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Zooplankton and Ichthyoplankton in Narragansett Bay:

Status and Trends; Part 1: Zooplankton 126 pp

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The Narragansett Bay Project

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STATUS AND TRENDS

PART 1: ZOOPLANKTON

Prepared For

The New England Interstate Water Pollution Control Commission

by

Ann G. Durbin

Edward G. Durbin

June 30, 1988

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The Narragansett Bay Project is sponsored by
the U.S. Environmental Protection Agency and
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FOREWORD

The United States Congress created the National Estuary Program in 1984, citing its concern for the "health and ecological integrity" of the nation's estuaries and estuarine resources. Narragansett Bay was selected for inclusion in the National Estuary Program in 1984 and designated an "estuary of national significance" in 1988. The Narragansett Bay Project (NBP) was established in 1985. Under the joint sponsorship of the U.S. Environmental Protection Agency and the Rhode Island Department of Environmental Management, the NBP's mandate is to direct a five-year program of research and planning focussed on managing Narragansett Bay and its resources for future generations. The NBP will develop a comprehensive management plan by December, 1990, which will recommend actions to improve and protect the Bay and its natural resources.

The NBP has established the following seven priority issues for Narragansett Bay:

* management of fisheries
* nutrients and potential for eutrophication
* impacts of toxic contaminants
* health and abundance of living resources
* health risk to consumers of contaminated seafood
* land-based impacts on water quality
* recreational uses

The NBP is taking an ecosystem/watershed approach to address these problems and has funded research that will help to improve our understanding of various aspects of these priority problems. The Project is also working to expand and coordinate existing programs among state agencies, governmental institutions, and academic researchers in order to apply research findings to the practical needs of managing the Bay and improving the environmental quality of its watershed.

This report represents the technical results of an investigation performed for the Narragansett Bay Project. The information in this document has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement #CX812680 to the Rhode Island Department of Environmental Management. It has been subject to the Agency's and the Narragansett Bay Project's peer and administrative review and has been accepted for publication as a technical report by the Management Committee of the Narragansett Bay Project. The results and conclusions contained herein are those of the author(s), and do not necessarily represent the views or recommendations of the NBP. Final recommendations for management actions will be based upon the results of this and other investigations.

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SUMMARY

The purpose of this study is to review zooplankton studies in Narragansett Bay to provide a description of the zooplankton community in Narragansett Bay and to describe any spatial and temporal trends. For the purpose of analysis studies are divided into those which look at numerical abundance of organisms and the species composition of the community, and those measuring the biomass of zooplankton.

1) There have been a number of studies of the seasonal changes in the composition and abundance of the zooplankton community in Narragansett Bay. These were carried out between 1950 and 1987. Most were in the mid to lower West Passage. Only two include stations in the upper bay. Every study has used a different method for sampling the zooplankton. In most cases the mesh sizes used to collect the zooplankton resulted in only the larger members of the zooplankton community being quantitatively sampled and it is only these groups which can be used in comparing data from different studies. Smaller but very abundant members such as copepod nauplii, bivalve larvae, polychaetes and rotifers which were not quantitatively sampled cannot be used in such intercomparisons.

2) The zooplankton were dominated by copepods. Other important taxa include cladocera, rotifers, and larvae of benthic organisms including bivalve larvae and polychaete larvae. Two copepods, Acartia hudsonica and A. tonsa, dominated the zooplankton. During 1976 these two species contributed 74% of the annual mean total zooplankton numbers at a station in the lower bay (off Wickford) and 54% at a station in the upper bay (south of Conimicutt light). At each station they contributed about 50% of the mean annual total zooplankton biomass.

3) The major taxa of zooplankton show large seasonal variations in abundance. With the two dominant copepods, A. hudsonica and A. tonsa, the time during which they were present was quite consistant from year to year; the former during the winter and spring and the latter during the summer and fall.

4) A comparison of data from different studies did not show that any major change in the composition of the zooplankton community, or abundance of different taxa within the community, have taken place between 1950 and 1986. However, there was considerable interannual variability.

5) The mean annual abundance of A hudsonica and A. tonsa during 1976 did not differ significantly between the upper and lower bay stations. However,

data from other studies demonstrated that the abundance of these species declined along a transect between the lower bay and Block Island Sound.

6) Significant differences in abundance of several of the subdominant copepod species were observed between the upper and lower bay. These reflected increased abundance of estuarine species in the upper bay and of coastal and shelf species in the lower bay. Planktonic larvae of benthic organisms were also more abundant in the upper bay.

