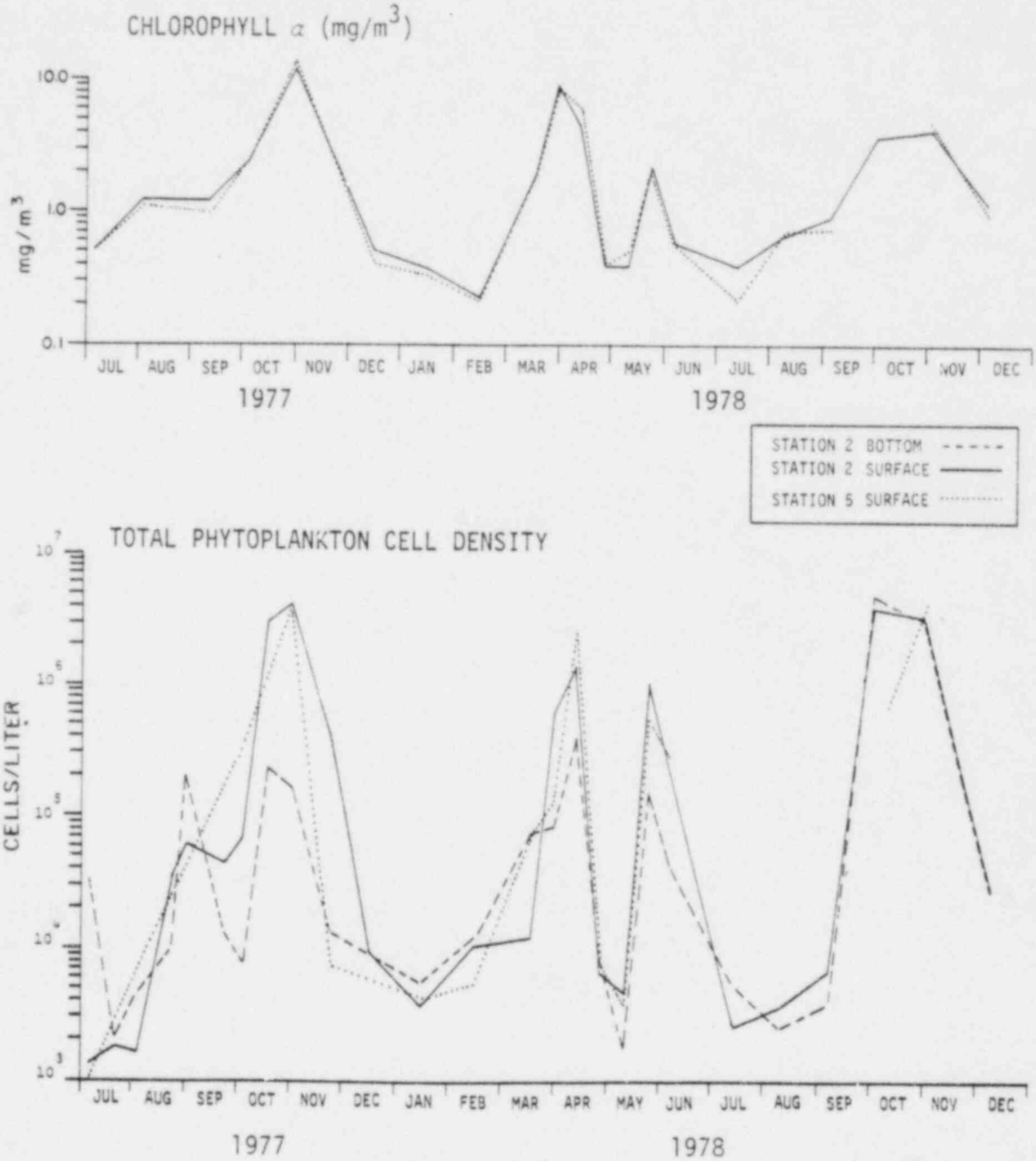


Figure 3.1-4. Total phytoplankton densities and chlorophyll *a* concentrations in the vicinity of the proposed intake (Station 2) and discharge (Station 5) sites from July 1977 through December 1978. Seabrook Ecological Studies, 1978.

remaining portion of November. Other species which contributed significantly to the 1978 fall bloom were *Thalassionema nitzschioides*, *Nitzschia delicatissima*, *N. longissima*, and unidentified pennate diatoms. *Olisthodiscus luteus* was not collected in whole water samples during fall 1978. Peak chlorophyll *a* concentrations corresponded to peak densities of *O. luteus* and *S. costatum* during fall 1977 and 1978, respectively.

Total phytoplankton densities and chlorophyll *a* concentrations at Stations 2 and 5 (surface) were comparable overall (Figure 3.1-4), although small-scale patchiness resulted in apparent differences on a few dates. At Station 2, near-bottom densities were generally less than surface densities except during fall 1978 when *S. costatum*, which has historically shown little depth preference, was dominant.

3.1.2.3 Indicator Species

Data from present and previous studies concerning the three indicator species, *Chaetoceros debilis*, *Skeletonema costatum* and *Ceratium longipes*, are presented in Table 3.1-3. Primarily a spring-blooming diatom, *C. debilis* has been most abundant in both net and whole water samples from March through June. Densities during 1978 were intermediate between 1976 (high) and 1977 (low) densities. Monthly density estimates of *S. costatum* have varied considerably from year to year. Peak densities in pumped net samples have, however, consistently occurred during the period from September through December. Whole water samples showed *S. costatum* density peaks during October and November 1977 and 1978, in addition to smaller secondary peaks during spring 1978 (March and June). During this and previous studies, *C. longipes* was collected in highest densities primarily during July in both whole water and net samples. Highest densities were recorded during July 1977 in both sample types. Densities in 1978 were at the lower range of previous years' values.

TABLE 3.1-3. SEASONAL ABUNDANCE (Cells/liter) OF PHYTOPLANKTON INDICATOR SPECIES FROM PUMPED NET (JULY 1975-DECEMBER 1978) AND WHOLE WATER (JULY 1977-DECEMBER 1978) COLLECTIONS AT STATION 2 IN THE VICINITY OF THE PROPOSED INTAKE SITE. SEABROOK ECOLOGICAL STUDIES, 1978.

A. NET PHYTOPLANKTON

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
						CHAETOCEROS DEBILIS						
1975							0	0	1	1	41	3
1976	3	5	36,700	35,700	169,000	28	0	0	14	0	7	93
1977	0	2	7	122	<1	10	0-0	0-0	7-0	0-0	0-0	0
1978	2	63	169-548	4,890-0	0-87,700	38-254	0-0	0-0	0-0	4-2	0-22	0
						SKELETONEMA COSTATUM						
1975							0	18	1,620	18	114	1
1976	0	6	0	27	23	135	0	2	94	161	3	1,154
1977	1	1	2	0	0	0	0-0	0-0	25-3	35-7	5-0	0
1978	0	4	53-109	0-0	0-0	1-576	2-0	0-0	0-7	266-421	516-47	0
						CERATIUM LONGIPES						
1975							76	32	31	7	<1	9
1976	2	<1	2	0	25	99	18	42	39	1	1	<1
1977	<1	0	<1	<1	13	63	350-165	14-3	4-28	8-92	18-40	1
1978	2	2	0-0	0-7	0-0	9-0	22-39	19-10	7-5	11-2	<1-0	0

B. WHOLE WATER PHYTOPLANKTON*

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
						CHAETOCEROS DEBILIS						
1977							0-0	0-0	0-0	0-0	0-0	0
1978	0	0	4,800-7,680	516-0	0-471,000	206-0	0-0	0-0	0-0	0-0	0-309	0
						SKELETONEMA COSTATUM						
1977							125-533	0-0	0-0	22,770-770	220-0	1,980
1978	309	8,460	47,700-153,000	0-2,420	361-1,805	3,506-240,000	413-4,590	773-206	0-5,620	3,930,000-2,260,000	1,870,000-134,000	3,610
						CERATIUM LONGIPES						
1977							7,480-54	165-0	0-55	110-110	0-0	0
1978	0	0	0-0	0-0	0-0	0-0	103-464	206-52	52-52	0-9	0-0	0

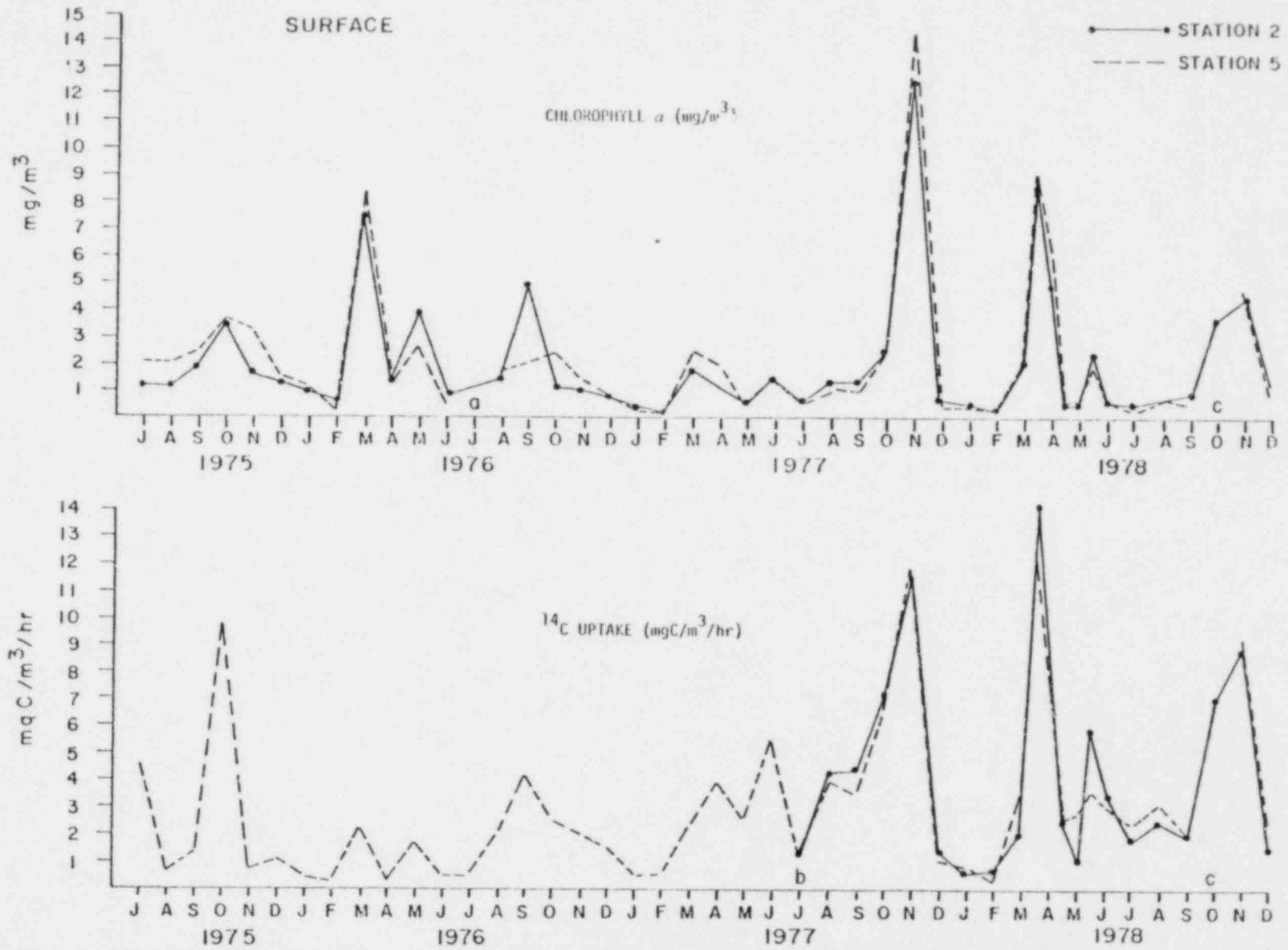
Data represent mean densities (cells/l) across all replicates, surface and near-bottom, during each sample period in each month.

*Sampling initiated July 1977

3.1.2.4 Primary Productivity, Biomass and Plant Nutrients

The magnitude and timing of primary productivity and biomass peaks have varied annually; however, the general seasonal cycle of spring and fall maxima has been consistent (Figure 3.1-5). Productivity and biomass cycles often showed poor correlation to net phytoplankton cell densities. The better correlation between whole water densities and productivity and biomass cycles observed in the July 1977 through December 1978 data indicates that peaks in productivity and biomass are often closely related to blooms of the smaller-celled taxa collected in whole water samples.

During this and previous studies, concentrations of phytoplankton nutrients have shown an annual cycle with lowest concentrations in summer and highest concentrations in winter (Figure 3.1-6). Nitrates have typically exhibited the greatest seasonal variation with winter values as high as two orders of magnitude greater than summer values. Although a complete multi-year data base is lacking, ammonia also appears to undergo relatively large seasonal variations with highest concentrations during fall and winter. Increasing ammonia concentrations during fall may be, to some degree, the result of increased nitrogen recycling (as ammonia) by zooplankton (Parsons and Takahashi, 1973), which are generally most dense in coastal New Hampshire waters during summer and early fall (NAI, 1978; 1979a). In the case of other nitrogen and phosphorus compounds, winter maxima appear largely related to decreased utilization due to phytoplankton growth limitations by low water temperatures and sub-optimal light conditions.



[a] no samples taken. [b] 14C collections were not taken at Station 2 prior to July 1977 [c] collections were not taken at Station 5 in October 1978

Figure 3.1-5. Biomass (chlorophyll *a*) and productivity (^{14}C uptake) of phytoplankton in the vicinity of the proposed intake (Station 2) and discharge (Station 5) sites from 1975-1978. Seabrook Ecological Studies, 1978.

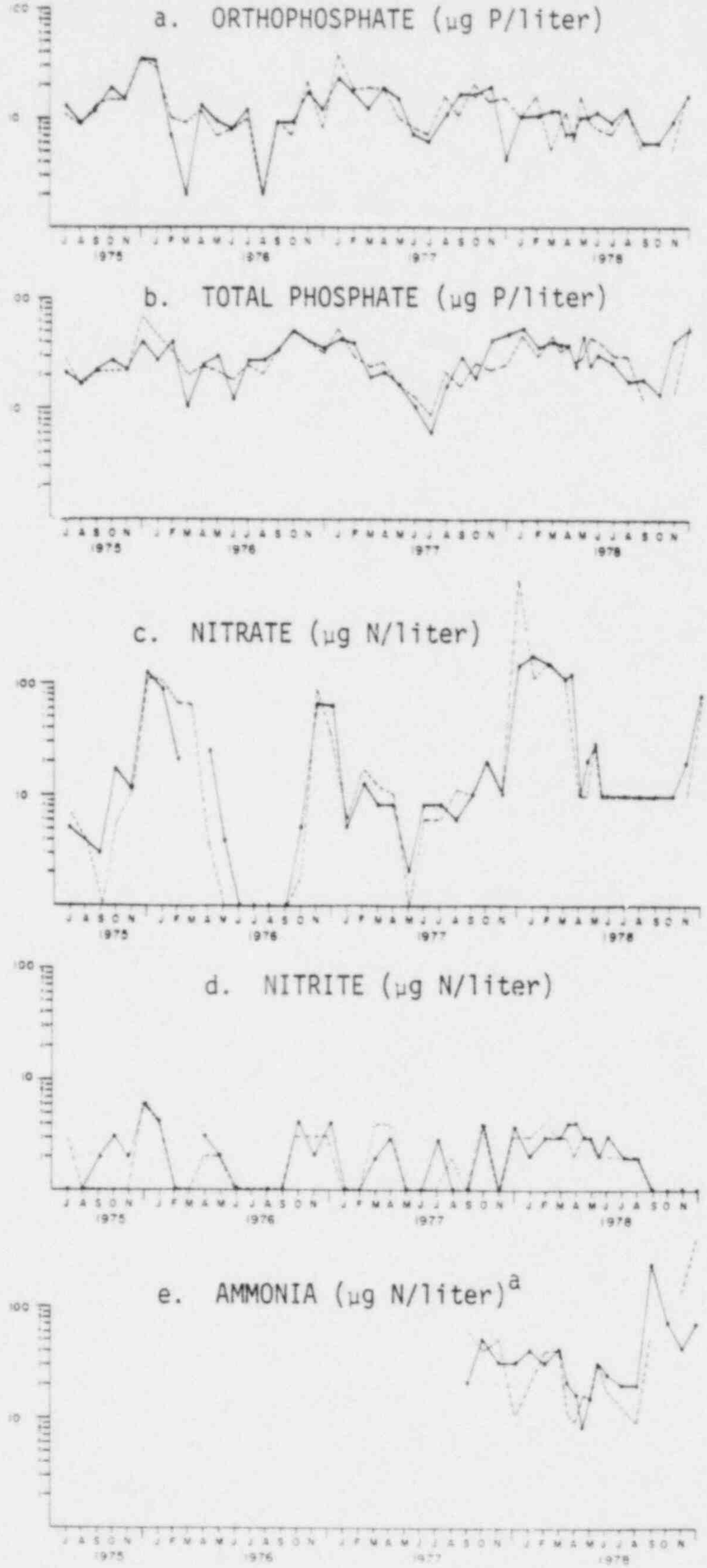


Figure 3.1-6. Phytoplankton nutrients in the vicinity of the intake (Station 2) and discharge (Station 5) sites from 1975-1978. Seabrook Ecological Studies, 1978.

3.2 ZOOPLANKTON

3.2.1 Results, 1978

3.2.1.1 Species Composition

Forty-three zooplankton taxa were enumerated from the 1978 microzooplankton samples at the intake site (Station 2) (Appendix 6.5). Microzooplankton were composed primarily of developmental stages of copepods and bivalve veliger larvae (Table 3.2-1). Copepod nauplii, including undifferentiated taxa, *Pseudocalanus/Calanus* nauplii and *Oithona* spp. nauplii, comprised 49% of the microzooplankton. Bivalve veliger larvae (umboned) ranked fourth, comprising approximately 11% of mean annual abundance. The copepodite stages of *Pseudocalanus* spp., *Oithona* spp., *Eurytemora herdmani* and *Acartia* spp. collectively comprised 19% of the microzooplankton (Table 3.2-1).

One hundred and forty-three zooplankton taxa were enumerated from the 1978 macrozooplankton samples (Appendix 6.6); less than 20 taxa comprised 90% of the mean annual abundance. Macrozooplankton in the study area were dominated by large calanoid copepods; collectively, this group comprised 68% of the macrozooplankton at the intake site (Station 2), 83% at the discharge site (Station 5) and 78% at the south site (Station 6) (Table 3.2-2). *Calanus finmarchicus* copepodites ranked first at all three sampling sites and comprised the greatest portion of the macrozooplankton (56%) at the south site. The ten top-ranking taxa at all three sites included *Centropages* spp., *Cancer* spp. zoeae, Cirripedia (barnacle) nauplii and cyprids, *Pseudocalanus* spp. females, *Sagitta elegans*, and developmental stages of *Eualus pusiolus, Crangon septemspinosa* and *Meganyctiphanes norvegica*. *Cancer* spp. zoeae comprised 8% of the macrozooplankton at the intake site, 2% at the discharge site and 1% at the south site. *Meganyctiphanes norvegica furcilia* comprised 7% of the total annual abundance at the south site and 1% at both the intake and the discharge sites (Table 3.2-2).

TABLE 3.2-1. PERCENT COMPOSITION OF MICROZOOPLANKTON† AT THE INTAKE SITE (STATION 2), SURFACE AND BOTTOM AVERAGED, JANUARY THROUGH DECEMBER 1978. SEABROOK ECOLOGICAL STUDIES, 1978.

TAXA	
Copepod nauplii, undifferentiated	23.21
Pseudocalanus/Calanus nauplii[Δ]	14.91
Oithona spp. nauplii	11.09
Bivalve veliger larvae, umbone	10.62
Oithona spp. copepodites	9.20
Pseudocalanus spp. copepodites	6.58
Foraminiferida	2.40
Eurytemora spp. copepodites	2.25
Polychaete larvae	2.14
Gastropod veliger larvae	1.83
Opisthobranchia veligers	1.67
Evadne spp.	1.63
Bivalve veliger larvae, straight-hinge	1.46
Acartia spp. copepodites	1.32
Tintinnida	1.25
Oithona spp. females	1.01
Microsetella norvegica	0.97
Larvacea	0.79
Temora longicornis copepodites	0.73
Calanus finmarchicus copepodites	0.63

† Zooplankton collected in 0.076mm mesh nets, pumped.

Δ *Pseudocalanus* spp. nauplii and *Calanus finmarchicus* nauplii combined.

TABLE 3.2-2. PERCENT COMPOSITION OF MACROZOOPLANKTON[†] IN HAMPTON-SEABROOK COASTAL WATERS[Δ], FROM OBLIQUE TOWS, JANUARY THROUGH DECEMBER 1978. SEABROOK ECOLOGICAL STUDIES, 1978.

TAXA	INTAKE SITE* STATION 2	DISCHARGE SITE STATION 5	SOUTH STATION 6
Calanus finmarchicus copepodites	37.37	44.05	56.47
Centropages typicus females	12.75	13.57	7.46
Centropages typicus males	8.23	9.29	4.77
Cancer spp. zoeae	7.69	1.52	1.34
Cirripedia nauplii	4.96	0.85	0.62
Pseudocalanus spp. females	2.78	2.14	1.95
Sagitta elegans	2.76	1.66	2.57
Eualus pusiolus larvae	1.78	1.68	1.20
Crangon septemspinosa larvae	1.70		
Cirripedia cypris	1.63		
Metridia lucens copepodites	1.48	2.33	0.99
Meganyctiphanes norvegica furcilia	1.48	0.99	6.69
Calanus finmarchicus females	1.39	3.12	1.59
Tortanus discaudatus females	1.37		
Tortanus discaudatus males	1.29		
Euphausiacea larvae	0.95		0.87
Oikopleura spp.	0.91	0.94	1.13
Temora longicornis females	0.82	1.14	0.92
Limacina retroversa	0.78		
Centropages hamatus females	0.75	2.63	0.55
Centropages spp. copepodites		2.03	2.05
Centropages hamatus males		2.01	0.77
Phialidium spp.		1.77	
Obelia spp.		1.01	2.95
Calanus finmarchicus males		0.93	0.88
Evadne spp.		0.72	
Thysanoessa spp. furcilia			0.77

† Zooplankton collected in 0.505mm mesh nets, towed

Δ See Figure 2.1-1 for station locations

* Includes seven sample dates when only the intake site was sampled

3.2.1.2 Seasonal and Spatial Distribution

Microzooplankton and macrozooplankton demonstrated similar seasonal distributions, with highest densities in summer and lowest in winter (Figure 3.2-1). Abundance of microzooplankton increased gradually from February through May, peaked in June and July and progressively decreased from August through December (Table 3.2-3, Appendix 6.7). Macrozooplankton abundance increased more sharply from February through April remained high throughout the summer, reached a maximum in early August and started to decline in November (Table 3.2-2, Appendix 6.8).

Microzooplankton abundance and species composition differed in surface and bottom collections. Microzooplankton abundance and species composition in surface and bottom collections were compared on selected dates of peak abundance and when surface and bottom abundance differed by approximately one order of magnitude:

TOTAL MICROZOOPLANKTON (no./m³)			DOMINANT TAXA/LIFE STAGE (%)	
DATE	SURFACE	BOTTOM	SURFACE	BOTTOM
May 24	38,930	3,991	Copepod nauplii* (31)	*Pseudocalanus* spp. copepodites (62)
Jun 7	149,840	4,694	Copepod nauplii* (50)	Copepod nauplii* (30) Polychaete larvae (30)
Jun 21	33,473	74,582	Copepod nauplii* (76)	Bivalve umbone veligers (33)
Jul 26	11,765	104,419	*Oithona* spp. copepodites (32)	Bivalve umbone veligers (43)
Sep 20	21,059	2,091	*Oithona* spp. nauplii (4[illegible])	Polychaete larvae (26)
Nov 15	16,936	1 663	Copepod nauplii* (35)	*Pseudocalanus/Calanus* nauplii (26)

* Undifferentiated

TABLE 3.2-3. ABUNDANCE OF MICROZOOPLANKTON (NO./m^3) AND MACROZOOPLANKTON (NO./1000m^3) COLLECTED AT THE INTAKE SITE, DISCHARGE SITE AND SOUTH. SEABROOK ECOLOGICAL STUDIES, 1978.

SAMPLE DATE	INTAKE SITE (STATION 2)			DISCHARGE SITE (STATION 5)	SOUTH (STATION 6)
	MICROZOOPLANKTON		MACROZOOPLANKTON	MACROZOOPLANKTON	MACROZOOPLANKTON
	SURFACE	BOTTOM			
Jan 16	5,956	6,583	44,149	30,866	27,630
Feb 15	2,586	4,889	1,556	2,898	1,975
Mar 8			25,162	14,061	7,784
Mar 17	7,742	13,914			
Mar 29*			24,155		
Mar 30	6,923	7,319			
Apr 12	30,067	10,676	376,559	176,594	430,924
Apr 26*	9,154	27,875	189,568		
May 10	19,538	13,469	544,586	448,470	585,868
May 24*	38,930	3,992	226,885		
Jun 7	149,840	4,694			
Jun 8			210,024	339,480	528,699
Jun 21	33,473	7[illegible],582			
Jun 22			244,423		
Jul 13	13,554	6,990	940,965	[illegible] 313	731,480
Jul 26*	11,765	104,419	285,378		
Aug 9	12,577	11,546	858,355	1,571,503	4,426,726
Aug 23*	18,405	9,155	460,619		
Sep 6	20,136	20,273	430,362	274,260	210,853
Sep 20	21,059	2,091			
Oct 4	21,661	3,529			
Oct 5			231,583	565,70[illegible]	564,781
Oct 18	13,141	9,636			
Nov 2	9,960	2,084	547,430	361,804	39,813
Nov 15	16,936	1,663			
Dec 5			27,039	110,983	469,269
Dec 6	1,540	2,043			
Dec 26*			4,560		
TOTAL	464,943	341,422	4,237,770†	4,130,932	8,025,802

*intake site only.

†include only those dates when all three sites were sampled.

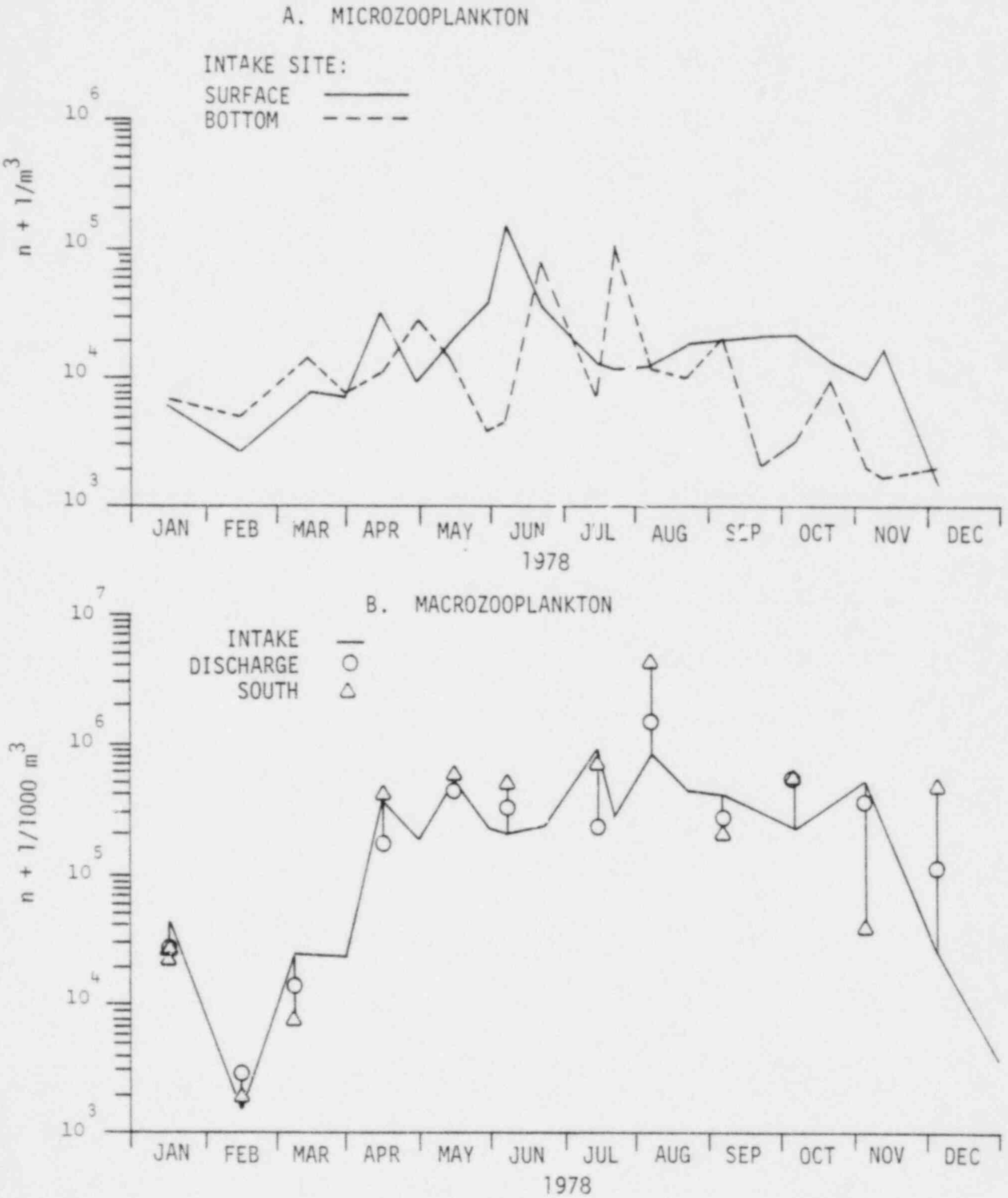


Figure 3.2-1. Seasonal distribution of microzooplankton at the intake site (Station 2), surface and bottom, and macrozooplankton at the intake site, discharge site (Station 5) and south (Station 6). Seabrook Ecological Studies, 1978.

The June 7 peak in surface microzooplankton abundance (Figure 3.2-1, Table 3.2-3) was comprised principally of undifferentiated copepod nauplii ($7.5 \times 10^4/m^3$), 50% of the microzooplankton collected on this date. Bottom microzooplankton exhibited bimodal abundance maxima on June 21 and July 26 (Figure 3.2-1, Table 3.2-3). The first of these peaks (June 21) was comprised principally of bivalve umbone veligers ($2.5 \times 10^4/m^3$, 33%) and *Pseudocalanus/Calanus* nauplii ($2.3 \times 10^4/m^3$, 31%). The largest contribution to the July 26 peak was from bivalve umbone veligers ($4.5 \times 10^4/m^3$), which comprised 43% of the microzooplankton. The number of taxa/life stages identified was greater in bottom than in surface collections (67 vs. 54); 19 taxa/life stages were unique to bottom collections, whereas only six taxa/life stages were unique to surface collections. Total annual abundance of microzooplankton was higher in surface waters than in near-bottom waters (Table 3.2-3).

Macrozooplankton abundance reached $10^5/1000\ m^3$ in April and maintained this order of magnitude through July (Figure 3.2-1). On April 12, the largest contributions to the macrozooplankton were from *Calanus finmarchicus* copepodites (32%) and barnacle nauplii (36%); *Oikopleura* spp. ranked third (16%) (Appendix 6.8). On April 26, species composition was basically the same; however, the major contribution shifted from barnacle nauplii to barnacle cyprids (47%). In early May, barnacle developmental stages settled out of the plankton and *C. finmarchicus* copepodites comprised 77% of the macrozooplankton. *Sagitta elegans* (23%) and *Cancer* spp. zoeae (14%) were dominant in late May. In June, there was a greater number of taxa comprising 1% or more of the macrozooplankton, including several of the seasonally occurring meroplankters (*Cancer* spp. zoeae, *C. septemspinosa* larvae, *E. pusiolus* larvae and hydromedusae); *Cancer* spp. zoeae comprised the largest portion of the macrozooplankton (16%) on June 22. *C. finmarchicus* copepodites dominated the macrozooplankton in July; abundance of *Cancer* spp. zoeae, a secondary dominant, continued to increase (Appendix 6.8).

Macrozooplankton abundance peaked in early August, increasing an order of magnitude to 10^6/1000 m^3 (Figure 3.2-1). *Calanus finmarchicus* copepodites reached maximum abundance (1.7 x 10^6/1000 m^3) and comprised 73% of the macrozooplankton; at a maximum density of 2.0 x 10^5/1000 m^3 *Meganyctiphanes novegica* comprised 9%. *Cancer* spp. zoeae also reached maximum abundance (9.4 x 10^4/1000 m^3); overshadowed by the enormous abundance of *C. finmarchicus* copepodites, they comprised only 4% of the macrozooplankton on August 3 (Appendix 6.8).

From late August through December, abundance of *C. finmarchicus* copepodites decreased and abundance of *Centropages typicus* females and males increased to comprise the major part of the macrozooplankton. *Cancer* spp., *C. septemspinosa* and *E. pusiolus* developmental stages settled out of the plankton in early October and there was a decrease in the number of taxa comprising >1% of the plankton (Appendix 6.8).

Spatial differences among sample sites were most evident from comparisons of percent composition of the three plankton types in macrozooplankton collections (holoplankton, meroplankton and tychoplankton)[3]. Larger holoplankters (e.g., *C. finmarchicus*, *Centropages* spp. and *S. elegans*) comprised approximately 75% of the mean annual macrozooplankton abundance (Figure 3.2-2). Percent composition of meroplankton differed among sampling sites. The April meroplankton peak, composed principally of barnacle nauplii, comprised approximately 80% of the macrozooplankton at the intake site and less than 20% at the discharge and south sites (Figure 3.2-2). *Obelia* spp. was the principal component of the meroplankton peak at the south site in July (Figure 3.2-2). In early August, the meroplankton were composed principally of *Cancer* spp. zoeae, *E. pusiolus* larvae and *C. septemspinosa* larvae; meroplankton comprised approximately 40% of the macrozooplankton at the intake site, 10% at the discharge site and less than 5% at the south site (Figure 3.2-2).

Abundance of total macrozooplankton, based on comparable sample periods, was approximately two times greater at the south site than at the intake and discharge sites (Table 3.2-3). Also, greater numbers of taxa/life stages, especially tychoplankters, were identified from the intake site and fewest at the south site:

3 The macrozooplankton study was confined to the intake site.

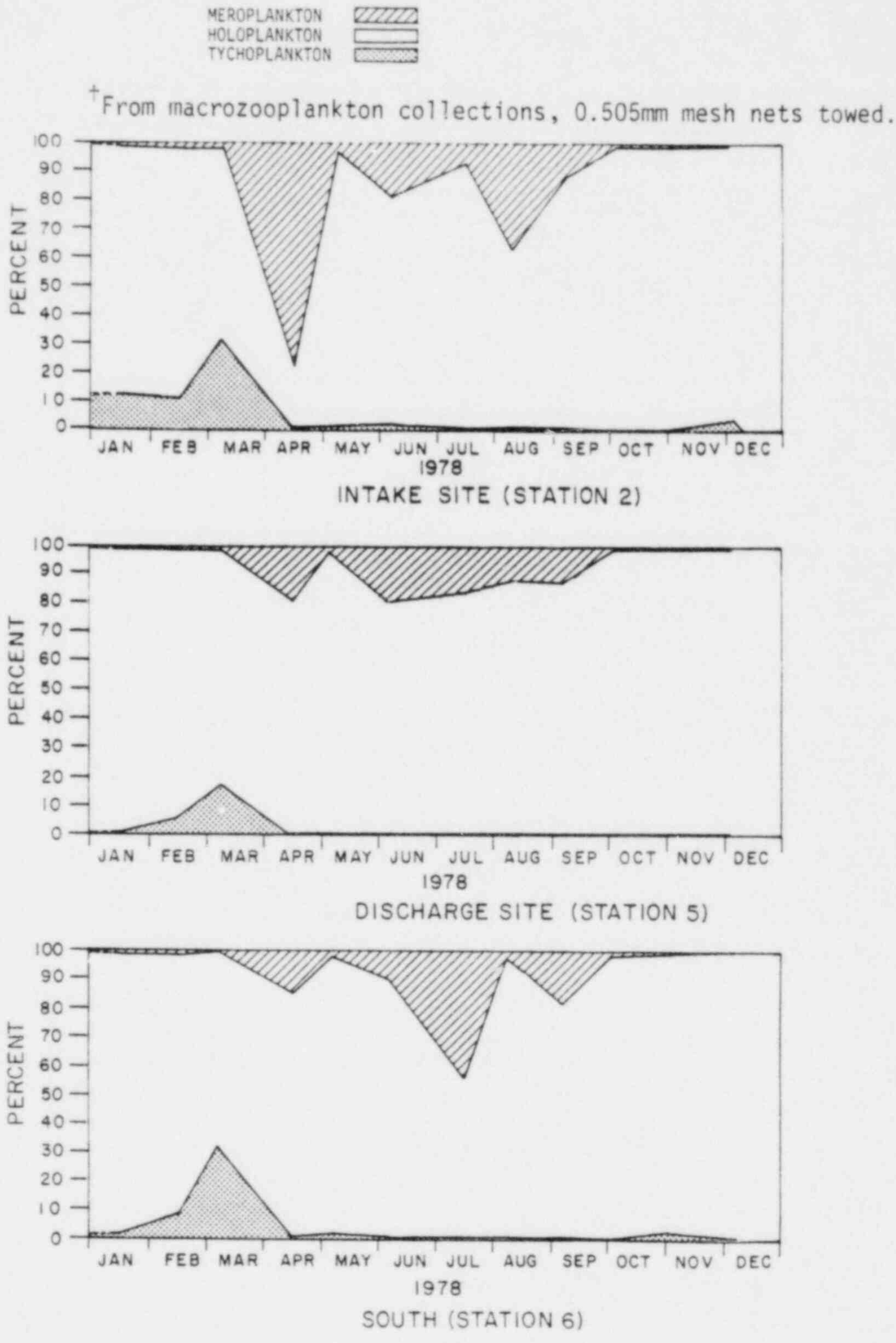


Figure 3.2-2. Cumulative contributions of holoplankton, meroplankton and tychoplankton at the intake site, discharge site and south.+ Seabrook Ecological Studies, 1978.

TYPE	INTAKE	NUMBER OF TAXA/LIFE STAGES DISCHARGE	SOUTH
Holoplankton	66	58	54
Meroplankton	75	70	70
Tychoplankton	130	101	93
TOTAL	271	229	217

Tychoplankton are principally those invertebrates which have undergone diel migrations into the water column from their daytime benthic/epibenthic habitat. Species comprising the tychoplankton differed among sampling sites. *Mysis mixta* juveniles comprised the majority of the March tychoplankton peak at the discharge (90%) and south (65%) sites (Figure 3.2-2). The March peak at the intake site was composed principally of *Neomysis americana* adults (60%); *M. mixta* juveniles (30%) were of secondary importance. The minor resurgence of tychoplankton in November/December was dominated by *N. americana* juveniles at all three sites, in addition to *Pseudoleptocuma minor* (Cumacea) at the discharge site, and *C. septemspinosa* post-larvae at the south site (Figure 3.2-2).

3.2.1.3 Indicator Species

Indicator species were selected based on their relative ecological and commercial importance and include taxa that are essential to the maintenance and productivity of the indigenous communities in Hampton-Seabrook coastal waters (NAI, 1974b; NAI, 1977b; NAI, 1979a). *Neomysis americana* was also selected as an indicator species because it comprised a major portion of the tychoplankton in the study area; it is widely distributed in North American coastal waters from New England south to Florida and its biology has been well-studied. Seven zooplankton indicator species were examined for seasonal and spatial distribution patterns: *Pseudocalanus* spp., *Eurytemora herdmani*, *Oithona* spp., *Calanus finmarchicus*, *Neomysis americana*, *Crangon septemspinosa* and *Cancer* spp.

Seasonal distribution of *Pseudocalanus* spp. adults was highly variable in surface waters at the intake site (Figure 3.2-3); greatest

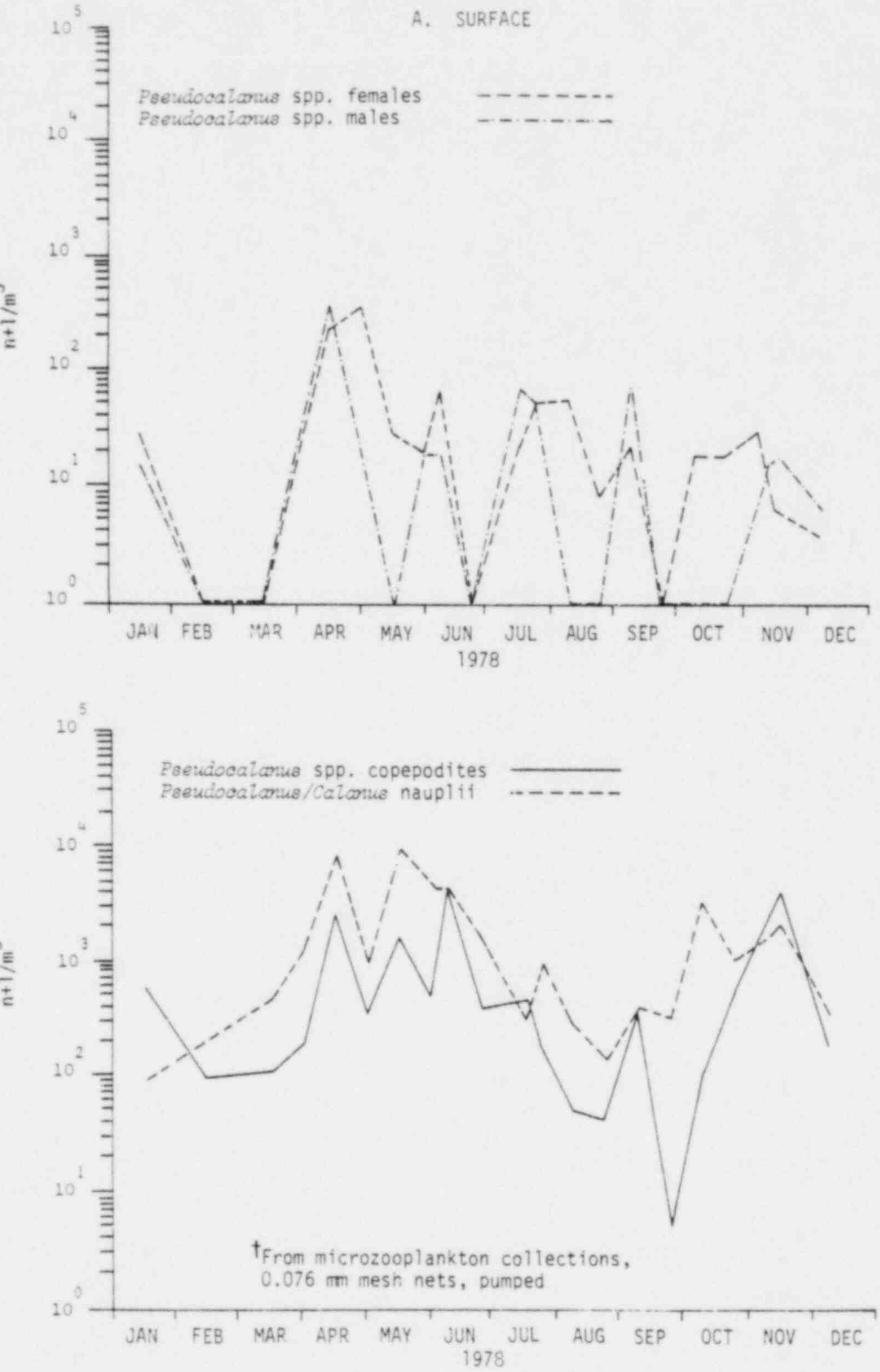
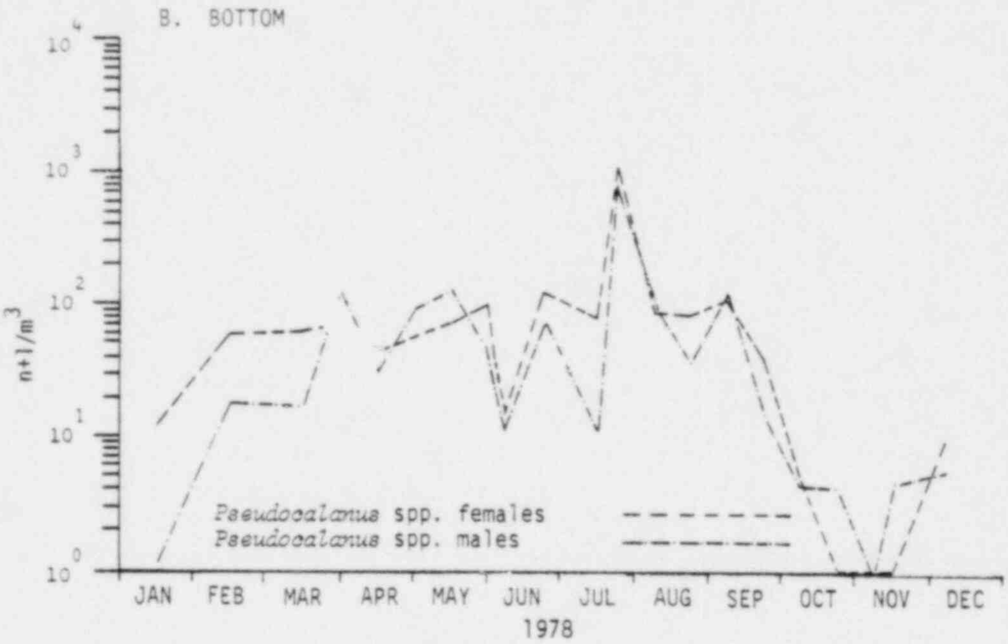


Figure 3.2-3. Seasonal distribution of *Pseudocalanus* spp. at the intake site, surface and bottom.† Seabrook Ecological Studies, 1978.