7) There have been several studies which provide a more complete spatial coverage of zooplankton biomass in Narragansett Bay than is available for species abundance. These showed that mean annual zooplankton biomass was not significantly different between the upper and lower bay but declined along a transect between the lower bay and Block Island Sound. Differences in methods of collection prevent any analysis of temporal trends in biomass.

8) Temperature strongly affects the potential secondary production rates of zooplankton and as a result the potential production rates of A. tonsa, which is present during the summer and fall when temperatures are high, are much greater than those of A. hudsonica. However field/laboratory experimental studies indicate that production rates of A. tonsa in the lower bay (off Wickford) are significantly food limited while those of A. hudsonica are not. Production rates of A. tonsa are limited by the amount of appropriately sized available food since the nanoplankters which are frequently dominant in the summer in Narragansett Bay are too small to be suitable food. As a result of these food limitation effects the production rates of A. hudsonica in the lower bay during the winter-spring period are similar to those of A. tonsa during the summer despite the large differences in temperature. Measurements of zooplankton production in the upper bay have not been made.

9) The population size of A. tonsa in Narragansett Bay is controlled by a series of factors which vary temporally in importance. These include food limitation, predation by gelatinous zooplankton and plantivorous fish, and cannibalism. With A. hudsonica these factors do not appear to be important. Rather, conditions at the time of the initial population recruitment in the late fall and temperature during the winter appear to control the observed population sizes.

10) A variety of different sampling methods have been used in studies of zooplankton in Narragansett Bay making intercomparisons of data sets difficult. These reflect changes in sampling technology and differences in the purposes

for which the samples were collected. Because of this it is strongly recommended that before any further sampling be done in the bay, investigators working with zooplankton meet and agree to standard procedures which would be used except in situations where the specialized nature of a study requires different gear.

11) A number of questions need to be addressed in order to more fully understand the role of zooplankton in Narragansett Bay and factors controlling their abundance. Some of these include:

a) To what extent are zooplankton controlling the size-structure and community composition of the phytoplankton in the Bay, and to what extent are abiotic factors (light, temperature, nutrients, etc) responsible for the phytoplankton community observed? Initial evidence suggests that zooplankton are not important during the winter-spring period, but that they play a major role in the summer and early fall. More in situ experiments are needed to answer this question.

b) What are the factors controlling the population dynamics of the zooplankton in the Bay? Initial studies of Acartia hudsonica and A. tonsa in Merl mesocosms indicate that temporal changes in recruitment to the populations, rather than changes in growth rate or stage-specific mortality, cause the major population changes observed. Field studies are needed to investigate this further.

c) What are the production rates of the dominant zooplankters in the upper and lower bays? Is there any food limiation of zooplankton production in the upper bay during the summer?

d) What are the causes of longer time period (interannual) variations in the zooplankton? What is the role of changes in mean winter temperatures on these variations?

e) What is the role of microzooplankton in the Bay? How important are they as grazers on pico- and nanoplankton, and what is their role as food for mesozooplankton?

INTRODUCTION

Zooplankton are divided into three groups (a) microzooplankton, animals smaller than about 60-80 µm in length; (2) mesozooplankton, animals between about 80 µm and 2-3 mm long; and (3) the macrozooplankton or micronecktcn, planktonic animals greater than 3 mm such as gelatinous zooplankton and mysids. In terms of biomass, the zooplankton in Narragansett Bay is normally dominated by the mesozooplankton. It is this group which has received the most attention in previous zooplankton studies in the bay and will be the major part of this review. This group of animals includes holoplankton (permanent members of the plankton) such as copepods, cladocera, rotifers and chaetognaths, and meroplankton (temporary plankton) which are planktonic larvae of benthic organisms such as bivalves, polychaetes, crabs, etc. The mesoplankton includes herbivorous, omnivorous , and carnivorous species.

Macrozooplankton are predators of mesozooplankton and at times one member of this group, the ctenophore Mnemiopsis leidyi, appear to have a major affect in controlling mesozooplankton populations. Microzooplankton include loricate (tintinnids) and aloricate ciliates. These may be important as grazers of nanoplankton flagellates but have not received much attention in Narragansett Bay.