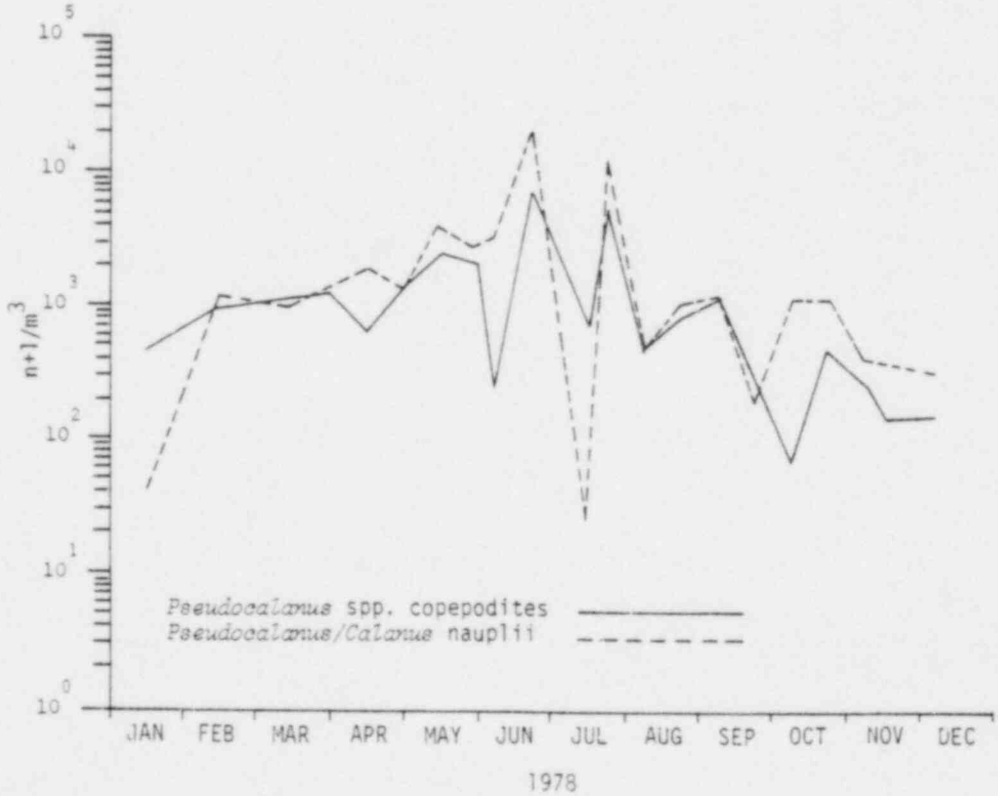


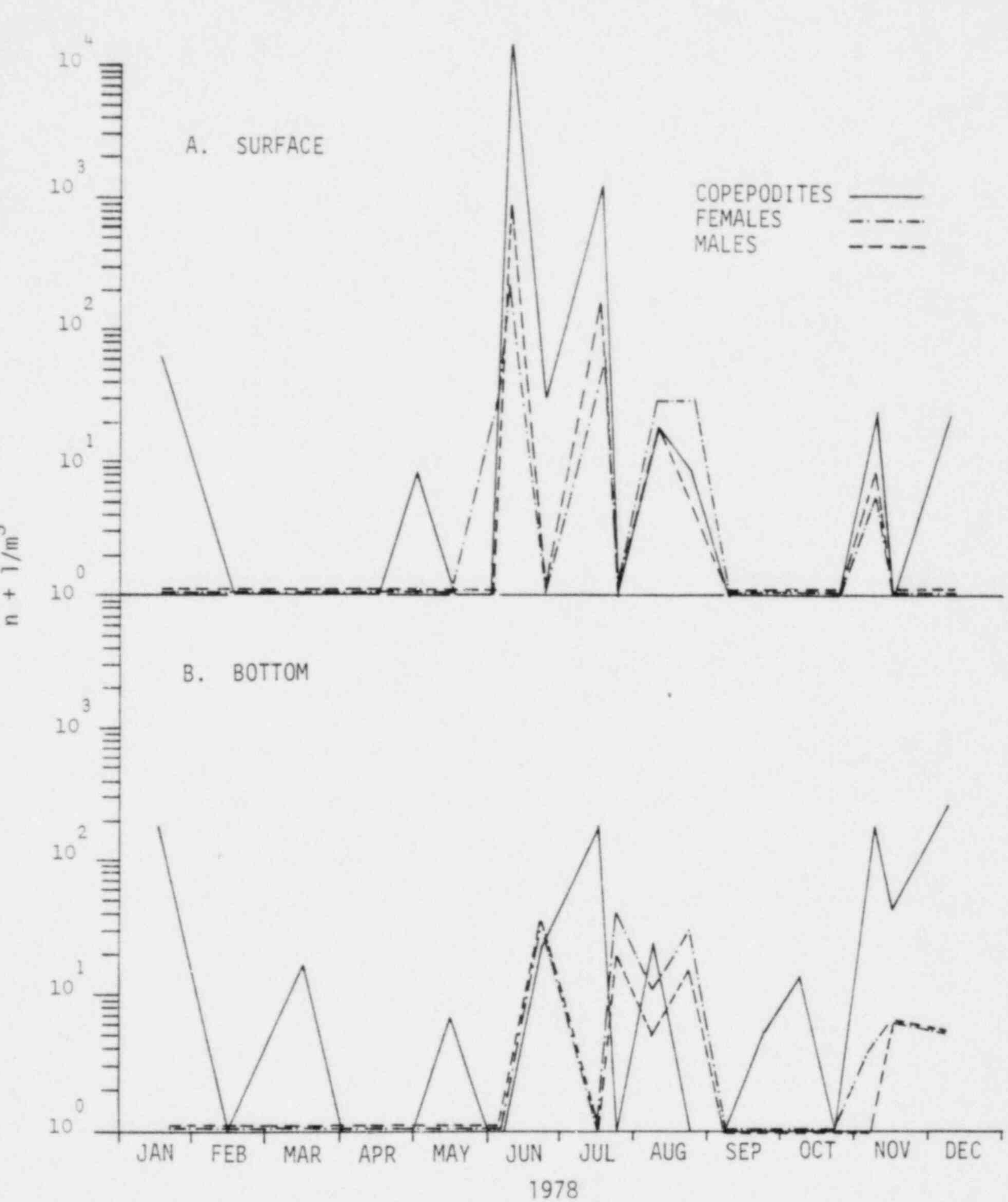
Figure 3.2-3. (Continued)

abundances occurred in April, on the order of 200 individuals/m^3. *Pseudocalanus* spp. females were generally more abundant than males, which were generally associated with fluctuations in female abundances. In near-bottom waters, *Pseudocalanus* spp. females and males were present in similar abundances; both exhibited well-defined patterns of seasonal occurrence, with highest densities (10^3 individuals/m^3, collectively) in late July (Figure 3.2-3B). *Pseudocalanus* spp. developmental stages were present in both surface and near-bottom waters throughout the sampling year (Figure 3.2-3). A bimodal abundance peak of *Pseudocalanus* spp. developmental stages occurred in April and May in surface waters and in June and July in near-bottom waters (Figure 3.2-3). Developmental stages were generally one to two orders of magnitude more abundant than the adults on any given sample date.

Eurytemora herdmani exhibited a bimodal, June/July, abundance peak in surface waters at the intake site (Figure 3.2-4). Densities during the June peak ranged from 100 individuals/m^3 (females) to 10^4 individuals/m^3 (copepodites) and were an order of magnitude lower during the July peak. Adults and copepodites followed similar patterns of seasonal occurrence. Seasonal distribution in near-bottom waters was variable; abundances were generally lower (Figure 3.2-4).

Oithona spp. adults and developmental stages exhibited similar patterns of seasonal occurrence in surface waters at the intake site (Figure 3.2-5). Adults were most abundant in June (10^3 individuals/m^3 and developmental stages were most abundant in late August (10^4 individuals/m^3, collectively). In near-bottom waters, adults and copepodites exhibited irregular patterns of seasonal distribution (Figure 3.2-5).

Calanus finmarchicus was collected in relatively high numbers and demonstrated similar seasonal distribution at all three sampling sites (intake, discharge and south) (Figure 3.2-6). Copepodites were present throughout the year at all three sampling sites, reaching maximum abundance in May and July/August (10^5 individuals/1000 m^3). Adults were absent from the plankton at the intake and discharge sites just prior to the May peak in copepodite abundance; throughout the remainder of the year copepodites and adults co-occurred. At the south site,



†From microzooplankton collections, 0.076 mm mesh nets, pumped

Figure 3.2-4. Seasonal distribution of *Eurytemora herdmani* at the intake site, surface and bottom.† Seabrook Ecological Studies, 1978.

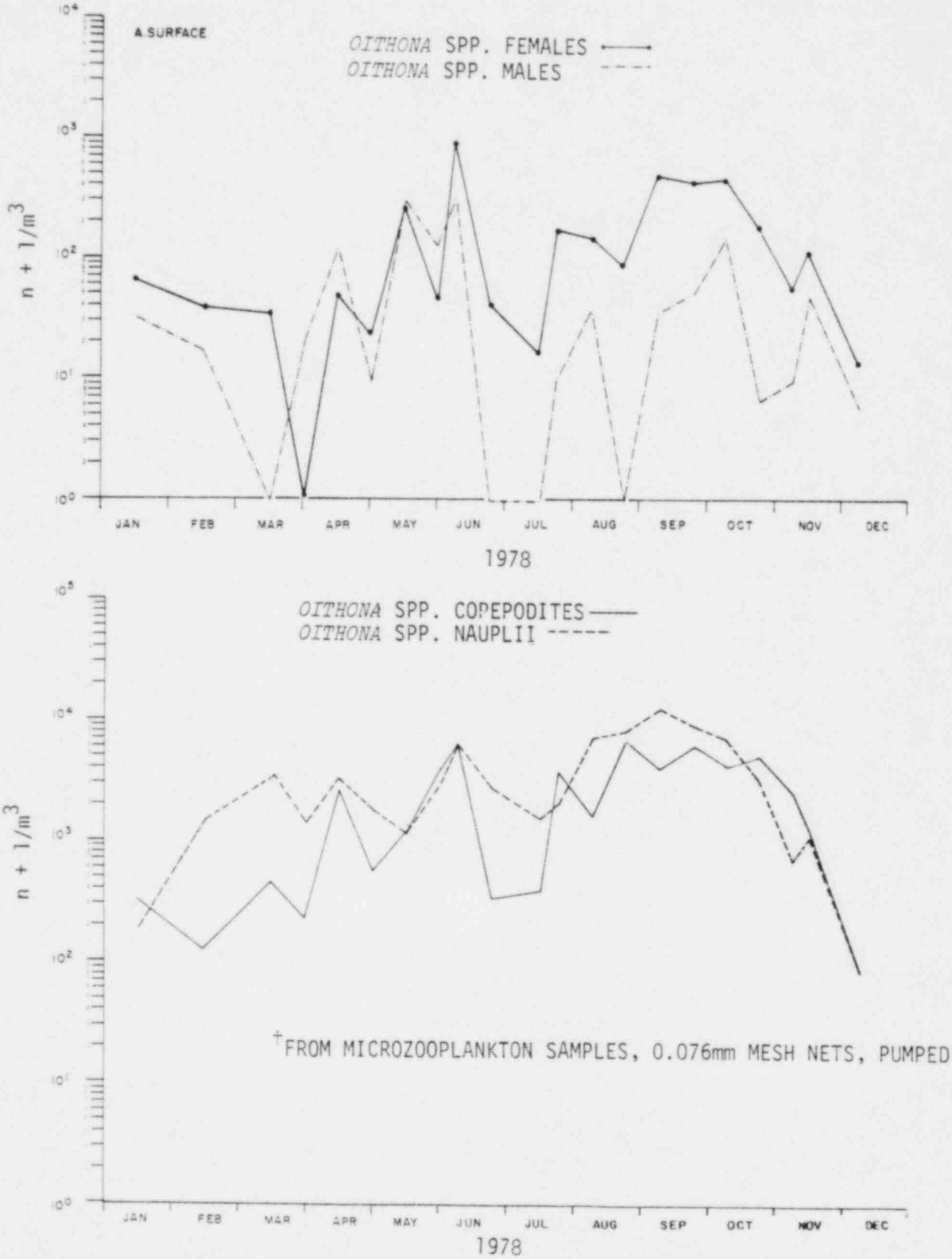
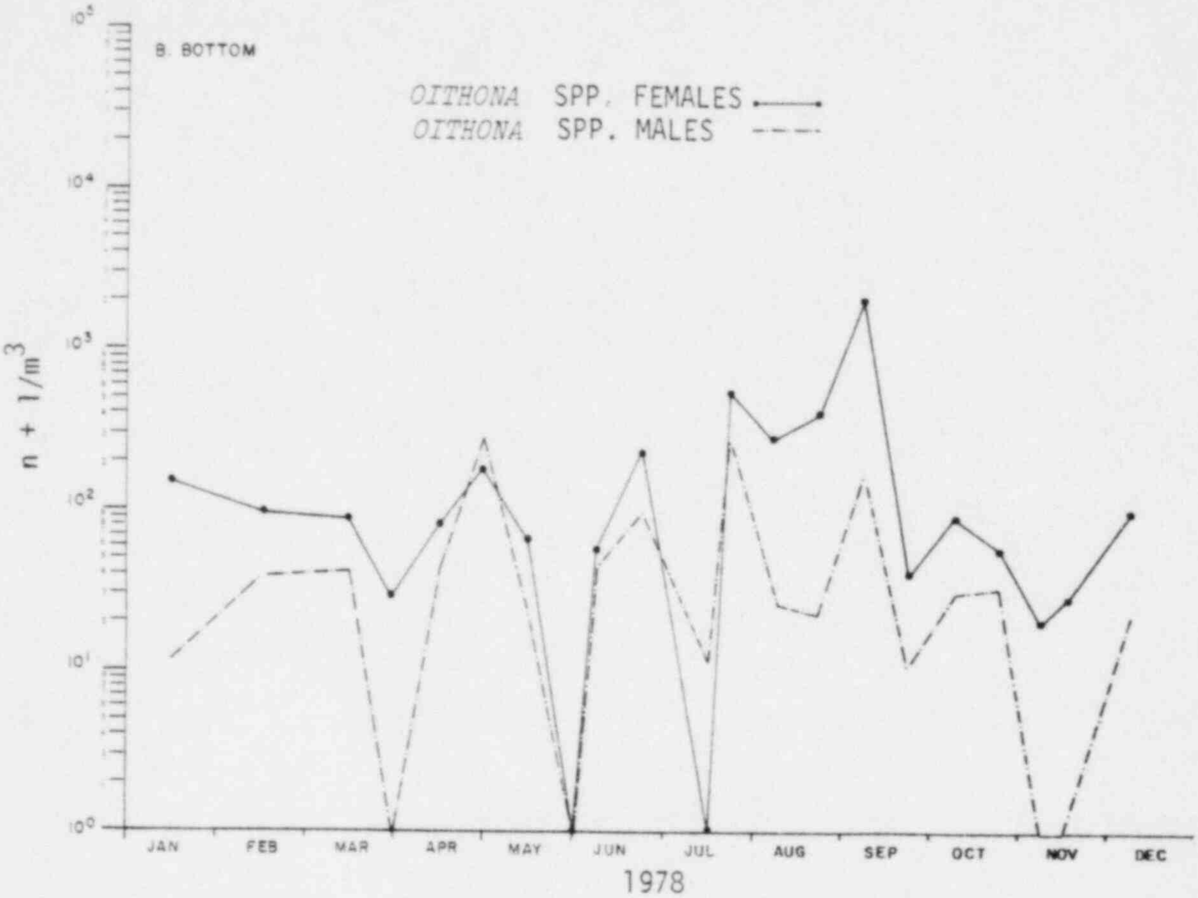


Figure 3.2-5. Seasonal distribution of *Oithona* spp. at the intake site, surface and bottom.† Seabrook Ecological Studies, 1978.



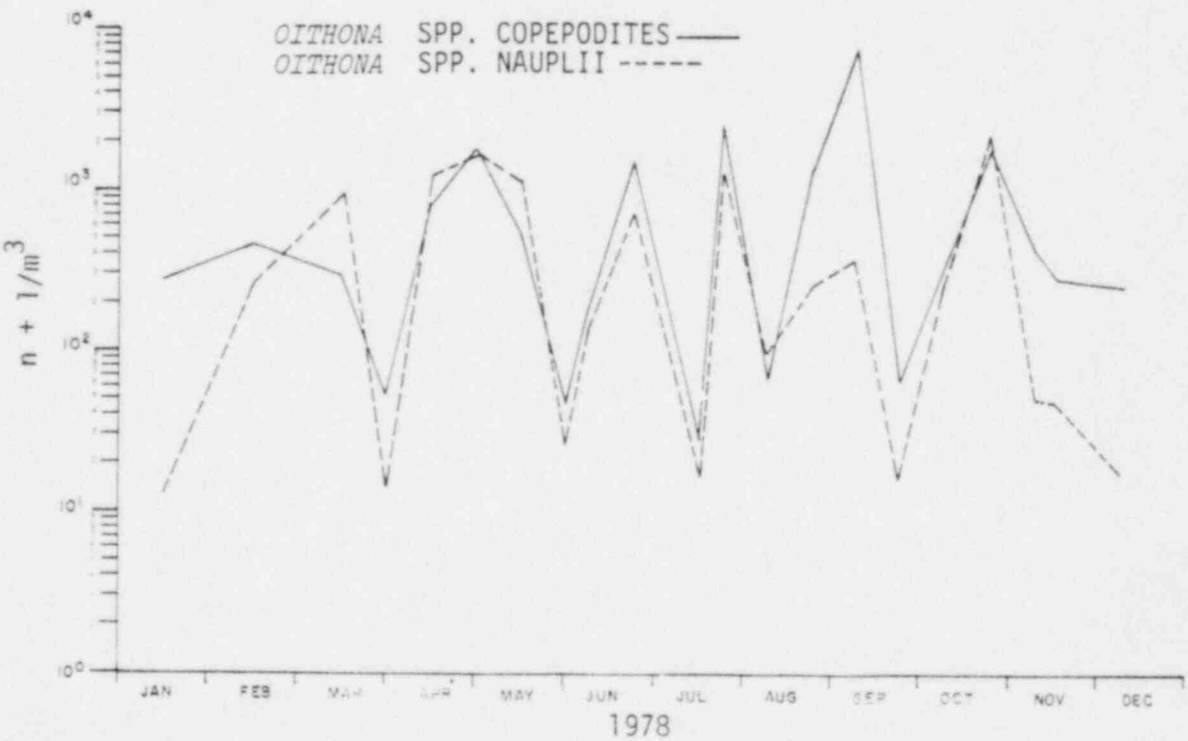


Figure 3.2-5. (Continued)

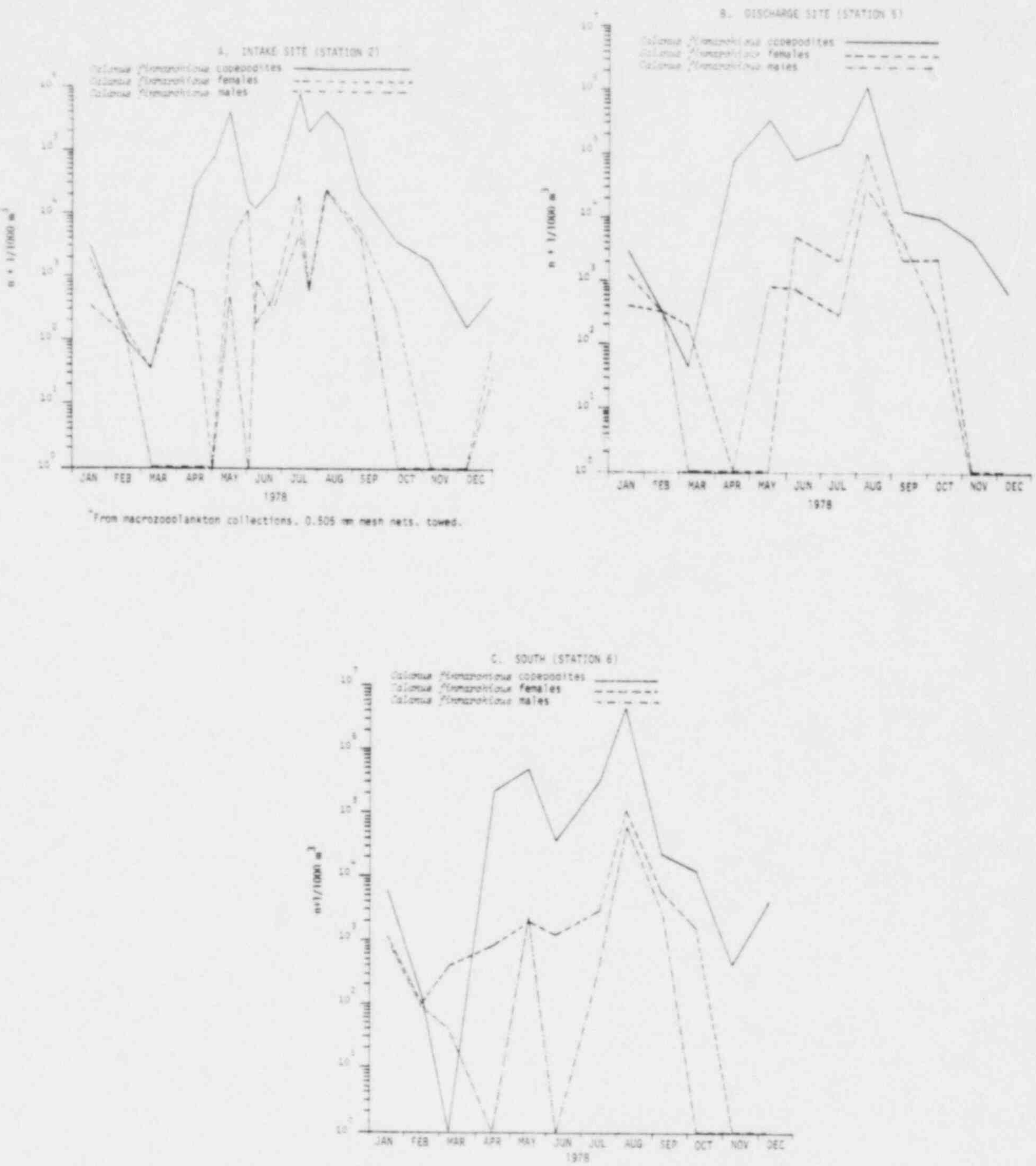


Figure 3.2-6. Seasonal distribution of *Calanus finmarchicus* at the intake site, discharge site and south.† Seabrook Ecological Studies, 1978.

females and copepodites followed the same pattern of seasonal occurrence while males were present in highest abundance on dates of peak female abundance (Figure 3.2-6).

With few exceptions, *Neomysis americana* was most abundant at the intake site (Figure 3.2-7; Appendix 6.9). Females and males exhibited virtually identical patterns of seasonal distribution at all three sampling sites. Adults were most abundant (10^3 individuals/1000 m^3) and comprised the major part of the tychoplankton at the intake site in March (Figures 3.2-2 and 3.2-7). Sex ratios based on mean abundance at all three sample sites showed that males were more abundant than females on seven out of twelve sample dates; on dates when only the intake site was sampled, males were more abundant than females on three of the five sample dates (Appendix 6.9). The largest percentage of ovigerous and larvigerous females was found on August 9; Appendix 6.9 summarizes the reproductive state and fecundity of *N. americana* collected in plankton samples during 1978. Juveniles were most abundant (10^2 individuals/1000 m^3) at all three sites in November/December contributing to the minor resurgence of tychoplankton abundance (Figures 3.2-2 and 3.2-7).

As with *N. americana, Crangon septemspinosa* was typically most abundant at the intake site (Figure 3.2-8). Adults appeared infrequently in the plankton; highest abundances approached 100 individuals/1000m^3 in late August/early September at the intake site. Larvae were present throughout the year at all three sample sites; abundance levels of 10^4/1000 m^3 were reached in June and were maintained through early September (Figure 3.2-8). The larvae were a major part of the meroplankton and in early August comprised a substantial part of the macrozooplankton at the intake site (Figure 3.2-2).

Seasonal distribution of *Cancer* spp. developmental stages was similar at all three sampling sites (Figure 3.2-9). *Cancer* spp. zoeae first appeared in the plankton in early May; by late May abundances reached 10^4 individuals/1000 m^3. A secondary dominant, the zoeae comprised 14% of the macrozooplankton in late May. On June 22, *Cancer* spp. zoeae comprised the largest portion (16%) of the macrozooplankton (Appen-

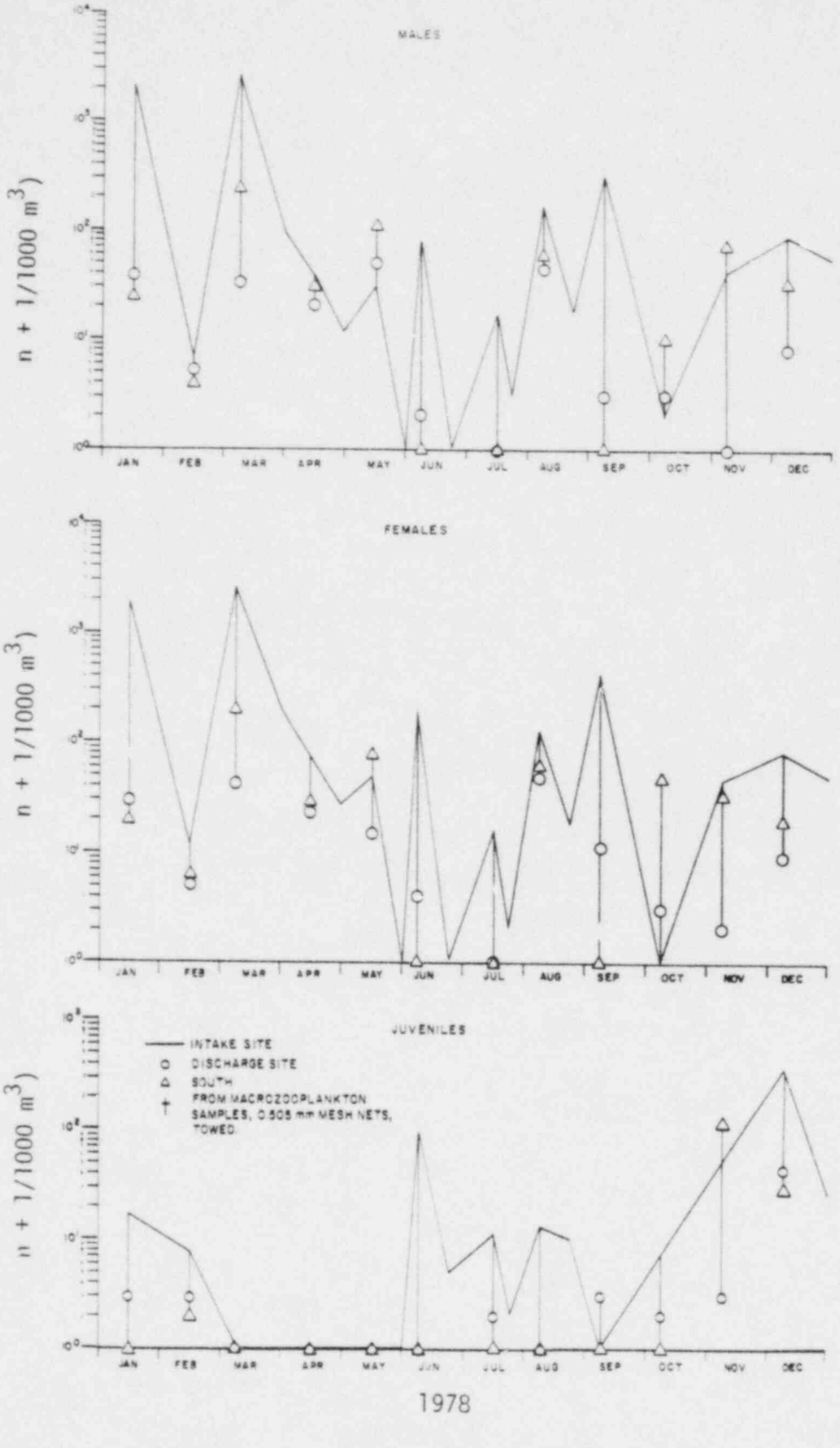


Figure 3.2-7. Seasonal distribution of *Neomysis americana* at the intake site, discharge site and south.† Seabrook Ecological Studies, 1978.

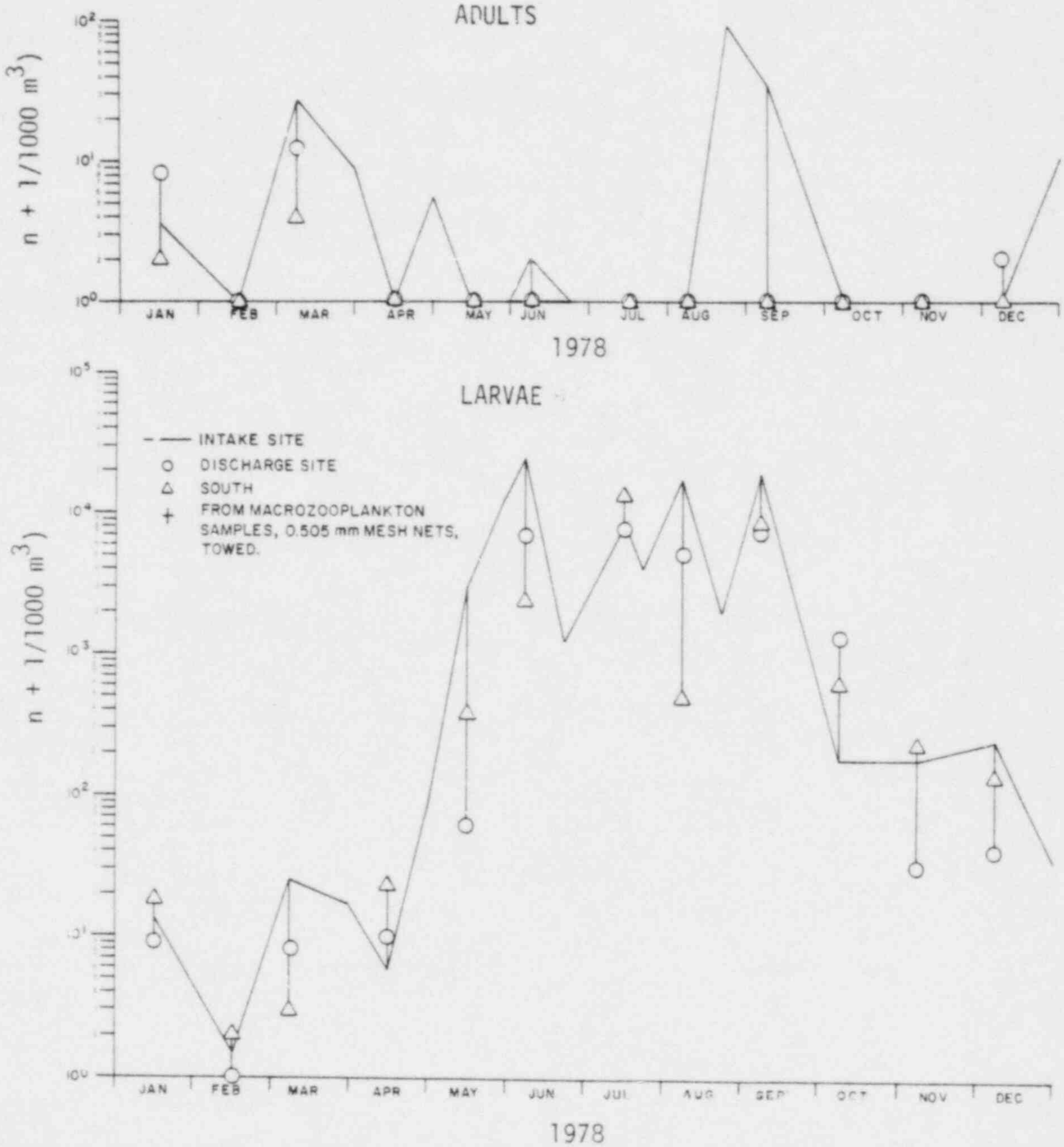


Figure 3.2-8. Seasonal distribution of *Crangon septemspinosa* at the intake site, discharge site and south.†
Seabrook Ecological Studies, 1978.

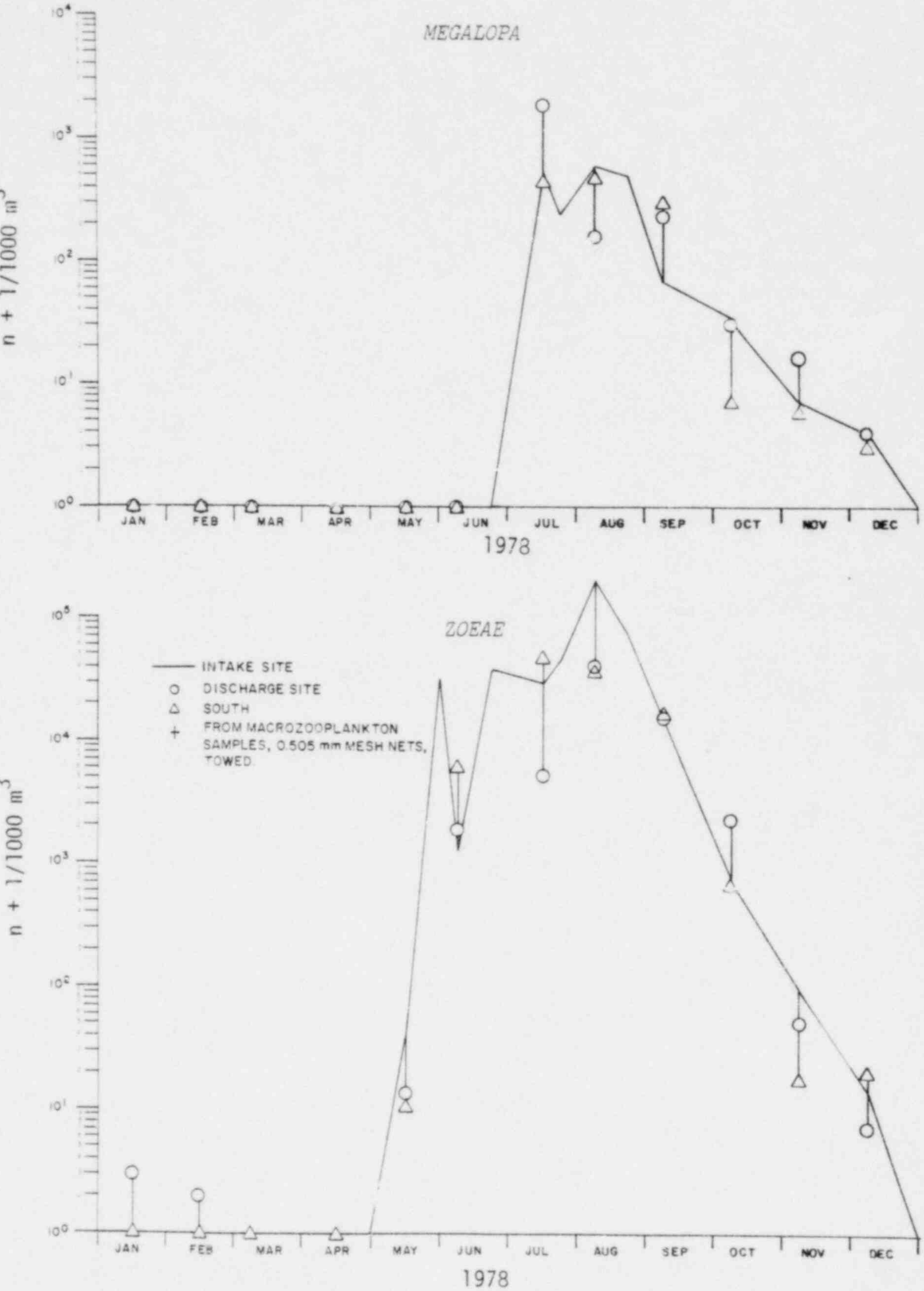


Figure 3.2-9. Se onal distribution of *Cancer* spp. at the intake site, di charge site and south.+ Seabrook Ecological Studies, 1978.

dix 6.8). Both the first appearance and seasonal peak of *Cancer* spp. megalopa coincided on July 13, approximately 45 days after the first zoeal pulse. *Cancer* spp. zoeae reached maximum abundance and were the principal component of the meroplankton on August 9; due to the enormous abundance of *C. finmarchicus*, they comprised only 4% of total macrozooplankton. Abundance of both zoeae and megalops decreased progressively from September through December.

3.2.2 Discussion, 1975-1978

3.2.2.1 Species Composition

Since 1975, microzooplankton at the intake site have been composed principally of the developmental stages of copepods and bivalves (Table 3.2-4). The five top-ranking taxa in all study years were undifferentiated copepod nauplii, *Oithona* spp. copepodites, bivalve veliger larvae, *Pseudocalanus* spp. copepodites and *Oithona* spp. nauplii.

Mesozooplankton (collected in 0.333 mm mesh nets) were sampled from July 1975 through June 1977. Calanoid copepods comprised approximately 80% of the mesozooplankton at the intake site; *Pseudocalanus* spp. females ranked first in both study years (Table 3.2-5). In July 1977 macrozooplankton sampling (0.505 mm mesh net) replaced mesozooplankton sampling. Species composition changed with the new collection method to include larger calanoid copepods and several meroplanktonic species (Table 3.2-5). *Calanus finmarchicus* copepodites ranked first, comprising approximately 40% of the macrozooplankton. Other top-ranking taxa were *Centropages typicus*, *Cancer* spp. zoeae and barnacle nauplii and cyprids.

3.2.2.2 Temporal and Spatial Distribution

Temporal and spatial distribution of microzooplankton in 1978 was similar to that observed in 1977 (Figure 3.2-10). In both years,

TABLE 3.2-4. PERCENT COMPOSITION OF MICROZOOPLANKTON[a] AT THE INTAKE SITE, SURFACE AND BOTTOM AVERAGED, JULY 1975 THROUGH DECEMBER 1978[b]. SEABROOK ECOLOGICAL STUDIES, 1978.

TAXA	TYPE[c]	JAN-DEC 1978[d]	JUL 1976-JUN 1977	JUL 1975-JUN 1976
Copepod nauplii, unidentified	H	40.84	32.63	27.99
Oithona spp. copepodite	H	9.86	16.13	19.80
Bivalve veliger larvae, unidentified	M	12.94	11.88[e]	16.49
Pseudocalanus spp. copepodite	H	7.05	10.21	9.70
Oithona spp. nauplii	H	11.88	14.55	8.45
Gastropod veliger larvae	M	1.96	2.34	3.21
Microsetella norvegica	H	1.04	1.44	2.56
Oithona spp. female	H	1.08	2.73	2.20
Cirripedia nauplii	M	0.21	1.15	1.69
Centropages spp. copepodite	H	0.64	1.92	1.60
Temora longicornis copepodite	H	0.78	0.54	1.35
Polychaete larvae	M	2.29	0.29	1.28
Rotifera	H	0.05		0.69
Opisthobranchia veliger	M	1.79	0.42	0.52
Harpacticoida	T	0.35		0.44
Cirripedia cypris	M	0.16	0.31	0.37
Foraminiferida	T	2.57		0.30
Oithona spp. male	H	0.33	0.72	0.26
Tintinnidae	H	1.34		0.25
Acartia spp. copepodite	H	1.41	0.52	0.22
Echinoderm larvae	M	0.39	0.19	0.20
Bryozoan cyphonautes larvae	M	0.13	0.58	
Eurytemora spp. copepodite	H	2.41	0.50	
Paracalanus parvus copepodite	H		0.42	

[a] Zooplankton collected in 0.076 mm mesh nets, pumped.

[b] Excluding July through December 1977; to provide results from comparable 12-month periods when the sampling program changed from a split-year schedule (Jul-Jun) to a calendar year schedule (Jan-Dec).

[c] H=Holoplankton, M=Meroplankton, T=Tychoplankton

[d] Selected taxa were enumerated in the 1975, 1976 and 1977 samples. All organisms were enumerated in the 1978 samples; however, only the selected taxa are included in this percent composition.

[e] Does not include *Modiolus modiolus* veliger larvae collected on 7 October 1976 (NAI, 1978).

TABLE 3.2-5. PERCENT COMPOSITION OF MESOZOOPLANKTON AND MACROZOOPLANKTON AT THE INTAKE SITE, FROM OBLIQUE TOWS, JULY 1975 THROUGH DECEMBER 1978 [a]. SEABROOK ECOLOGICAL STUDIES, 1978.

TAXA	TYPE[b]	MACROZOOPLANKTON[c] JAN-DEC 1978	MESOZOOPLANKTON[d] JUL 1976-JUN 1977	MESOZOOPLANKTON[d] JUL 1975-JUN 1976
Pseudocalanus spp. females	H	2.78	38.50	19.53
Evadne spp.	H		3.01	12.54
Temora longicornis males	H		2.90	10.28
Calanus finmarchicus copepodites	H	37.37	5.30	7.16
Temora longicornis females	H		1.93	7.14
Centropages typicus females	H	12.75	5.75	6.90
Acartia tonsa adults	H			5.50
Larvacea	H			4.93
Pseudocalanus spp. males	H		10.08	4.17
Centropages typicus males	H	8.23	4.93	3.44
Podon sp.	H		3.95	3.36
Metridia lucens copepodites	H	1.48	5.76	3.01
Acartia longiremus adults	H			2.22
Tortanus discaudatus males	H	1.29	0.84	2.13
Eurytemora herdmani females	H		2.76	1.71
Sagitta elegans	H	2.76		1.61
Centropages hamatus females	H			1.06
Centropages hamatus males	H			0.96
Tortanus discaudatus females	H	1.37	0.86	0.91
Acartia hudsonica adults	H		4.09	
Eurytemora herdmani males	H		2.22	
Cancer spp. stage I[e]	M	5.59		
Cirripedia nauplii[e]	M	4.96		
Eualus pusiolus[e]	M,T	1.78		
Cirripedia cypris[e]	M	1.63		
Meganyctiphanes norvegica furcilia[e]	H	1.47		
Calanus finmarchicus females	H	1.39		
Euphausiacea calyptopis	H	0.95		

[a] Excluding July through December 1977; to provide results from comparable 12-month periods when the sampling program changed from a split-year schedule (Jul-Jun) to a calendar year (Jan-Dec).

[b] H=Holoplankton, M=Meroplankton, T=Tychoplankton

[c] Zooplankton collected in 0.505 mm mesh nets, towed.

[d] Zooplankton collected in 0.333 mm mesh nets, towed.

[e] Not enumerated in mesozooplankton samples.

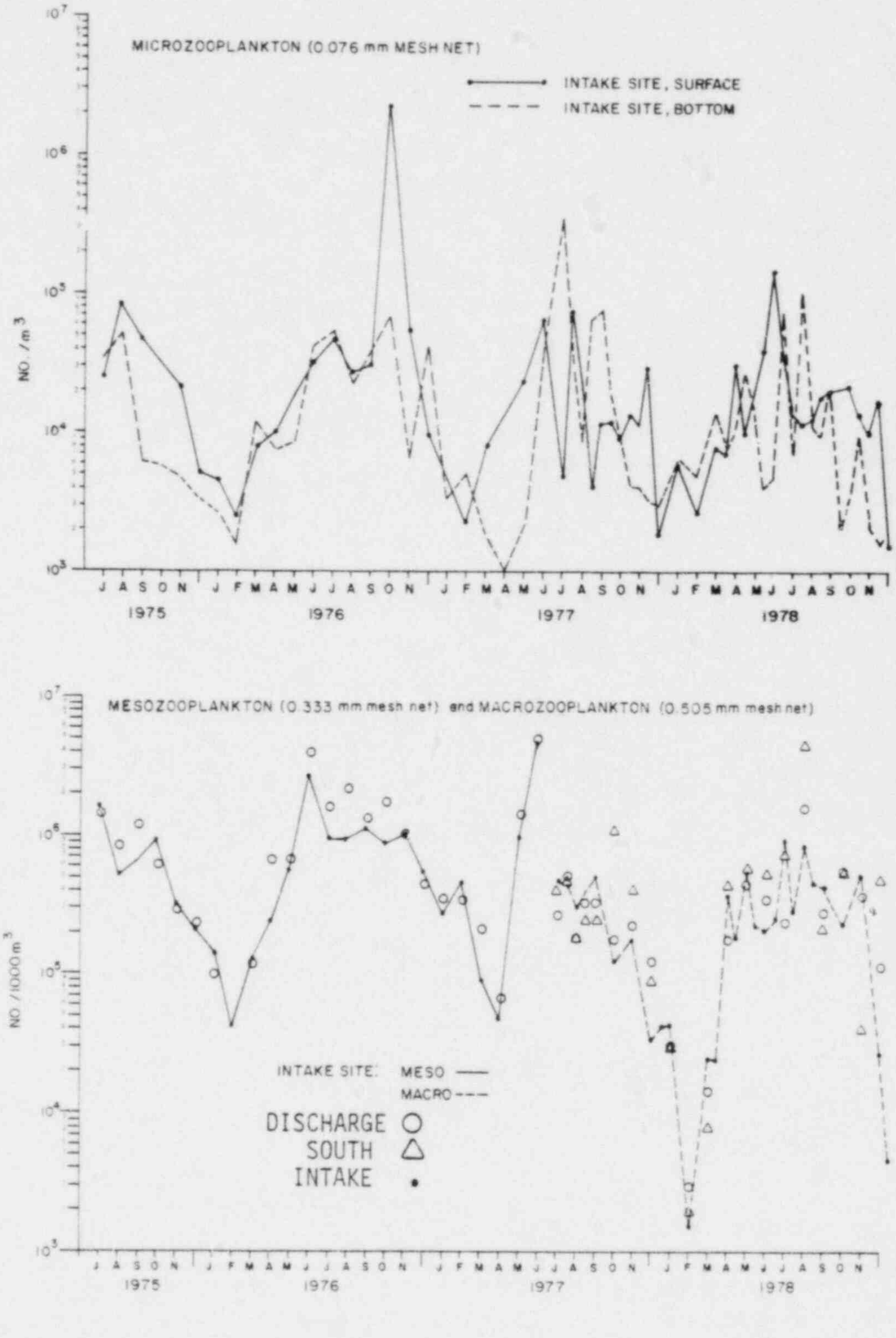


Figure 3.2-10. Temporal distribution of microzooplankton, mesozooplankton and macrozooplankton in Hampton-Seabrook coastal waters, July 1975 through December 1978. Seabrook Ecological Studies, 1978.

microzooplankton showed peaks in June, following May phytoplankton blooms (see Figure 3.1-4). The minor resurgence in microzooplankton abundance (principally copepod nauplii) in November 1978 (following the fall phytoplankton bloom) was also observed in 1977 (Figure 3.2-10). In 1976 the fall peak, predominantly copepod nauplii, was much larger than the early summer peak; during September 1976 densities were an order of magnitude higher than recorded in any other year. Total annual abundance of microzooplankton was higher in surface waters than in near-bottom waters during all study years.