MESOZOOPLANKTON

Studies of mesozooplankton may be divided into;

(a) studies of seasonal changes in abundance of the whole zooplankton community (Frolander, 1955; Faber, 1959; Martin, 1965; Marine Research, 1971; 1972 a, b, c; 1973 a, b, c, d; 1974; Hulsizer, 1976; Durbin and Durbin, 1981; MERL, 1987; Smayda, 1987) and individual species within the community (Sweatt, 1980; Lawrence, 1982);

(b) studies of seasonal changes in biomass (Hulsizer, 1976; Kremer and Nixon, 1978; MERL, 1980; Durbin and Durbin, 1981; Smayda, 1987);

(c) studies of secondary production (Durbin and Durbin, 1981; Durbin et al., 1983).

The whole zooplankton community studies are perhaps the most useful for this review. Table 1 shows the station locations of thse studies, the time periods over which they were carried out, and a brief description of the methods. Station locations are also shown in Fig. 1a, b. As can be seen in these figures, with the exception of the studies by Durbin and Durbin (1981) and Smayda (1987), all of the studies took place in the mid to lower West Passage.

Comparison of Methods

A problem in comparing these studies is that the methods are different in every case (Table 1). The mesh size used to collect the organisms is the most critical aspect. In order to quantitatively collect smaller members of the community such as the younger developmental stages of the copepods, rotifers, bivalve larvae and polychaetes, which are not only numerically dominant at times but are also a significant part of the total biomass, a mesh size of about 60-80 µm is required. Because of clogging problems a plankton net with this mesh size cannot be used for quantitative sampling. The only alternative is to use a plankton pump where the vigorous action of the water flowing through a net on deck reduces clogging. A disadvantage of a pump is that a smaller volume is generally sampled so that the rarer members of the community are not quantitatively sampled.

The different mesh sizes used can be seen from Table 1. It can be seen that most studies were carried out with mesh sizes somewhat larger than those required to sample all members of the zooplankton community. The 153 µm mesh net used by Hulsizer (Hulsizer, 1976), for example, does not quantitatively sample copepod nauplii, bivalve larvae or rotifers. The 240 µm mesh net used by Frolander (Frolander, 1955) in his otherwise very careful study not only does not quantitatively sample these groups, but also does not quantitatively sample many of the smaller copepodite stages as well. Since he did not distinguish between younger and older copepodite stages, only his counts of adult copepods can be considered quantitative and in the present analysis only his counts of adult copepods have been included. Thus we can only compare this data with values for adults only in other studies. Martin (Martin, 1965), in his study, used a 120 µm Clarke-Bumpus net. While this samples most of the smaller forms, he cited problems caused by clogging where the meter did not register accurately resulting in erroneously high values for the calculated numbers per cubic meter.

In addition to some of these sampling differences described above, there are differences in the way in which the data were recorded and presented. For example, Martin, (Martin, 1965) citing the large variations due to mechanical and natural causes, calculated an average monthly concentration of zooplankton collected over the three-year period. This gave twelve monthly average concentrations. In calculating these averages he deleted the highest and lowest numbers for each species or taxonomic group that occurred in each month. In addition, only data for adult copepods were presented. In her study, Hulsizer (Hulsizer, 1976) lumped the older developmental stages of Acartia hudsonica and A. tonsa, the two dominant zooplankton species into two groups. These were C1-C3 and C4-C6, C6 being the adult stage. Thus the adults of these species were not differentiated from the younger stages, as they were in all of the other studies. In addition, at some times of the year she did not distinguish between A. hudsonica and A. tonsa. For the present analysis total counts of Acartia were apportioned between these two species. The formula by which this was done is given at the bottom of Appendix Table 4.

Because of these differences in methods and level of reporting of the data, intercomparison of data from different studies is difficult, and can only be done at a rather superficial level since only the larger members of the zooplankton were quantitatively captured in all studies. It is strongly recommended that some standardized zooplankton sampling methods be developed and adopted by the different groups working in Narragansett Bay. In addition, at intervals there should be intercalibration of methods between groups.

Synopsis of Study by Durbin and Durbin

The following discussion of seasonal changes in abundance of zooplankton in Narragansett Bay and up Bay-down Bay differences is based on the study by Durbin and Durbin (1981). This is the only study which quantitatively sampled the smaller but very abundant members of the zooplankton community such as copepod nauplii, bivalve larvae, rotifers, and polychaete larvae in the upper and lower bay. In this study, seven stations were sampled (Fig. 1b). Data collected at each station included temperature, water transparency, phytoplankton abundance in different size fractions as measured by chlorophyll a and zooplankton dry weight. in a 64-153 µm size fraction and a > 153 µm size fraction. Zooplankton were counted only at an up-Bay (station 5, just south of Conimicut Pt.) and down-Bay (station 1, south of Quonset Pt.). Phytoplankton and zooplankton production rates were estimated at these two stations. While this is the most complete study to date, unfortunately it did not cover a full annual cycle (3/1/76 - 11/5/76). This is because it was part of a larger study of menhaden (Brevoortia tyrannus) - plankton interactions in Narragansett Bay and menhaden are only present from late spring until fall.