Although the seasonal distribution of macrozooplankton (collected in 0.505 mm mesh nets) was similar to that of mesozooplankton (collected in 0.333 mm mesh nets), total annual densities were considerably lower (Figure 3.2-10). The decrease in overall densities and the sharp decline in densities in the fall and winter months reflect the shift in percent composition, due to collection methods, to include the larger and generally less abundant holoplankton and meroplankton (Table 3.2-5). Total annual abundances, in both mesozooplankton and macrozooplankton collections, were slightly higher at the discharge site than at the intake site. At the south site, sampled from July 1977 through December 1978, total abundance was higher than at the intake or discharge sites; in 1978, total abundance was an order of magnitude higher than at the intake or discharge sites. The generally high variation across sample periods for both microzooplankton and macrozooplankton, in part, reflects the marked seasonal pulsations of the component taxa as well as the distribution of life stages within these taxa. Variation between stations was generally less than that observed between sample periods. Interstation variation was greatest on December 6 (Table 3.2-3) when *C. typicus* was particularly abundant at the discharge and south sites and less abundant at the intake site.

3.2.2.3 Indicator Species

Abundances of indicator species have been examined since July 1975; some species were added to the list of indicator species more re-

cently and were not enumerated in earlier years. Since 1975, collection methods have changed and a taxon may have been collected concurrently by more than one method. Therefore, abundance data are presented selectively from collection methods that sampled an individual taxon (or life stage) most effectively.

In the Gulf of Maine, *Pseudocalanus* spp. is widely distributed in both neritic and offshore waters; it is second in importance only to *Calanus finmarchicus* (Fish, 1936a). A dominant microzooplankter, *Pseudocalanus* spp. occurs throughout the year in near-shore waters. With rising temperatures in April and May there is a general tendency to leave shallow areas and surface waters (Bigelow, 1926; Figure 3.2-3). *Pseudocalanus* spp. adults and copepodites at the intake site have exhibited similar seasonal distribution since 1975, with highest densities in summer and lowest densities in winter (Table 3.2-6). Both adults and copepodites have ranked among the top five in percent composition of microzooplankton during all study years (Table 3.2-4).

Eurytemora herdmani, usually associated with near-shore waters, can tolerate a wide salinity range (Katona, 1971). This species was generally low in abundance if present at all at the intake site prior to May; highest abundances occurred in June and July (Table 3.2-7). Both adults and copepodites were most abundant in 1978. *Eurytemora herdmani* comprised less than 3% of the microzooplankton, and considerably less of the macrozooplankton, during all study years (Tables 3.2-4 and 3.2-5).

Oithona spp. is a euryhaline taxon dependent on neritic recruitment (Jeffries, 1967). *Oithona* spp. was collected at the intake site throughout all study years. Overall abundance was similar among years with highest densities generally occurring in summer and early fall (Table 3.2-8). *Oithona* spp. copepodites have ranked second or third in percent composition of microzooplankton since 1975.

TABLE 3.2-6. MEAN ABUNDANCE OF *PSEUDOCALANUS* SPP. (NO/m^3) AT THE INTAKE SITE (STATION 2), 1975 THROUGH 1978. SEABROOK ECOLOGICAL STUDIES, 1978.

ADULTS

A. From microzooplankton samples; 0.076mm mesh net, pumped (surface and bottom averaged)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1978			42	375	120	63	100	134	182	15	18	
	30	40	117	283	102	108	1,102	68	30	12	16	13
1977[a]							1,169	282	1,234	221	76	
							1,152	919	535	35	276	107

B. From mesozooplankton samples; 0.333mm mesh bongo net (oblique tows)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1977	209	438	31	16	78	3,577	b					
1976	74	29	22	68	106	192	225	49	485	45	491	144
1975[c]							935	23	146	154	37	121

COPEPODITES

From microzooplankton samples; 0.076mm mesh net, pumped (surface and bottom averaged)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1978			711	1,729	2,397	2,533	655	323	849	98	1,193	
	576	601	860	973	1,497	4,515	3,294	522	189	571	2,261	179
1977							34,889	5,352	9,313	993	281	
	1,472	811	322	585	1,196	11,541	16,331	7,137	2,973	107	588	447
1976	95	227	278	1,243	1,843	1,245	2,970	325	2,814	384	499	1,810
1975[c]							2,588	2,633	8,380	1,893	2,213	238

[a] Adults were not enumerated in microzooplankton samples (0.076 mm pumped nets) prior to July 1977.

[b] Mesozooplankton sampling (0.333 mm towed net) was replaced by "macrozooplankton" sampling (0.505 mm towed net) in July 1977.

[c] Collections for mesozooplankton and microzooplankton were made routinely beginning in July 1975.

Two collection dates/month: 1st
2nd

TABLE 3.2-7. MEAN ABUNDANCE OF *EURYTEMORA HERDMANI* (No./m^3) AT THE INTAKE SITE (STATION 2), 1975 THROUGH 1978. SEABROOK ECOLOGICAL STUDIES, 1978.

ADULTS

A. From microzooplankton samples; 0.076mm mesh net, pumped (surface and bottom averaged)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1978			0	0	0	580	110	23	0	7	10	
	0	0	0	0	8	31	33	4	3	0	6	5
1977[a]							8	23	68	18	0	
							118	0	0	77	3	0

B. From mesozooplankton samples; 0.333mm mesh bongo net (oblique tows)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1977	0	<1	4	<1	418	31	b					
1976	0	<1	1	<1	3	149	114	9	12	3	2	0
1975[c]							2	2	1	0	1	0

COPEPODITES

From microzooplankton samples; 0.076mm mesh net, pumped (surface and bottom averaged)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1978			9	0	4	7,790	764	33	0	0	115	
	127	0	0	5	0	28	0	43	0	0	23	164
1977							57	35	79	2	39	
	0	0	5	10	291	747	368	124	0	25	8	16
1976	2	0	0	0	0	77	21	38	0	51	25	11
1975[c]							9	35	0	0	0	14

[a] Adults were not enumerated in microzooplankton samples (0.076 mm pumped nets) prior to July 1977.

[b] Mesozooplankton sampling (0.333 mm towed net) was replaced by "macrozooplankton" sampling (0.505 mm towed net) in July 1977.

[c] Collections for mesozooplankton amd microzooplankton were made routinely beginning in July 1975

Two collection dates/month: 1st / 2nd

TABLE 3.2-8. MEAN ABUNDANCE OF *OITHONA* SPP. (NO./m^3) AT THE INTAKE SITE (STATION 2), 1975 THROUGH 1978. SEABROOK ECOLOGICAL STUDIES, 1978.

From microzooplankton samples; 0.076mm mesh net, pumped (surface and bottom averaged)

ADULTS

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1978 (1st)			83	149	327	661	14	242	1,362	362	44	
1978 (2nd)	126	95	25	252	87	181	515	246	259	137	95	71
1977 (1st)							3,737	570	209	281	100	
1977 (2nd)	171	90	79	132	1,369	1,502	1,320	186	181	262	120	30
1976	90	53	206	132	158	1,687	1,164	1,666	623	918	349	283
1975[a]							1,034	404	590	516	783	155

COPEPODITES

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1978 (1st)			371	1,691	866	3,295	208	1,140	6,028	2,234	1,474	
1978 (2nd)	294	289	143	1,162	2,005	940	3,240	4,206	3,106	3,445	794	176
1977 (1st)							11,063	2,114	868	2,226	529	
1977 (2nd)	214	67	110	907	2,550	5,348	3,894	569	1,617	1,857	819	179
1976	423	77	556	[illegible]67	808	9,480	10,178	7,792	3,984	4,334	2,585	957
1975[a]							3,556	17,387	5,517	5,693	2,059	565

[a] Collections for microzooplankton were made routinely beginning in July 1975.

Two collection dates/month: 1st
2nd

Calanus finmarchicus was the most abundant organism collected in the macrozooplankton (0.505 mm mesh net), comprising approximately 40% of the total annual macrozooplankton abundance in 1978 (Table 3.2-9). As a result of a study using similar mesh nets, Fish (1936b) reported *C. finmarchicus* as "the most abundant pelagic animal in the Gulf of Maine". *Calanus finmarchicus* comprised a much smaller percentage of the mesozooplankton (0.333 mm mesh net) samples (Table 3.2-5), although similar abundances were collected by both sample methods (Table 3.2-9). Copepodites were present in Hampton-Seabrook coastal waters throughout all study years; their abundance was generally two orders of magnitude higher than adult abundance. Adults and copepodites occurred in maximum abundance from May through August during all study years, except in 1977 when densities were highest in September.

Neomysis americana is a widely distributed North American species commonly found in near-shore waters (Wigley and Burns, 1971). Like other mysid species, *N. americana* follows regular diurnal vertical migration patterns. In response to light intensity, they inhabit bottom waters in the daytime and move toward the surface during the night (Hurlburt, 1957; Herman, 1963). In Hampton-Seabrook coastal waters, *N. americana* was collected from oblique tows at all times of the year in low abundances. Recruitment of juveniles was indicated by relatively high densities from fall 1977 - winter 1978 (Table 3.2-10, Appendix 6.9). Spatial densities were generally considerably higher at the intake compared with the other two sites, differences at times being up to two orders of magnitude (Appendix 6.9).

Crangon septemspinosa "is a principal link in the nutrient cycle of coastal ecosystems" (Modlin, 1980). Richards (1963), in her studies of demersal fish populations in Long Island Sound, found that 50% of the fish species fed on *C. septemspinosa*. Widely distributed on both the Atlantic and Pacific coasts of North America, *C. septemspinosa* is common in shallow coastal waters and estuaries. This caridean shrimp is well adapted to benthic habitats and can tolerate a wide range of salinity and temperature (Price, 1962). *Crangon septemspinosa* was

TABLE 3.2-9. MEAN ABUNDANCE OF *CALANUS FINMARCHICUS* (NO./.000 m^3) IN HAMPTON-SEABROOK COASTAL WATERS, 1975 THROUGH 1978. SEABROOK ECOLOGICAL STUDIES, 1978.

From macrozooplankton samples, 0.505mm mesh net (oblique tows), July 1977-December 1978; and mesozooplankton samples, 0.333mm mesh bongo net, July 1975-June 1977.

ADULTS

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1978[a]			225	483	3,031	2,775	9,711	122,778				0
	2,216	373	831	0	11,739	784	1,174	18,470	8,173	1,490	0	111
1977[b]							967	630				0
	474	3,6[illegible]	516	22	338	3,780	432	2,662	2,901	165	132	464
1976[c]	107	0	381	0	134	0	634	425	0	0	0	0
1975[d]							2,345	113	228	0	0	0

COPEPODITES

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1978[a]			26	106,002	406,469	45,168	403,584	1,665,805				1,674
	3,993	179	1,420	67,500	16,954	23,119	180,506	191,014	19,290	9,146	2,260	483
1977[b]							23,639	124,721				1,445
	3,220	2,454	24,905	14,234	473,974	125,968	80,962	137,098	189,288	34,832	4,180	2,829
1976[c]	838	172	2,536	17,636	11,252	124,978	174,307	598,587	14,608	305	11,992	4,120
1975[d]							282,813	48,672	101,034	10,102	8,823	2,220

[a] Intake site (Sta. 2), discharge site (Sta. 5) and south (Sta. 6) combined; includes seven dates when only the intake site was sampled.

[b] January-June includes intake and discharge; July-December includes intake, discharge, and south.

[c] Includes intake and discharge.

[d] Collections for mesozooplankton were made routinely beginning in July 1975; includes intake and discharge.

Two collection dates/month: 1st
2nd

TABLE 3.2-10. MEAN ABUNDANCE (NO./1000 m^3) OF *NEOMYSIS AMERICANA*, *CRANGON SEPTEMSPINOSA* AND *CANCER* SPP. IN HAMPTON-SEABROOK COASTAL WATERS, 1976 THROUGH 1978. SEABROOK ECOLOGICAL STUDIES, 1978.

From macrozooplankton samples, 0.505mm mesh net (oblique tows), July 1977-December 1978; and mesozooplankton samples, 0.333mm mesh bongo net, July 1976-June 1977.

NEOMYSIS AMERICANA (all life stages)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1978[a]			5,810	210	330	366	42	508				677
	4,230	44	320	38	0	4	4	43	777	69	356	124
1977[b]						d	115	868				3,154
							3,359	161	150	18,874	2,208	1,246

CRANGON SEPTEMSPINOSA (all life stages)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1978[a]			73	37	4,044	35,268	29,073	23,889				434
	49	2	24	90	13,135	1,218	4,052	2,085	35,782	2,143	443	44
1977[b]							350	397				6
	0	0	0	0	4,041	3,835	1,466	4,978	14,939	3,252	267	37
1976[c]						e						
							18,735	17,673	24,705	0	1,903	0

CANCER SPP. (zoeae and megalopa)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1978[a]			0	0	59	9,226	82,367	282,773				47
	2	1	0	0	31,563	38,939	45,308	71,618	44,478	3,768	187	0
1977[b]						d	27,767	23,240				1
							34,858	48,366	18,257	1,652	146	0

[a] Intake site (Sta. 2), discharge site (Sta. 5) and south (Sta. 6) combined; includes seven dates when only the intake site was sampled.

[b] January-June includes intake and discharge; July-December includes intake, discharge, and south.

[c] Includes intake and discharge.

[d] Not enumerated prior to July 1977.

[e] Not enumerated prior to July 1976.

Two collection dates/month: 1st
2nd

collected in highest abundance in Hampton-Seabrook coastal waters throughout the warmer months (May-October) during all years (Table 3.2-10). Abundance of *C. septemspinosa* was as variable within a given month (e.g., June 1978; $3.5 \times 10^4/1000\ m^3$ and $1.2 \times 10^3/1000\ m^3$) as it was over the entire May - October sampling period (Table 3.2-10).

Cancer spp. developmental stages appeared in Hampton-Seabrook coastal waters in early summer and reached peak abundance in August, during both 1977 and 1978 (Table 3.2-10). Zoeae and megalopa were more abundant in 1978. *Cancer* spp. stage I zoeae ranked fourth in percent composition of macrozooplankton in 1978 (Table 3.2-5).

3.3 *HOMARUS AMERICANUS* LARVAE

3.3.1 Results

Lobster larvae were first collected on July 7 and persisted through October 3 (Table 3.3-1; Figure 3.3-1); maximum density occurred on August 22. Supplemental data from macrozooplankton collections (Table 3.3-2) showed that stage I larvae were present over a 68-day period (July 13 - September 19) and were most abundant on July 31 (Figure 3.3-1). Stage I larvae comprised 12.5% of lobster larvae collected; no stage II larvae and only two stage III larvae were found. Stage IV larvae, which comprised 86.4% of the total catch, were most abundant on August 22 when 56 larvae were collected among large amounts of drift macroalgae/saltmarsh grass. Seasonal (July 7 - October 3) averaged for all stages were 5.4 larvae/1000 m^3 in neuston collections and 0.2/1000 m^3 in mid-depth samples (Table 3.3-3). Ninety-six percent (169) of the larvae were collected in neuston tows.

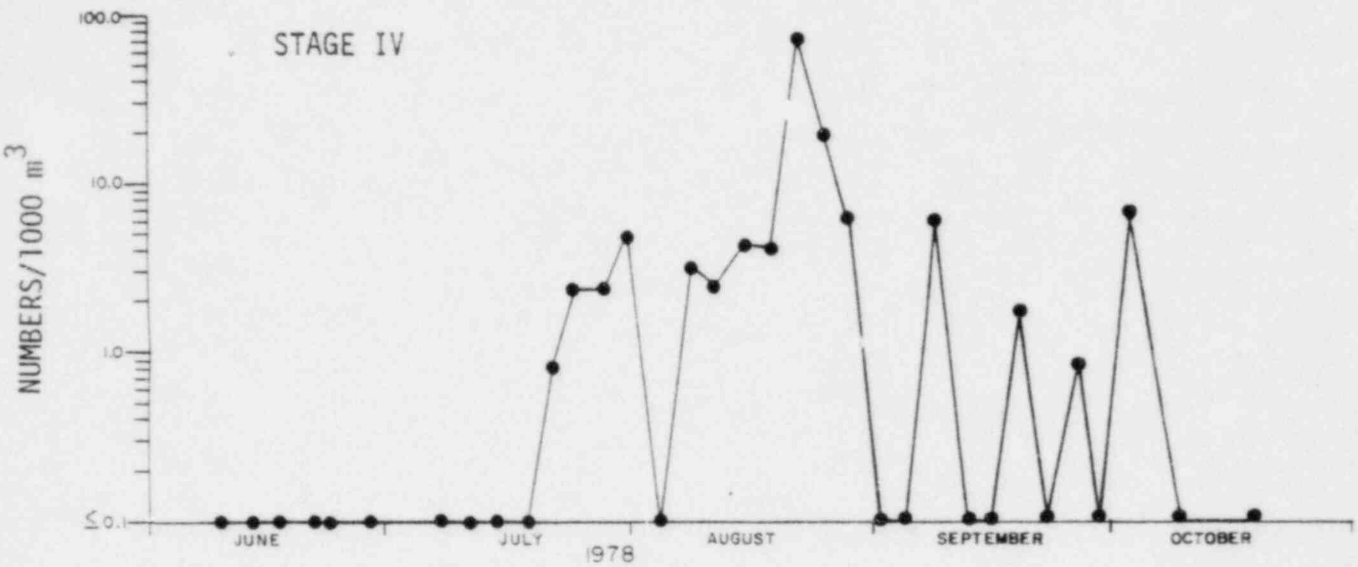
Size frequency analysis indicated that stage IV larvae ranged from 13.6 to 22.0 mm total length; mean length was 16.8 mm (Figure 3.3-2). Mean carapace length was 8.2 mm. The relationship between total length (TL) and carapace length (CL) was:

TABLE 3.3-1. SUMMARY OF ABUNDANCE (NO./1000m³) OF LOBSTER LARVAE IN MID-DEPTH TOWS. SEABROOK ECOLOGICAL STUDIES, 1978.

DATE[a,b]	TOTAL LARVAE	STAGE I	STAGE II	STAGE III	STAGE IV
Jul 7	1.69	0	0	1.69	0
Aug 4	0.58	0.58	0	0	0
Aug 11	0.97	0.97	0	0	0
Aug 22	0.53	0.53	0	0	0
Sep 12	0.63	0	0	0	0.63
Sep 19	0.64	0.64	0	0	0

[a] No larvae collected on June 9, 13, 16, 21 and 23; July 11, 14, 18, 21, 24, 28 and 31; August 8, 15, 18, 25 and 28; September 1, 5, 8, 15, 22, 26 and 29; and October 3, 9 and 18.

[b] No sample collected June 28.



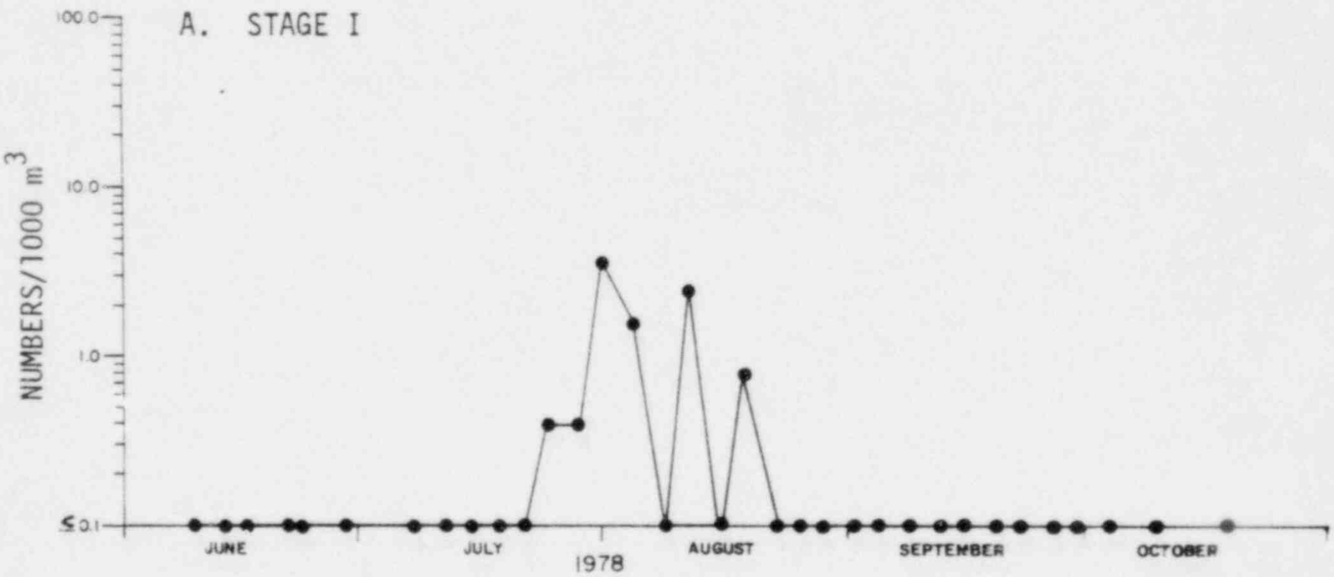


Figure 3.3-1. Abundance of Stage I and Stage IV lobster larvae in neuston collections. Seabrook Ecological Studies, 1978.

TABLE 3.3-2. ABUNDANCE (NO./1000m³)[a] OF STAGE I LOBSTER LARVAE IN OBLIQUE MACROZOOPLANKTON TOWS, JUNE-OCTOBER. SEABROOK ECOLOGICAL STUDIES, 1978.

DATE	STATION 2	STATION 5	STATION 6
Jun 8	0	0	0
Jun 22	0	NA	NA
Jul 13	2.3	0	4.6
Jul 26	0	NA	NA
Aug 9	0	1.7	0
Aug 23	9.9	NA	NA
Sep 6	0	0	0
Oct 5	0	0	0

[a] = Mean of 3 replicates.

NA = Samples not analyzed.

TABLE 3.3-3. MEAN ABUNDANCE (NO./1000m³) OF LOBSTER LARVAE, BY STAGE AND DEPTH. SEABROOK ECOLOGICAL STUDIES, 1978.

	$\overline{X}$ OVER ALL DATES[a]	$\overline{X}$ OVER PERIOD LARVAE WERE PRESENT (JUL 7 - OCT 3)
Neuston		
Total Larvae	4.5	5.4
Stage I	0.3	0.4
Stage II	0.0	0.0
Stage III	<0.1	<0.1
Stage IV	4.2	5.0
Mid-Depth		
Total Larvae	0.2	0.2
Stage I	0.1	0.1
Stage II	0.0	0.0
Stage III	0.1	0.1
Stage IV	<0.1	<0.1

[a] No mid-depth sample on June 28, 1978.

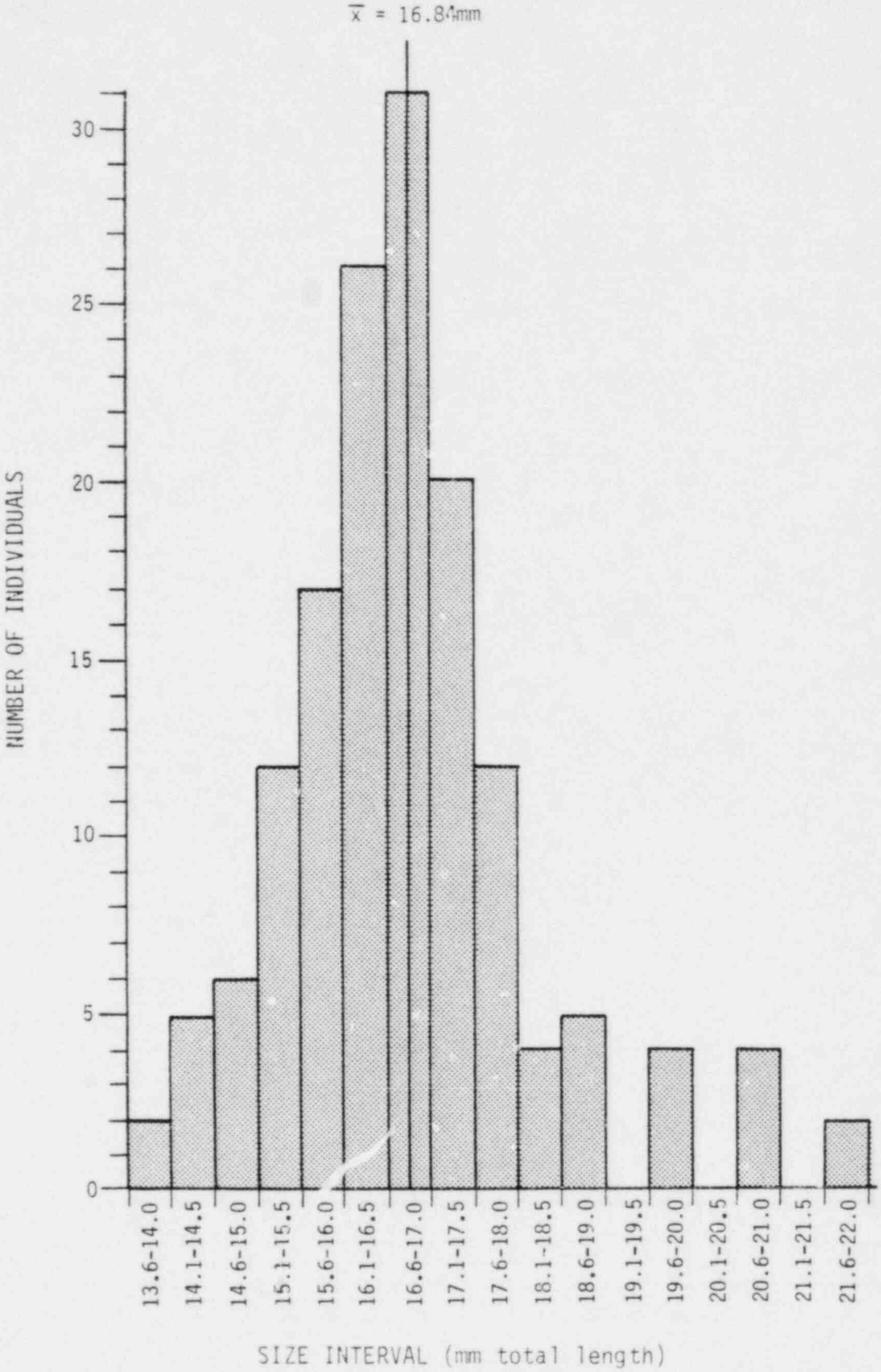


Figure 3.3-2. Size frequency distribution of Stage IV lobster larvae from the Hampton-Seabrook area. Seabrook Ecological Studies, 1978.

$$TL = 0.679\ CL + 11.125 \quad (r_{141} = 0.359)$$

3.3.2 Discussion

The occurrence of and period of peak abundance of lobster larvae in the Hampton-Seabrook area generally agree with data reported elsewhere (Lund and Stewart, 1970; Sherman and Lewis, 1967; Raytheon, 1977; 1979), although densities observed were generally lower than those reported in other New England Studies (Mass. Div. Mar. Fish., 1979 unpubl. data). The majority of larvae were collected in neuston tows, as has been observed by other investigators (Scarratt, 1973; Raytheon, 1977; 1979). The explanation for this pronounced stratification is that lobster larvae are positively phototactic through stage III; only during stage IV does negative phototactic behavior originate (Herrick, 1896; Scarratt, 1973). Of the seven larvae collected at mid-depth, 5 were stage I. Their presence may be indicative of recently-hatched larvae migrating to the surface, or behavioral responses to light producing true vertical stratification.

Cluster analysis was used to compare the stage composition of lobster larvae from the Hampton-Seabrook area with data from other areas of New England and Canada (Wilder, 1953; Scarratt, 1964; 1968; 1969; Sherman and Lewis, 1967; Lund and Stewart, 1970; Raytheon, 1977; Mass. Div. Mar. Fish., unpubl. data, 1978). Three primary groups were identified (Figure 3.3-3). Cluster I (Southern New England and Cape Cod Bay) was composed of areas in which stage distribution was not skewed in favor of any particular stage (Table 3.3-4). Cluster II (Canadian, Maine, Block Island Sound and Cape Cod Bay collections) was dominated by stage I larvae. The Hampton-Seabrook area, composed largely of stage IV larvae, formed a third, distinct cluster. The relatively low numbers of stage I larvae in the Hampton-Seabrook area coupled with this predominance of stage IV larvae suggest that recruitment of lobsters may not be dependent upon a local spawning population.

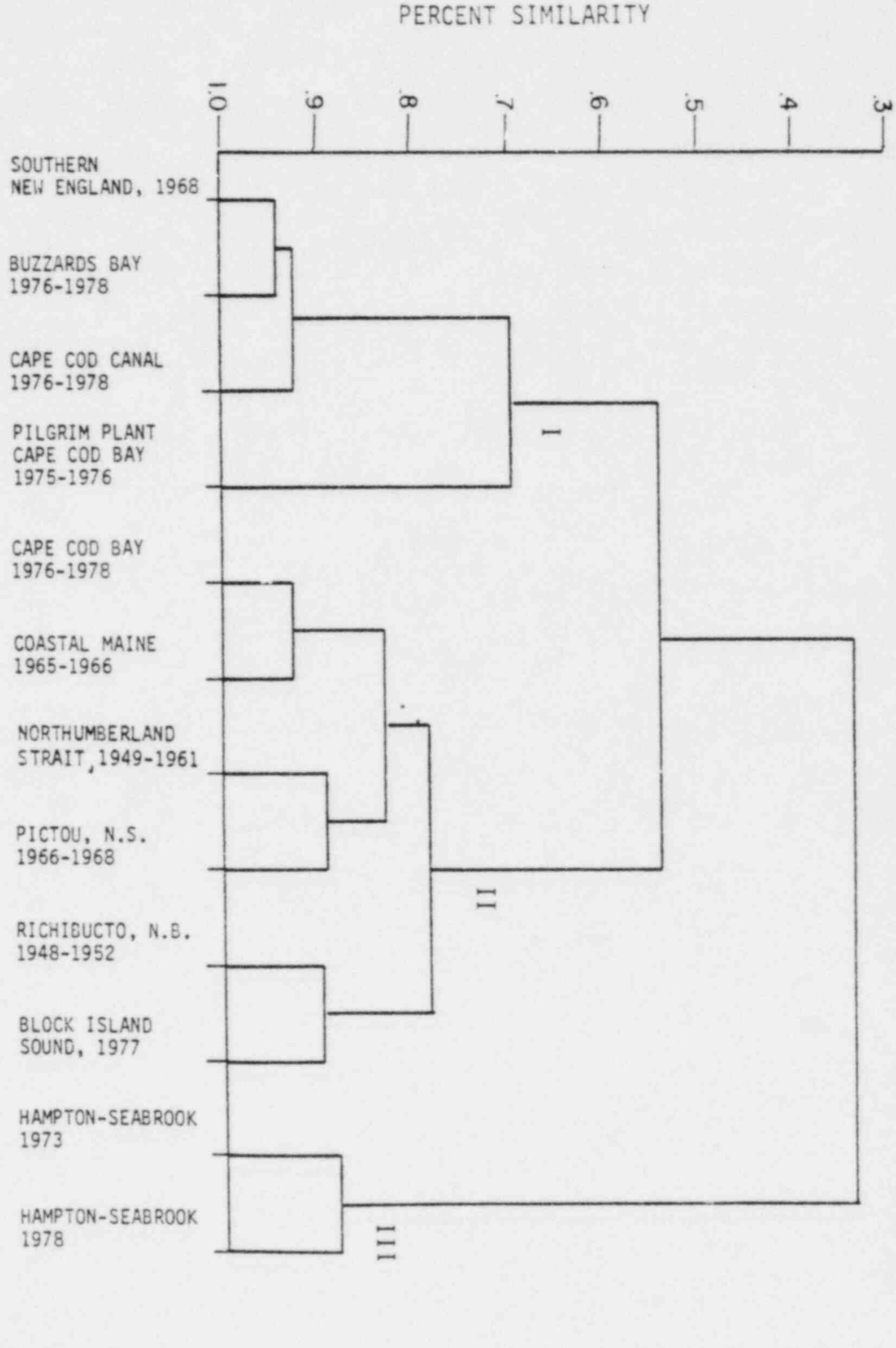


Figure 3.3-3. Dendrogram of percent similarity of the stage composition of lobster larvae populations from New England and Canadian waters. Seabrook Ecological Studies, 1978.

TABLE 3.3-4. PERCENT COMPOSITION BY STAGE OF LOBSTER LARVAE IN CLUSTERS I, II AND III. SEABROOK ECOLOGICAL STUDIES, 1978.

STAGE	CLUSTER I		CLUSTER II		CLUSTER III	
	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE
I	32.4	20.97 - 40.28	77.9	63.0 - 93.52	14.0	12.5 - 15.6
II	18.9	14.75 - 23.87	8.8	1.9 - 21.0	4.5	0 - 8.9
III	22.0	18.58 - 24.02	4.7	0.27 - 12.0	0.6	0 - 1.1
IV	26.6	18.03 - 45.69	7.6	0.56 - 17.39	81.0	75.6 - 86.4

Stage IV larvae from the Hampton-Seabrook area were generally larger than those collected from Canadian and southern New England waters (Table 3.3-5). Templeman (1948) noted that larvae collected in the warmer waters of the Northumberland Strait were smaller than larvae collected from cooler waters; however, he did not provide temperature data. Templeman also suggested that cooler water temperatures may permit greater growth between molts than warmer temperatures. Wilder (1953) compared larval and juvenile growth in the cooler Bay of Fundy with that in the southern Gulf of St. Lawrence and made observations similar to Templeman's. It may be then, that lobster larvae from relatively cool waters of coastal New Hampshire grow considerably larger between molts than their counterparts in southern New England and in some Canadian waters.

Comparisons of meteorological data and presence of stage IV larvae suggest that wind direction may be a factor affecting larval distribution. Scarratt (1968) has suggested that both wind direction and displacement by wind driven currents are factors affecting larval distribution. However, relationship between larval occurrence and meteorological conditions in the Hampton-Seabrook area require further corroborative evidence.

The evidence to date, then, suggests that local recruitment of lobster larvae is relatively unimportant. Presence of later-stage larvae may be influenced by onshore winds, suggesting an offshore source of larvae. Another factor affecting distribution is the presence of floating algae and detritus, which offer a refuge and perhaps an abundant food source from algal-associated organisms.

Further circumstantial evidence that local recruitment is unimportant is based on the low percentages of ovigerous females in the Hampton-Seabrook area relative to other areas. Normandeau Associates, Inc. (1974a) found that an average of 0.75% and 1.51% of the females in the Hampton-Seabrook area were ovigerous during 1972 and 1973, respectively, and less than 5% were ovigerous in the nearby Piscataqua River

TABLE 3.3-5. COMPARISON OF CARAPACE AND TOTAL LENGTH OF STAGE IV LOBSTER LARVAE FROM THE HAMPTON-SEABROOK AREA IN 1978 WITH LARVAE FROM OTHER AREAS. SEABROOK ECOLOGICAL STUDIES, 1978.

	CARAPACE LENGTH (mm)	TOTAL LENGTH (mm)
Hampton-Seabrook, 1978	8.16 (6.0 - 9.7)	16.84 (13.7 - 22.0)
Woods Hole (Herrick, 1896)	-	12.6 (11 - 14)
Southern New England - Inshore (Rogers *et al*, 1968)	7.66	15.64
Southern New England - Offshore (Rogers *et al*, 1968)	8.00	15.87
New Brunswick, Nova Scotia (Templeman, 1948a)	(3.15 - 8.51)	-

Mean (Range)

- Data not available.

(NAI, 1979b). Public Service Company of New Hampshire (unpubl. data) found that between 1974 and 1978, ovigerous females never made up more than 2.4% of the catch, even though females generally made up almost 60% of the population. In contrast, Skud and Perkins (1969) found that an average of 22% of the females were ovigerous from areas on the continental shelf off New England and Squires (1970) reported that between 10% and 35% of the females in Port au Port Bay, Newfoundland were ovigerous.

4.0 SUMMARY

4.1 PHYTOPLANKTON

Phytoplankton assemblages in Hampton-Seabrook coastal waters are usually dominated by diatoms, most notably *Skeletonema costatum*, with seasonal contributions from small flagellates such as *Phaeocystis poucheti* and *Olisthodiscus luteus*. Total phytoplankton densities estimated by whole water collections averaged two orders of magnitude higher than pumped net densities. The whole water method, instituted in July 1977, provided a more representative assessment of abundance levels due to the inclusion of smaller cells and chains not effectively sampled by the 0.076 mm net.

Seasonal patterns of total phytoplankton cell densities, primary productivity and chlorophyll *a* corresponded closely, indicating annual cycles of spring and fall maxima; phytoplankton nutrients are generally at minimal levels in summer and reach maxima during winter. Dominant species during the 1978 spring bloom were the diatoms, *Skeletonema costatum* and *Chaetoceros debilis*, and the haptophyte, *Phaeocystis poucheti*. During fall 1977, the dinoflagellate, *Peridinuim trochoideum*, *Skeletonema costatum* and the chrysophyte, *Olisthodiscus luteus* bloomed in sequence. During fall 1978, *Skeletonema costatum* was succeeded by another diatom, *Rhizosolenia delicatula*; a suite of pennate diatoms was also abundant. Total cell densities and chlorophyll *a* concentrations were usually similar at the intake and discharge; near-bottom cell densities were generally less than surface densities.

4.2 ZOOPLANKTON

The zooplankton assemblage in Hampton-Seabrook coastal waters is composed principally of copepods. Microzooplankton were dominated by developmental stages of copepods and bivalve veliger larvae; the five

top-ranking microzooplankton taxa in all study years were undifferentiated copepod nauplii, *Oithona* spp. copepodites, bivalve veliger larvae, *Pseudocalanus* spp. copepodites and *Oithona* spp. nauplii. Mesozooplankton samples (0.333 mm mesh net), collected from July 1975 through June 1977, were comprised almost exclusively of calanoid copepods. Macrozooplankton sampling (0.505 mm mesh net) replaced mesozooplankton sampling in July 1977; species composition changed with the new collection method to include larger calanoid copepods and several meroplanktonic species. *Calanus finmarchicus* comprised the major portion of the macrozooplankton; other top-ranking macrozooplankton included *Centropages* spp., *Cancer* spp. zoeae, barnacle nauplii and cyprids, *Pseudocalanus* spp. females, *Sagitta elegans*, and developmental stages of *Eualus pusiolus, Crangon septemspinosa* and *Meganyctiphanes norvegica*.

The temporal distribution of microzooplankton was most similar in 1977 and 1978; June and November peaks directly followed phytoplankton blooms. Microzooplankton abundance and species composition differed in surface and bottom collections. Total annual abundance of microzooplankton was higher in surface waters than in near-bottom waters during all study years. The number of taxa/life stages identified was greater in bottom than in surface collections.

Although the seasonal distribution of macrozooplankton was similar to mesozooplankton, total annual densities were considerably lower. The decrease in overall densities and the sharp decline in densities in the fall and winter months reflect the shift in percent composition, due to collection methods, to include the larger and generally less abundant holoplankton and meroplankton. Macrozooplankton abundance increased sharply in April and remained high through July. Species contributing to total macrozooplankton abundance varied seasonally and spatially. Total annual abundances, in both mesozooplankton and macrozooplankton collections, were slightly higher at the discharge site than at the intake site. At the south site, sampled from July 1977 through December 1978, total abundance was higher than at the intake or

discharge sites; in 1978, total abundance was an order of magnitude higher than at the intake or discharge sites.

4.3 *HOMARUS AMERICANUS* LARVAE

Lobster larvae were present in the Hampton-Seabrook area from July through October, with greatest abundance on August 22. Ninety-six percent of the larvae were collected in neuston tows. Size-frequency analysis indicated that stage IV larvae from coastal New Hampshire are larger than those collected from Canadian waters; this is likely a response to cooler water temperatures prolonging stage duration and permitting greater growth between stages.

The relatively high numbers of stage IV lobster larvae and low percentages of ovigerous females in the area suggest that recruitment of lobster larvae in the Hampton-Seabrook area is not dependent upon local contributions. Meteorological data also suggest that recruitment is from more distant stocks.

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APPENDIX 6.1. TAXONOMIC LIST OF NET AND WHOLE WATER PHYTOPLANKTON COLLECTED AT STATIONS 2 AND 5. SEABROOK ECOLOGICAL STUDIES, 1978.

	SAMPLE TYPE
CLASS: BACILLARIOPHYCEAE	
ORDER: Centrales	
Biddulphia alternans	B
Biddulphia aurita	C
Cerataulina bergoni	B
Chaetoceros affinis	A
Chaetoceros atlanticus	A
Chaetoceros brevis	C
Chaetoceros compressus	C
Chaetoceros concavicornis	C
Chaetoceros convolutus	B
Chaetoceros danicus	C
Chaetoceros debilis	C
Chaetoceros decipiens	C
Chaetoceros diadema	C
Chaetoceros furcellatus	B
Chaetoceros laciniosus	C
Chaetoceros lauderi	B
Chaetoceros lorenzianus	C
Chaetoceros lorenzianus f. forceps	C
Chaetoceros socialis	C
Chaetoceros teres	C
Chaetoceros spp.	C
Coscinodiscus spp.	C
Coscinosira polychorda	C
Ditylum brightwelli	A
Detonula confervacea	C
Guinardia flaccida	C
Leptocylindrus danicus	B
Leptocylindrus minimus	B
Melosira moniliformis	C
Melosira nummuloides	A
Paralia sulcata	C
Porosira glacialis	C
Rhizosolenia delicatula	C
Rhizosolenia hebetata	C
Rhizosolenia setigera	B
Rhizosolenia spp.	A
Skeletonema costatum	C
Thalassiosira nordenskioldii	C
Thalassiosira rotula	C
Thalassiosira spp.	C
Unspecified centrales	A

(Continued)

APPENDIX 6.1. (Continued)

CLASS: DINOPHYCEAE

ORDER: Prorocentrales

Ceratium arcticum	A
Ceratium fusus	A
Ceratium horridum	A
Ceratium lineatum	A
Ceratium longipes	C
Ceratium macroceros	A
Ceratium tripos	C
Ceratium spp.	A
Gyrodinium spp.	B
Heterocapsa triquetra	B
Peridinium depressum	C
Peridinium trochoideum	C
Peridinium spp.	B
Prorocentrum micans	C
Prorocentrum redfieldi	B
Prorocentrum triestinum	B

ORDER: Dinophysiales

Dinophysis norvegica	B
Dinophysis rotundatum	B

ORDER: Peridiniales

Gonyaulax sp.	B
Oxytoxum spp.	B

CLASS: CHLOROPHYCEAE

ORDER: Chlorococcales

Pediastrum duplex	B
Scenedesmus armatus	B
Scenedesmus spp.	B

ORDER: Zygnematales

Staurastrum spp.	B

CLASS: HAPTOPHYCEAE

ORDER: Prymnesiales

Phaeocystis poucheti	B

(Continued)

APPENDIX 6.1. (Continued)

ORDER: Pennales

Amphora spp.	B
Asterionella formosa	C
Asterionella glacialis	C
Bacillaria paxillifer	A
Campylodiscus spp.	A
Cocconeis scutellum	B
Cylindrotheca closterium	C
Fragilaria spp.	C
Grammatophora angulosa	C
Grammatophora marina	C
Grammatophora spp.	A
Gyrosigma balticum	B
Gyrosigma fasciola	C
Gyrosigma/Pleurosigma spp.	C
Isthmia nervosa	A
Licmophora abbreviata	C
Licmophora flabellata	C
Licmophora spp.	A
Navicula crucigera	B
Navicula spp.	A
Nitzschia delicatissima	C
Nitzschia longissima	C
Nitzschia seriata	C
Pleurosigma angulatum	C
Pleurosigma naviculaceum	B
Rhabdonema adriaticum	A
Rhabdonema arcuatum	A
Tabellaria fenestrata	B
Tabellaria spp.	A
Thalassionema nitzschioides	C
Unspecified pennales	C

CLASS: CHRYSOPHYCEAE

ORDER: Ochromonadales

Dinobryon spp.	A
Olisthodiscus luteus	B

ORDER: Dictyochales

Dictyocha fibula	B
Dictyocha speculum	B
Ebria tripartita	B

(Continued)

APPENDIX 6.1. (Continued)

CLASS: CRYPTOPHYCEAE

ORDER: Cryptomonadales

Chroomonas sp. C

CLASS: CYANOPHYCEAE

ORDER: Chroococcales

Merismopedia (Agmenellum) spp. B

CLASS: EUGLENOPHYCEAE

ORDER: Englenales

Eutreptiella sp. C

A = collected in 0.076 mm net samples.

B = collected in whole water samples.

C = collected in both 0.076 mm net and whole water samples.

APPENDIX 6.2. ABUNDANCE (Cells/liter) AND PERCENT COMPOSITION OF SELECTED NET PHYTOPLANKTON TAXA COLLECTED AT STATION 2 (depths averaged). SEABROOK ECOLOGICAL STUDIES, 1978.

SAMPLE DATES	*Chaetoceros debilis*		*Thalassiosira nordenskioldii*		*Chaetoceros laciniosus*		*Chaetoceros decipiens*		*Chaetoceros diadema*		*Chaetoceros* sp.		*Chaetoceros lorenzianus*		*Skeletonema costatum*		*Peridinium depressum*		*Rhizosolenia hebetata*		*Thalassionema nitzschioides*		*Chaetoceros affinis*		*Coscinodiscus* sp.		*Ceratium longipes*	
	#/ℓ	%	#/ℓ	%	#/ℓ	%	#/ℓ	%	#/ℓ	%	#/ℓ	%	#/ℓ	%	#/ℓ	%	#/ℓ	%	#/ℓ	%	#/ℓ	%	#/ℓ	%	#/ℓ	%	#/ℓ	%
Jan 16	2	2					7	7			4	4													59	62	2	2
Feb 15	63	40			5	3	27	17	1	<1	15	10			4	2							16	10	4	2	2	1
Mar 17	169	3	1,391	27	173	3	866	17	2,303	46					53	1					<1	<1			19	<1		
30	548	3	9,285	52	1,207	7	1,965	11	4,298	24	9	<1			109	<1			13	<1	60	<1			7	<1		
Apr 12	4,889	26	1,129	6	6,195	34	2,762	15	281	2	2,547	14					6	<1	2	<1	134	<1						
26			3	6	5	10					3	5					<1	2							<1	<1	7	15
May 10							4	6			7	11					1	2							5	7		
24	87,684	90			2,802	3	911	<1			2	<1	2,369	2					762	<1			495	<1	<1			
Jun 7	38	3			1,033	78	17	1			123	9			<1	<1	89	7	<1	<1							9	<1
21	254	8			166	5	156	5			879	28			576	18	1,090	34	<1	<1								
Jul 13					5	11	1	3							2	3	<1	2	<1	<1			10	21	<1	2	22	47
26					5	7											25	33	2	2			3	4	1	2	39	52
Aug 9																			1	5							19	82
23																	<1	2									10	49
Sep 6																			30	53			5	9			7	12
20					7	3					2	<1	2	<1	7	3			130	62	<1	<1	41	20			5	3
Oct 4	4	<1			5	1	22	5			2	<1			266	58			88	19	7	2	23	5			11	2
18	2	<1					4	<1							421	73			22	4	106	18	<1	<1	1	<1	2	<1
Nov 2							11	2			2	<1			516	79			14	2	75	11	12	2	2	<1	<1	<1
15	22	3					49	7			16	2			47	7			9	1	347	50			5	<1		
Dec 6					1	<1	85	33			2	<1									5	2			155	60		

Blanks indicate zero occurrences.

APPENDIX 6.3. ABUNDANCES (CELLS/LITER) AND PERCENT COMPOSITION OF SELECTED WHOLE WATER PHYTOPLANKTON TAXA COLLECTED AT STATIONS 2 (DEPTHS AVERAGED EXCEPT WHEN NOTED) AND 5 (SURFACE) FROM JANUARY THROUGH DECEMBER 1978. SEABROOK ECOLOGICAL STUDIES, 1978.

	Skeletonema costatum		Rhizosolenia delicatula		Nitzschia delicatissima		Thalassiosira nitzschioides		Phaeocystis pouchetii		Pennales		Chaetoceros debilis	
STATION 2	#/l	%	#/l	%	#/l	%	#/l	%	#/l	%	#/l	%	#/l	%
Jan 16	309	7									722	15		
Feb 15	8,460	75									670	6		
Mar 17	47,700	48			1,550	2	361	<1			5,670	6	4,800	5
30	153,000	47	413	<1	4,180	1	361	<1			5,160	2	7,680	2
Apr 7*	11,400	3			5,480	1			354,000	78	1,031	<	5,980	1
12					670	<1			734,000	82	2,220	<1	516	<1
18*					5,470	2			294,000	94				
26	2,420	33									1,080	15		
May 1*											1,750	24		
10	361	11			'03	3					1,390	44		
18*	1,960	10							13,000	67			2,170	11
24	1,800	<1	361	<1	103	<1			107,000	13	206	<1	471,000	80
31*	97,800	14	619	<1	28,900	4							366,000	51
Jun 7	3,510	3	155	<1	12,000	10			81,400	69	825	<1	206	<1
14*											722	17		
21	240,000	40	258	<1	276,000	46			72,400	12	567	<1		
28*	10,000	<1	16,000	1	1,570,000	98					1,860	<1		
Jul 13	413	10									516	13		
28	4,590	39	309	3							825	7		
Aug 9	773	25	52	2							928	30		
23	206	5									516	12		
Sep 6											464	9		
20	5,620	12	5,570	12			6,80[illegible]	15			3,820	8		
27*	283,000	72	25,800	7	1,920	1	12,700	3			13,100	3		
Oct 4	3,930,000	92	75,000	2	56,700	1	55,100	1			104,000	2		
12*	1,530,000	77	102,000	5	23,400	1	106,000	5			31,500	2		
18	2,260,000	65	637,000	18	20,900	<1	364,000	11			146,000	4		
25*	1,150,000	47	607,000	[illegible]	18,700	1	348,000	14			271,000	11		
Nov 2	1,870,000	61	79[illegible],000	26	17,300	<1	237,000	8			300	4		
9*	403,000	19	942,000	44	101,000	5	319,000	15			34[illegible],000	16		
15	174,000	11	691,000	57	33,700	38	206,000	17			111,000	9	309	<1
Dec 6	3,610	13	6,240	23			4,540	17			8,040	30		
STATION 5														
Jan 16											309	7		
Feb 15	2,990	53									722	13		
Mar 17	40,000	54			1,960	3					4,330	6	3,820	5
30	54,600	53	206	<1	2,480	2					2,269	2	309	<1
Apr 12					23,900	<1			2,390,000	97	1,960	<1	18,600	<1
26											928	13		
May 10					1,030	25					1,340	33		
24	2,890	<1			722	<1	309	<1			516	<1	495,000	97
Jun 7					65,400	23			212,000	74				
Oct 9	553,000	85	14,700	2	13,000	2	22,600	3			12,600	2		
Nov 2	2,520,000	66	974,000	25	17,000	<1	21[illegible],000	6			80,500	2		

	Nitzschia longissima		Chaetoceros laciniosus		Ceratium longipes		Chaetoceros socialis		Chromulina sp.		Cylindrotheca closterium		Paralia sulcata	
STATION 2	#/l	%	#/l	%	#/l	%	#/l	%	#/l	%	#/l	%	#/l	%
Jan 16	206	4									413	9	877	19
Feb 15	567	5									206	[illegible]		
Mar 17	5,775	6	516	<1			9,178	9	155	<1	3,400	3	309	<1
30	4,023	1	4,692	1			16,191	5			258	<1	1,080	<1
Apr 7*			2,578	<1			69,609	15						
12	516	<1					3,760	<1			1,130	<1		
18*							7,320	2	1,860	<1				
26	258	4							3,300	44	52	<1		
May 1*									2,780	38				
10									206	7	309	10		
18*														
24	103	<1	1,031	<1					1,960	<1	309	<1		
31*	825	<1	138,188	19			15,400	2	11,344	2				
Jun 7	670	<1	7,734	7					670	<1	1,700	1	206	<1
14*	206	5							722	17				
21	3,558	<1									3,820	1		
28*	413	<1	619	<1					516	<1				
Jul 13	2,031	26			103	3					980	25		
28	413	4			464	4			309	3	52	<1		
Aug 9	258	8			206	7			567	18			309	10
23					52	1			464	11	52	1	464	11
Sep 6	516	10			52	1			1,340	25	52	1	619	11
20	16,191	35			52	<1					52	<1	464	1
27*	34,031	9											722	<1
Oct 4	62,133	1									1,600	<1		
12*	34,444	2							619	<1	722	<1		
18	41,456	1									825	<1	1,700	<1
25*	17,016	<1									412	<1		
Nov 2	11,602	<1									155	<1	619	<1
9*	6,394	<1							4,330	<1				
15	6,033	<1												
Dec 6	464	2									258	1		
STATION 5														
Jan 16	309	7											2,060	49
Feb 15	722	13			103	2							1,030	18
Mar 17	8,870	12	1,031	1			2,890	4			103	<1	309	<1
30	2,170	2	309	<1							413	<1	1,240	1
Apr 12	1,650	<1	1,650	<1			19,200	<1	1,960	<1				
26					103	1			5,360	76				
May 10													1,030	25
24	413	<1	1,440	<1	619	<1			2,480	<1				
Jun 7	309	<1	1,440	<1	103	<1			1,340	<1	309	<1		
Oct 9	31,200	5									309	<1	3,400	<1
Nov 2	13,600	<1												

* surface collection only. Blanks indicate zero occurrences.

APPENDIX 6.4. PRIMARY PRODUCTIVITY, CHLOROPHYLL *a* AND PLANT NUTRIENTS IN SURFACE WATERS AT STAIONS 2 AND 5 FROM JANUARY THROUGH DECEMBER 1978. SEABROOK ECOLOGICAL STUDIES, 1978.

SAMPLE DATE	STATION	PRIMARY PRODUCTIVITY ($mgC/m^3/hr$) REP.1	REP.2	$\bar{X}$	*CHLOROPHYLL *a* (mg/m^3)	*PHAEOPHYTIN (mg/m^3)	RATIO OF PRODUCTIVITY TO BIOMASS (C/Chl/hr)	TEMP. C	SALINITY ppt	ORTHOPHOSPHATE PO_4-P (μg/ℓ)	TOTAL PHOSPHOROUS TOTAL P (μg/ℓ)	NITRATE NO_3-N (μg/ℓ)	NITRITE NO_2-N (μg/ℓ)	AMMONIA NH_3-N (μg/ℓ)
Jan 16	2	0.89	0.37	0.63	0.38 ± 0.03	1.56 ± 0.12	1.66	2.3	32.4	10.0	53.0	170.0	2.0	40.0
	5	0.78	0.89	0.84	0.34 ± 0.03	1.19 ± 0.30	2.47	2.1	32.0	10.0	45.0	110.0	3.0	20.0
Feb 15	2	0.69	0.62	0.66	0.22 ± 0.02	0.33 ± 0.03	3.00	0.0	31.7	10.0	35.0	150.0	3.0	30.0
	5	0.24	0.36	0.30	0.22 ± 0.03	0.29 ± 0.01	1.36	0.0	31.9	16.0	30.0	160.0	4.0	40.0
Mar 17	2	1.91	2.15	2.03	1.93 ± 0.04	0.93 ± 0.08	1.05	1.0	32.2	11.0	41.0	110.0	3.0	40.0
	5	2.15	4.27	3.21	2.09 ± 0.13	0.76 ± 0.07	1.54	1.1	31.6	5.0	46.0	120.0	3.0	40.0
Mar 30	2	13.91	14.80	14.36	9.01 ± 0.56	4.30 ± 0.39	1.59	2.3	31.7	11.0	38.0	120.0	4.0	20.0
	5	11.25	13.42	12.34	8.78 ± 0.25	5.23 ± 0.65	1.40	2.5	28.5	8.0	33.0	30.0	3.0	10.0
Apr 12	2	4.96	9.04	7.00	4.84 ± 1.43	3.11 ± 0.85	1.45	3.6	30.5	7.0	38.0	10.0	4.0	16.0
	5	8.85	7.08	8.00	5.97 ± 0.31	3.39 ± 0.43	1.34	3.4	29.9	11.0	3[illegible].0	10.0	2.0	9.0
Apr 25	2	2.66	2.88	2.77	0.38 ± 0.03	0.33 ± 0.03	7.29	6.4	28.8	7.0	24.0	20.0	3.0	8.0
	5	2.73	2.50	2.62	0.42 ± 0.02	0.31 ± 0.01	6.24	6.3	29.1	6.0	26.0	10.0	3.0	16.0
May 10	2	1.54	0.61	1.08	0.38 ± 0.06	0.82 ± 0.14	2.84	5.5	31.9	10.0	45.0	30.0	3.0	15.0
	5	2.81	2.97	2.89	0.52 ± 0.04	0.98 ± 0.11	5.56	5.6	31.8	16.0	30.0	30.0	3.0	14.0
May 24	2	5.84	5.88	5.86	2.23 ± 0.22	1.55 ± 0.22	2.63	9.6	29.9	10.0	24.0	10.0	2.0	32.0
	5	3.93	3.42	3.68	2.03 ± 0.25	1.65 ± 0.26	1.81	9.9	29.4	9.0	44.0	10.0	2.0	32.0
Jun 7	2	3.13	3.78	3.46	0.58 ± 0.04	0.66 ± 0.07	5.97	12.1	29.3	11.0	30.0	10.0	3.0	24.0
	5	3.32	2.82	3.07	0.57 ± 0.05	0.55 ± 0.04	5.39	12.7	29.2	8.0	41.0	10.0	2.0	18.0
Jul 13	2	1.67	2.00	1.84	0.40 ± 0.05	0.34 ± 0.09	4.60	13.5	32.1	9.0	25.0	10.0	2.0	19.0
	5	2.50	2.05	2.28	0.22 ± 0.01	0.19 ± 0.02	10.36	12.6	31.9	7.0	30.0	10.0	2.0	12.0
Aug 9	2	2.87	2.10	2.49	0.68 ± 0.04	0.52 ± 0.03	3.66	16.2	31.2	12.0	17.0	10.0	2.0	19.0
	5	3.21	3.89	3.02	0.72 ± 0.05	0.75 ± 0.09	4.19	16.4	31.0	12.0	30.0	10.0	2.0	9.0
Sep 6	2	1.91	1.97	1.94	0.90 ± 0.11	0.37 ± 0.03	2.16	15.2	31.9	<5.0	18.0	10.0	<1.0	240.0
	5	2.22	1.81	2.02	0.76 ± 0.02	0.26 ± 0.05	2.65	15.2	31.5	<5.0	12.0	10.0	<1.0	50.0
Oct 4	2	7.68	6.46	7.07	3.71 ± 0.13	1.06 ± 0.28	1.91	12.2	32.5	<5.0	13.0	10.0	<1.0	70.0
	5	-	-	-	- -	- -	-	-	-	-	-	-	-	-
Nov 2	2	8.90	8.95	8.93	4.24 ± 0.23	1.33 ± 0.19	2.11	9.1	33.0	9.0	41.0	20.0	<1.0	40.0
	5	9.66	8.96	9.31	4.91 ± 0.18	1.23 ± 0.34	1.90	9.2	32.9	5.0	14.0	10.0	<1.0	130.0
Dec 6	2	1.24	1.48	1.36	1.14 ± 0.07	0.43 ± 0.02	1.19	6.6	33.3	15.0	53.0	90.0	1.0	70.0
	5	2.39	2.38	2.39	1.00 ± 0.07	0.43 ± 0.09	2.39	6.4	33.2	16.0	57.0	70.0	1.0	400.0

* mean ± one standard deviation

- not sampled

APPENDIX 6.5. TAXONOMIC LIST OF MICROZOOPLANKTON+ COLLECTED AT THE INTAKE SITE. SEABROOK ECOLOGICAL STUDIES, 1978.

		ankton ype
Phylum: Protozoa		
Subphylum: Sarcomastigophora		
Order: Dinoflagellida		
Order: Foraminiferida		T
Subphylum: Ciliophora		
Order: Tintinnida		H
Phylum: Mesozoa		
Phylum: Cnidaria		
Class: Hydrozoan		
	Hydrozoan, medusal stage	M
Phylum: Aschelminthes		
Class: Rotifera		H
Class: Nematoda		T
Phylum: Chaetognatha		
	Sagitta elegans	H
Phylum: Bryozoa		
	Bryozoan cyphonautes larvae	M
Phylum: Mollusca		
Class: Gastropoda		
Subclass: Prosobranchia		
	Gastropod veliger	M
Subclass: Opisthobranchia		
	Opisthobranch veliger	M
Class: Bivalvia		
	Bivalve straight-hinge veliger	M
	Bivalve umbone veliger	M
Phylum: Annelida		
Class: Polychaeta		M
Phylum: Arthropoda		
Class: Crustacea		
Subclass: Brachiopoda		
Order: Cladocera		
	Podon spp.	H
	Evadne spp.	H
Subclass: Ostracoda		
Subclass: Copepoda		
	Copepod nauplii	H
Order: Calanoida	*Acartia* spp. copepodite	H

(Continued)

APPENDIX 6.5 (Cont.)

	Acartia hudsonica female	H
	Acartia hudsonica male	H
	Acartia longiremus female	H
	Acartia longiremus male	H
	Calanus finmarchicus copepodite	H
	Calanus finmarchicus female	H
	Calanus finmarchicus male	H
	Centropages spp. copepodite	H
	Centropages hamatus female	H
	Centropages hamatus male	H
	Centropages typicus female	H
	Centropages typicus male	H
	Eurytemora spp. copepodite	H
	Eurytemora americana female	H
	Eurytemora americana male	H
	Eurytemora herdmani female	H
	Eurytemora herdmani male	H
	Metridia spp. copepodite	H
	Metridia longa male	H
	Metridia lucens male	H
	Paracalanus parvus copepodite	H
	Paracalanus parvus female	H
	Pseudocalanus/Calanus nauplii	H
	Pseudocalanus spp. copepodite	H
	Pseudocalanus spp. female	H
	Pseudocalanus spp. male	H
	Temora longicornis copepodite	H
	Temora longicornis female	H
	Temora longicornis male	H
	Tortanus discaudatus copepodite	H
	Tortanus discaudatus female	H
	Tortanus discaudatus male	H
Order: Cyclopoida		
	Oithona spp. copepodite	H
	Oithona spp. female	H
	Oithona spp. male	H
Order: Harpacticoida		
	Microsetella norvegica	H
Subclass: Cirripedia		
	Cirripedia nauplii	M
	Cirripedia cypris	M
	Hansen's nauplii	M
Subclass: Malacostraca		
Order: Amphipoda		T
Order: Euphausiacea		
	Euphausiacea furcilia	H
	Euphausiacea calyptopis	H

(Continued)

APPENDIX 6.5 (Cont.)

Order: Decapoda		
	Crangon septemspinosa larvae	M,T
	Pagurus sp. zoea	M
	Cancer spp. zoea	M
	Carcinas maenas zoea	M
Phylum: Echinodermata		
	Echinoderm larva	M
Phylum: Chordata		
	Larvacea	H

† Zooplankton collected in 0.076 mm mesh nets, pumped; surface and bottom

APPENDIX 6.6. TAXONOMIC LIST OF MACROZOOPLANKTON+ COLLECTED IN HAMPTON-SEABROOK COASTAL WATERS. SEABROOK ECOLOGICAL STUDIES, 1978.

Taxon		Plankton Type
Phylum: Cnidaria		
Class: Hydrozoa		
Order: Athecata		
	Bougainvillia spp.	M
	Bougainvillia principis	M
	Dipurena sp.	M
	Euphysa aurata	M
	Hybocodon prolifer	M
	Rathkea octopuncata	M
	Sarsia tubulosa	M
Order: Thecata		
	Phialidium sp.	M
Order: Trachymedusae		
	Aglantha digitale	M
Order: Siphonophora		
	Nanomia cara	M
Order: Semaeostomae		
	Aurelia aurita	M
	Cyanea capillata	M
Phylum: Ctenophora		
Class: Tentaculata		
Order: Cydippida		
	Pleurobrachia pileus	H
Class: Nuda		
Order: Beroida		
	Beroe cucumis	H
Phylum: Platyhelminthes		
Class: Cestoda		T
Phylum: Rhynchocoela		
Class: Anopla		
Order: Heteronemertea		
	Cerebratulus spp.	T
Class: Enopla		
Order: Hoplonemertea		
Suborder: Monostylifera		
	Tetrastemma spp.	T
Phylum: Chaetognatha		
	Sagitta elegans	H
Phyllum: Mollusca		
Class: Gastropoda		

(Continued)

APPENDIX 6.6 (Cont.)

Subclass: Prosobranchia		
Order: Mesogastropoda		
	Alvania sp.	M
	Lacuna vincta	M
Subclass: Opisthobranchia		
Order: Thecosomata		
Suborder: Euthecosomata		
	Limacina retroversa	H
Order: Gymnosomata		
	Clione limacina	H
Order: Nudibranchia		
Suborder: Aeolidacea		T
Class: Cephalopoda		H
Phylum: Annelida		
Class: Polychaeta		
Order: Phyllodocida		
	Aglaophamus circinata	T
	Eteone spp.	T
	Eteone trilineata	T
	Nephtys spp.	T
	Nephtys ciliata	T
	Nereis pelagica	M
	Procereae sp.	M
	Tomopteris helgolandica	H
Order: Capitellida		
	Scalibregma inflatum	T
Order: Spionida		
	Scolelepis squamata	T
	Spio filicornis	T
	Unidentified larvae	M
Order: Ariciida		
	Orbinia swani	T
Order: Cirratulida		
	Chaetozone setosa	T
Order: Terebellida		
	Polycirrus eximius	T
Class: Hirudinea		T
Phylum: Arthropoda		
Subphylum: Pycnogonida		
Class: Pantopoda		
Class: Crustacea		
Subclass: Branchiopoda		
Order: Cladocera		
	Podon spp.	H
	Evadne spp.	H
Subclass: Ostracoda		H
Subclass: Copepoda		
Order: Calanoida		
	Acartia hudsonica	H

(Continued)

APPENDIX 6.6 (Cont.)

	Acartia longiremis	H
	Aetideus armatus	H
	Anomalocera opalus	H
	Calanus finmarchicus	H
	Calanus hyperboreus	H
	Candacia armata	H
	Centropages hamatus	H
	Centropages typicus	H
	Eurytemora herdmani	H
	Labidocera aestiva	H
	Metridia longa	H
	Metridia lucens	H
	Paracalanus parvus	H
	Pseudocalanus spp.	H
	Rhincalanus nasutus	H
	Temora longicornis	H
	Tortanus discaudatus	H
Order: Cyclopoida		
	Caligus elongata	M
Order: Harpacticoida		
	Alteutha oblonga	T
	Thalestris longimana	T
	Tisbe spp.	T
Order: Monstrilloida		
	Monstrillopsis sarsi	M
Subclass: Cirripedia		M,T
Subclass: Malacostraca		
Series: Leptostraca		
Superorder: Peracarida		
Order: Cumacea		
	Diastylis polita	T
	Diastylis quadrispinosa	T
	Diastylis sculpta	T
	Eudorella pusilla	T
	Eudorellopsis deformis	T
	Lamprops quadriplicata	T
	Leucon americanus	T
	Mancocuma stellifera	T
	Petalosarsia declivis	T
	Pseudoleptocuma minor	T
Order: Isopoda		
Suborder: Valvifera		
	Chiridotea arenicola	T
	Chiridotea caeca	T
	Chiridotea tuftsi	T
	Edotea triloba	T
	Idotea balthica	T
	Idotea phosphorea	T
Order: Amphipoda		
Suborder: Hyperiidea		
	Hyperia galba	H
	Hyperoche medusarum	M
	Parathemisto guadichaudi	H

(Continued)

APPENDIX 6.6 (Cont.)

Suborder: Gammaridea		
	Acanthonotozoma serratum	T
	Ampelisca agassizi	T
	Anonyx sarsi	T
	Argissa hamatipes	H
	Calliopius laeviusculus	H
	Corophium acherusicum	T
	Corophium bonelli	T
	Corophium insidiosum	T
	Cymadusa compta	T
	Dexamine thea	T
	Dulichia falcata	T
	Gammarellus angulosus	T
	Gammarus duebeni	T
	Gammarus lawrencianus	T
	Gammarus oceanicus	T
	Hyale nilssoni	T
	Ischyroceros anguipes	T
	Jassa falcata	T
	Lembos websteri	T
	Leptocheirus pinguis	T
	Metopa borealis	T
	Metopa bruzelli	T
	Metopella carinata	T
	Metopella longimana	T
	Monoculodes sp.	T
	Monoculodes tuberculatus	T
	Orchomenella minuta	T
	Orchomenella pinguis	T
	Photis macrocoxa	T
	Phoxocephalus holbolli	T
	Pontogeneia inermis	T
	Psmmonyx nobilis	T
	Rhachotropis oculata	H
	Syrrhoe crenulata	T
	Tiron spiniferum	T
	Unciola irrorata	T
Suborder: Caprellidea		
	Aeginina longicornis	T
	Caprella septentrionalis	T
Order: Mysidacea		
Suborder: Mysida		
	Erythrops erythropthalma	T
	Mysis mixta	T
	Neomysis americana	T
Superorder: Eucarida		
Order: Euphausiacea		
	Meganyctiphanes norvegica	H

(Continued)

APPENDIX 6.6 (Cont.)

	Thysanoessa inermis	H
	Thysanoessa raschi	H
Order: Decapoda		
Infraorder: Caridea		
	Caridion gordoni	M
	Crangon septemspinosa	M
	Eualus spp.	M
	Eualus fabricii	M,T
	Eualus pusiolus	M,T
	Lebbeus polaris	M,T
	Palaemonetes spp.	M
	Pandalus montagui	T
	Spirontocaris phippsii	M,T
Infraorder: Astacidea		
	Homarus americanus	M,T
Infraorder: Anomura		
Superfamily: Thalassinoidea		
	Axius serratus	M,T
Superfamily: Paguroidea		
	Pagurus arcuatus	M,T
	Pagurus longicarpus	M,T
	Pagurus pubescens	M,T
Infraorder: Brachyura		
	Cancer spp.	M
	Carcinas maenas	M
	Hyas coarctatus	M,T
Phylum: Echinodermata		
Class: Stelleroidea		
Subclass: Ophiuroidea		
Order: Ophiurida		
	Ophiopholis aculeata	T
Phylum: Chordata		
Class: Larvacea		
	Oikopleura spp.	H

† Zooplankton collected in 0.505 mm mesh nets, oblique tows.

APPENDIX 6.7. ABUNDANCE (NO./m^3) AND PERCENT COMPOSITION OF DOMINANT MICROZOOPLANKTON COLLECTED AT THE INTAKE SITE (STATION 2), SURFACE AND BOTTOM AVERAGED. SEABROOK ECOLOGICAL STUDIES, 1978.

SAMPLE DATE	JAN 16		FEB 15		MAR 17		MAR 30		APR 12		APR 26		MAY 10		MAY 24		JUN 7		JUN 21		JUL 13	
TAXA	NO./M^3	%	NO./M^3	%	NO./M^3	%	NO./M^3	%	NO./M^3	%	NO./M^3	%	NO./M^3	%	NO./M^3	%	NO./M^3	%	NO./M^3	%	NO./M^3	%
Copepod nauplii, undifferentiated	217	3	394	11	1,301	12	1,337	19	3,275	16	2,844	15	1,406	9	6,281	29	38,041	49	14,713	27	2,256	22
Pseudocalanus/Calanus nauplii	72	1	833	22	857	8	1,470	21	5,792	28	8,472	46	8,193	50	2,751	13	2,494	3	12,545	23	169	2
Oithona spp. naupl.i	101	2	859	23	2,222	21	689	10	2,293	11	1,740	9	1,127	7	1,470	7	3,112	4	1,744	3	789	8
Bivalve veliger larvae, umbone	0	0	0	0	9	<1	149	2	26	<1	167	1	75	<1	63	<1	3,498	5	12,618	23	798	8
Oithona spp. copepodites	294	5	289	8	371	3	143	2	1,691	8	1,162	6	866	5	2,005	9	3,285	4	940	2	208	2
Pseudocalanus spp. copepodites	576	9	601	16	711	7	860	12	1,729	8	973	5	2,397	15	1,497	7	2,533	3	4,515	8	655	6
Foraminiferida	3,954	63	46	1	3,627	33	1,037	15	127	1	19	<1	331	2	48	<1	0	0	19	<1	5	<1
Eurytemora spp. copepodites	127	2	0	0	9	<1	0	0	0	0	5	<1	4	<1	0	0	7,790	10	28	<1	764	7
Polychaete larvae	0	0	5	<1	52	<1	327	5	956	5	112	1	435	3	86	<1	1,411	2	3,886	7	723	7
Gastropod veligers	22	<1	18	<1	0	0	0	0	5	<1	29	<1	23	<1	19	<1	285	<1	170	<1	166	2
Opistnobranchia veligers	16	<1	5	<1	0	0	7	<1	0	0	0	0	0	0	0	0	10	<1	158	<1	362	4
Evadne spp.	0	0	0	0	0	0	0	0	0	0	7	<1	4	<1	130	1	5,434	7	149	<1	713	7
Bivalve veliger larvae, straight-hinge	0	0	0	0	9	<1	193	3	116	1	13	1	6	<1	4,384	20	709	1	299	1	18	<1

SAMPLE DATE	JUL 26		AUG 9		AUG 23		SEP 6		SEP 20		OCT 4		OCT 18		NOV 2		NOV 15		DEC 6	
TAXA	NO./M^3	%	NO./M^3	%	NO./M^3	%	NO./M^3	%	NO./M^3	%	NO./M^3	%	NO./M^3	%	NO./M^3	%	NO./M^3	%	NO./M^3	%
Copepod nauplii, undifferentiated	4,201	7	2,396	20	2,355	17	1,388	7	2,140	18	2,387	19	2,402	21	886	15	3,064	33	301	17
Pseudocalanus/Calanus nauplii	7,740	13	412	3	703	5	942	5	270	2	2,403	19	1,202	11	1,071	18	1,366	15	354	20
Oithona spp. nauplii	1,715	3	3,721	31	4,261	31	6,584	33	4,657	40	3,749	30	2,851	25	386	6	580	6	54	3
Bivalve veliger larvae, umbone	22,676	39	1,415	12	73	1	911	5	50	<1	181	1	56	<1	10	<1	27	<1	12	1
Oithona spp. copepodites	3,240	6	1,140	9	4,206	31	6,028	30	3,106	27	2,234	18	3,445	30	1,474	24	794	9	176	10
Pseudocalanus spp. copepodites	3,294	6	323	3	522	4	849	4	189	2	98	1	571	5	1,193	20	2,261	24	179	10
Foraminiferida	3	<1	0	0	0	0	7	<1	3	<1	29	<1	94	1	109	2	92	1	109	6
Eurytemora spp. copepodites	0	0	23	<1	4	<1	0	0	3	<1	7	<1	0	0	115	2	23	<1	164	9
Polychaete larvae	33	<1	21	<1	25	<1	107	1	277	2	110	1	6	<1	13	<1	14	<1	6	<1
Gastropod veligers	5,451	9	546	5	181	1	366	2	22	<1	30	<1	10	<1	3	<1	27	<1	5	<1
Opisthobranchia veligers	4,053	7	945	8	2.6	2	775	4	55	<1	13	<1	5	<1	22	<1	9	<1	6	<1
Evadne spp.	91	<1	21	<1	0	0	0	0	0	0	0	0	3	<1	0	0	7	<1	0	0
Bivalve veliger larvae, straight-hinge	44	<1	13	<1	5	<1	0	0	0	0	51	<1	10	<1	14	<1	2	<1	0	0

APPENDIX 6.8. ABUNDANCE (No./1000m^3) AND PERCENT COMPOSITION OF MACROZOOPLANKTON, INCLUDING ONLY THOSE TAXA WHICH COMPRISE ONE PERCENT OR GREATER WITHIN EACH SAMPLE DATE; INTAKE SITE, DISCHARGE SITE AND SOUTH COMBINED.+ SEABROOK ECOLOGICAL STUDIES, 1978.

SAMPLE DATE TAXA	JAN 16 No./1000m^3	%	FEB 15 No./1000m^3	%	MAR 8 No./1000m^3	%	MAR 29* No./1000m^3	%	APR 12 No./1000m^3	%	APR 26* No./1000m^3	%	MAY 10 No./1000m^3	%
Sagitta elegans	20,385	60	175	8	1,483	9	354	1						
Calanus finmarchicus copepodites	3,993	12	179	8			1,420	6	106,002	32	67,500	36	406,469	77
Calanus finmarchicus females	1,402	4	194	9	211	1	831	3						
Tortanus discaudatus females	1,063	3	24	1	205	1							7,820	1
Calanus finmarchicus males	814	2	179	8										
Pleurobrachia pileus	774	2												
Neomysis americana males	727	2			983	6								
Metridia lucens females	699	2												
Temora longicornis females	655	2												
Neomysis americana females	617	2			937	6	195	1						
Tortanus discaudatus males	489	1	15	1									6,857	1
Metridia lucens copepodites	365	1					576	2	3,390	1			48,001	9
Centropages typicus females	326	1	272	13							1,688	1		
Pseudocalanus spp. females	295	1	514	24	8,060	51	11,923	49	24,904	8	13,384	7	13,248	2
Metridia lucens males	276	1											8,844	2
Pseudoleptocuma minor	226	1	22	1			166	1						
Centropages typicus males			155	7			252	1						
Pontogeneia inermis			99	5	176	1								
Centropages spp. copepodites			63	3										
Diastylis sculpta			47	2										
Monoculodes tuberculatus			20	1										
Pseudocalanus spp. copepodites			16	1	652	4	2,825	12						
Tisbe spp.			17	1										
Mysis mixta juveniles					2,029	13	1,903	8						
Eurytemora herdmani females					174	1								
Monoculodes sp.					133	1								
Cirripedia nauplii							928	4	117,353	36			3,277	1
Pseudocalanus spp. males							808	3	3,940	1				
Spirontocaris phippsii larvae							366	2						
Hyas coarctatus zoeae							257	1						
Acartia spp. copepodites							178	1						
Lamprops quadriplicata							122	1						
Oikopleura spp.									50,933	16				
Spionid nectochaete									13,416	4				
Cirripedia cypris											89,569	47		
Evadne spp.											8,383	4		
Thysanoessa spp. furcilia													199	1
Euphausiacea calyptopis													4,651	1
Cancer spp. zoeae														
Eualus pusiolus larvae														
Crangon septemspinosa larvae														
Obelia spp.														
Rathkea octopunctata														
Hydrozoan/Medusal stage														
Podon spp.														
Eurytemora herdmani females														
Centropages hamatus females														
Limacina retroversa														
Carcinas maenas zoeae														
Meganyctiphanes norvegica furcilia														
Phialidium spp.														
Centropages hamatus male														
Neomysis americana														
Aetideus armatus copepodites														
Erythrops erythrophthalma														
Syrrhoe crenulata														
Unciola irrorata														
Aetideus armatus males														
Lembos websteri														
Column Totals	33,100	97	1,991	93	15,043	94	23,104	96	319,932	98	180,524	95	499,366	95
Total Abundance/Sample Period	34,215		2,143		15,669		24,155		328,025		189,568		526,308	

*Intake site only.

+Mean of nine replicates.

Continued

TABLE 6.8. (Continued)

SAMPLE DATE TAXA	MAY 24* No./1000m^3	%	JUN 8 No./1000m^3	%	JUN 22* No./1000m^3	%	JUL 13 No./1000m^3	%	JUL 26* No./1000m^3	%	AUG 9 No./1000m^3	%	AUG 23* No./1000m^3	%
Sagitta elegans	51,684	23	99,093	28										
Calanus finmarchicus copepodites	16,954	7	45,168	13	23,199	9	403,584	63	180,506	63	1,665,805	73	191,014	41
Calanus finmarchicus females	11,739	5	2,238	1			7,816	1			84,111	4	10,070	2
Tortanus discaudatus females	16,806	7			31,584	13	4,366	1						
Calanus finmarchicus males											38,667	2	8,400	2
Pleurobrachia pileus														
Neomysis americana males														
Metridia lucens females			2,536	1	3,446	1								
Temora longicornis females	1	1	30,840	9	17,282	7	12,770	2						
Neomysis americana females														
Tortanus discaudatus males	9,[illegible]	4	8,774	2	21,882	9			5,970	2				
Metridia lucens copepodites	2,975	1	21,159	6	11,838	5								
Centropages typicus females									10,862	4	23,148	1	74,826	16
Pseudocalanus spp. females	6,859	3	19,544	5	5,210	2	12,993	2			25,228	1		
Metridia lucens males			11,189	2	246	5								
Pseudoleptocuma minor														
Centropages typicus males									8,910	3			20,191	4
Pontogeneia inermis														
Centropages spp. copepodites														
Diastylis sculpta														
Monoculodes teberculatus														
Pseudocalanus spp. copepodites														
Tisbe spp.														
Mysis mixta juveniles														
Eurytemora herdmani females														
Monoculodes sp.														
Cirripedia nauplii														
Pseudocalanus spp. males														
Spirontocaris phippsii larvae														
Hyas coarctatus zoeae														
Acartia spp. copepodites														
Lamprops quadriplicata														
Oikopleura spp.	24,698	11												
Spionid nectochaete														
Cirripedia cypris														
Evadne spp.	13,775	6	18,891	5	9,785	4								
Thysanoessa spp. furcilia			126	6	19,881	1								
Euphausiacea calyptopis			10,311	3	5,785	2	19,043	3	10,585	4				
Cancer spp. zoeae	31,563	14	3,075	1	38,939	16	26,536	4	45,071	16	93,855	4	71,132	15
Eualus pusiolus larvae	17,140	8	8,534	2	2,173	1	12,921	2	4,477	2	45,752	2	21,830	5
Crangon septemspinosa larvae	13,134	7	11,755	3			9,691	2	4,052	1				
Obelia spp.	1,8[illegible]1	1	18,617	5	17,968	7	76,267	12						
Rathkea octopunctata			3,603	1										
Hydrozoan/Medusal stage			3,535	1										
Podon spp.			2,515	1										
Eurytemora herdmani females			2,143	1										
Centropages hamatus females			4,325	1	1,385	1								
Limacina retroversa					29,234	12	7,523	1	2,339	1				
Carcinas maenas zoeae					1,696	1	10,765	2						
Meganyctiphanes norvegica furcilia							8,003	1			195,354	9	48,081	10
Phialidium spp.											39,625	2		
Centropages hamatus male														
Neomysis americana														
Aetideus armatus copepodites														
Erythrops erythrophthalma														
Syrrhoe crenulata														
Unciola irrorata														
Aetideus armatus males														
Lembos websteri														
Column Totals	220,146	98	327,971	97	241,533	96	612,278	96	272,772	96	2,211,545	98	445,544	95
Total Abundance/Sample Period	226,885		359,401		244,423		635,586		285,378		2,285,528		460,619	

*Intake site only.

‡Mean of nine replicates.

Continued

TABLE 6.8. (Continued)

SAMPLE DATE TAXA	SEP 6 No./1000m³	%	OCT 5 No./1000m³	%	NOV 2 No./1000m³	%	DEC 5 No./1000m³	%	DEC 26* No./1000m³	%
Sagitta elegans									33	1
Calanus finmarchicus copepodites	19,290	6	9,146	2	2,260	1	1,674	1	483	11
alanus finmarchicus females	4,337	1							73	2
Tortanus discaudatus females									42	1
Calanus finmarchicus males	3,836	1							38	1
Pleurobrachia pileus										
Neomysis americana males										
Metridia lucens females										
Temora longicornis females										
Neomysis americana females										
Tortanus discaudatus males										
Metridia lucas copepodites										
Centropages typicus females	160,758	53	206,227	45	145,403	46	56,391	28	160	4
Pseudocalanus spp. females			3,273	1	8,695	3	3,644	2	1,642	36
Metridia lucens males										
Pseudoleptocuma minor									46	1
Centropages typicus males	68,927	23	136,158	30	123,447	39	62,995	31	83	2
Pontogeneia inermis									152	3
Centropages spp. copepodites			15,115	3	21,164	7	49,859	25	65	1
Diastylis sculpta									63	1
Monoculodes tuberculatus									279	6
Pseudocalanus spp. copepodites										
T.sbe spp.										
Mysis mixta juveniles										
Eurytemora herdmani females										
Monoculodes sp.									37	1
Cirripedia nauplii										
Pseudocalanus spp. males					2,077	1			35	1
Spirontocaris phippsii larvae										
Hyas coarctatus zoeae										
Acartia spp. copepodites										
Lamprops quadriplicata									64	1
Oikopleura spp.										
Spionid nectochaete										
Cirripedia cypris										
Evadne spp.										
Thysanoessa spp. furcilia										
Euphausiacea calyptopis										
Cancer spp. zoeae	14,633	5								
Eualus pusiolus larvae	4,606	2								
Crangon septemspinosa larvae	11,915	4							34	1
Obelia spp.										
Rathkea octopunctata										
Hydrozoan/Medusal stage										
Podon spp.										
Eurytemora herdmani females										
Centropages hamatus females			39,280	9	3,953	[illegible]	15,825	8	405	9
Limacina retroversa										
Carcinas maenas zoeae	1,834	1								
Meganyctiphanes norvegica furcilia										
Phialidium spp.	7,401	2								
Centropages hamatus male			36,376	8	5,981	2	6,977	3	93	2
Neomysis americana									100	2
Aetideus armatus copepodites									47	1
Erythrops erythrophthalma									27	1
Syrrhoe crenulata									95	2
Unciola irrorata									65	1
Aetideus armatus males									47	1
Lembos websteri									28	1
Column Totals	297,537	98	447,074+	98	312,980	100	1[illegible]65	98	4,236	94
Total Abundance/Sample Period	305,158		454,021		316,346		202,430		4,560	

*Intake site only.

+Mean of nine replicates.

APPENDIX 6.9. *NEOMYSIS AMERICANA* ABUNDANCES, SEX RATIOS, REPRODUCTIVE STATE AND FECUNDITY DATA AT THE INTAKE SITE, DISCHARGE SITE AND SOUTH. SEABROOK ECOLOGICAL STUDIES, 1978.

A. Mean abundance (No./1000m^3)[1]

DATE	FEMALES[2]			MALES[3]			JUVENILES			TOTAL[4]		
	INTAKE	DISCHARGE	SOUTH	INTAKE	DISCHARGE	SOUTH	INTAKE	DISCHARGE	SOUTH	INTAKE	DISCHARGE	SOUTH
Jan 16	1,896	27	18	2,123	35	23	16	2	0	4,124	65	41
Feb 15	11	4	5	6	4	3	7	2	1	25	10	9
Mar 8	2,575	40	195	2,679	32	236	0	0	0	5,289	78	443
May 29*	195			92			0			320		
Apr 12	72	22	28	38	19	29	0	0	0	111	42	57
Apr 26*	27			11			0			38		
May 10	49	14	78	28	48	102	0	0	0	83	67	180
May 24*	0			0			0			0		
Jun 8	186	3	0	79	1	0	97	0	0	362	4	0
Jun 22*	0			0			4			4		
Jul 13	15	0	0	16	0	0	10	1	0	41	1	0
Jul 26*	1			2			1			4		
Aug 9	122	47	61	165	44	57	12	0	0	299	91	118
Aug 23*	17			17			9			43		
Sep 6	425	10	0	325	2	0	0	2	0	760	17	0
Oct 5	0	2	48	1	2	9	6	1	0	7	5	57
Nov 2	45	1	32	40	0	70	51	2	115	136	3	217
Dec 5	83	8	19	86	7	31	365	42	28	541	57	79
Dec 26*	48			52			22			124		
Mean[5]	457	15	40	466	16	47	47	4	12	981	37	100

[1] Mean of three replicates
[2] Includes: mature, ovigerous, larvigerous and immature females
[3] Includes: mature and immature males
[4] Includes: females, males, juveniles, unsexed immatures and unstaged *Neomysis americana*
[5] Includes only those dates in which all three sites were sampled
* Intake site only

B. Sex ratio (M:F)†

DATE	IMMATURE	MATURE	COMBINED
Jan 16	NA	NA	1.12:1
Feb 15	NA	NA	0.68:1
Mar 8	NA	NA	1.05:1
May 29*	NA	NA	0.47:1
Apr 12	NA	NA	0.71:1
Apr 26*	NA	NA	0.39:1
May 10	NA	NA	1.26:1
May 24*	NA	NA	-
Jun 8	NA	NA	0.42:1
Jun 22*	NA	NA	-
Jul 13	NA	NA	1.02:1
Jul 26*	NA	NA	2.00:1
Aug 9	0.03:1	1.33:1	1.11:1
Aug 23*	0.32:1	1.24:1	1.02:1
Sep 6	0.11:1	1.16:1	0.75:1
Oct 5	=	0.18:1	0.22:1
Nov 2	1.61:1	0.58:1	1.41:1
Dec 5	1.04:1	=	1.14:1
Dec 26*	0.82:1	3.43:1	1.09:1

† Based on mean abundance of immature and mature individuals at all three sites, unless otherwise indicated.
* Intake site only.
NA Sexually immature not distinguished from sexually mature individuals.
\- No *Neomysis* collected.
= No females collected.

C. Abundance (No./1000m^3)†, reproductive state and fecundity

DATE	ABUNDANCE			% TOTAL FEMALES WITH BROOD	$\bar{x}$ FECUNDITY	
	TOTAL FEMALES[Δ]	OVIGEROUS FEMALES	LARVIGEROUS FEMALES		EGGS NO./FEMALE (n)	LARVAE NO./FEMALE (n)
Jan 16	647	0	30	4.6	0.0	NA
Feb 15	7	0	0	0.0	0.0	0
Mar 8	937	0	0	0.0	0.0	0
Mar 29*	195	0	0	0.0	0.0	0
Apr 12	41	0	0	0.0	0.0	0
Apr 26*	27	<1	0	1.8	29.0 (1)	0
May 10	47	4	1	11.1	19.5 (2)	20.0 (2)
May 24*	0	0	0	0.0	0.0	35.3 (6)
Jun 8	63	1	0	1.6	62.0 (1)	30.5 (2)
Jun 22*	0	0	0	0.0	0.0	0.0
Jul 13	5	0	0	0.0	0.0	0.0
Jul 26*	1	0	0	0.0	0.0	0.0
Aug 9	77	12	13	31.0	18.2 (12)	19.2 (16)
Aug 23*	17	0	3	16.0	0.0	16.0 (2)
Sep 6	145	6	9	9.9	14.2 (16)	13.9 (19)
Oct 5	17	1	1	13.8	16.5 (2)	0.0
Nov 2	26	1	0	2.7	0.0	0.0
Dec 5	37	0	0	0.0	0.0	0.0
Dec 26*	48	0	0	0.0	0.0	0.0

† Mean abundance at all three sites, unless otherwise indicated.
* Intake site only.
Δ Includes mature, ovigerous, larvigerous and immature females.
NA Data not available.
(n) Sample size.