Mean Annual Abundance of Zooplankton

Table 2 shows the mean abundance of zooplankton in lower (station 1) and upper (station 5) Narragansett Bay during the period 3/1/76 to 10/22/76. The zooplankton in the bay during the 1976 study period were dominated by two copepod species, Acartia hudsonica and Acartia tonsa. The nauplii, copepodites and adults of A. hudsonica together constituted 47.6% of the mean zooplankton numbers in the lower bay (station 1) and 27% in the upper bay (station 5), while those of A. tonsa constituted 27% of the total at both stations. Thus 74% of the mean total zooplankton numbers in the lower bay and 54% in the upper bay were contributed by these two copepod species. The other numerically important members of the zooplankton were bivalve and polychaete larvae, rotifers and the cladoceron, Podon polyphemoides. With the exception of Oithona sp. at station 5, other copepod species never constituted more than 1% of the mean zooplankton numbers. The more important of these other species were Hemicyclops sp., Parvocalanus crassirostris and Pseudocalanus sp.

Seasonality

Most members of the zooplankton show large seasonal changes in abundance (Figs. 2a-g, Appendix Table 1a, b). This is due to the large annual temperature range (0-22°C) and the fact that individual members of the zooplankton and the benthos have restricted temperature ranges over which they reproduce and grow.

Acartia hudsonica is present from late fall to early summer (Fig. 2a) while A. tonsa is present from early summer to late fall (Fig. 2b). These species survive unfavorable periods through the production of resting eggs which remain in the sediments. Peak numbers of A. hudsonica occurred on 4/9/76, Julian Day 100 (223928/m^3 at station 1 and 185540/m^3 at station 5). There was a slow decline in numbers at both stations following this until they disappeared in early July. Nauplii disappeared first from the population (Fig. 3a) indicating a lack of recruitment to the population.

Numbers of adult A. hudsonica were much lower at station 1 than at station 5 in the later spring (Fig. 2a). This resulted in significantly lower zooplankton biomass levels and lower Acartia production rates (Durbin and Durbin, 1981). A possible reason for this is the lower phytoplankton concentration present at station 1 at this time.

A. tonsa appeared in the plankton in late June (Fig. 2b) and increased in numbers at both stations very rapidly, reaching a peak during July. This was followed by a decline in August (due to ctenophores and menhaden, see later) and a second peak in September.

The younger naupliar stages (N1-N6) of both these species were numerically dominant (Table 2, Fig. 3a, b). The immature copepodite stages (C1-C5) were intermediate while the adults were lowest. On most sampling dates there was an approximate exponential decline in numbers with increasing stage up to C5. (See Fig. 12 from Durbin and Durbin, 1981). Adults were more abundant than the last immature copepodite stage. This is because they survive as adults for a longer time than they remain in the C5 stage.

It is interesting to note that each time A. tonsa adults reached a peak of abundance, nauplii appeared to decline in abundance at the same time (Fig. 3b). In Fig. 4 we have compared abundance of adult A. tonsa with total naupliar abundance within each sample. There appears to be an inverse relationship between the two with high concentrations of adults being accompanied by low concentrations of nauplii; high concentrations of nauplii and adults did not co-occur. This suggests some density-dependent interaction between the two such as direct predation or competition for the same food resource. In contrast, with A. hudsonica, there was a positive relation between adult abundance and naupliar abundance (Fig. 4).

Bivalve larvae show two peaks in abundance, one in the late spring and early summer and the other during late summer and early fall. Maximum concentrations attained in the spring (4/23/76, Julian Day 114) were 77326/m^3 at station 5 and 33088/m^3 at station 1. In the late summer (8/30/76 Julian Day, 243) maximum concentrations were 258,000/m^3 at station 5 and 60,500/m^3 at station 1. Polychaete larvae were present throughout the study but with peaks in late spring and early summer at station 5 (188,400/m^3 on 5/19/76, Julian Day 140, and 74,196/m^3 on 6/28/76, Julian Day 180), and early summer at station 1.

There was no peak abundance in polychaetes at station 1 on 5/19/76 as there was at station 5. Peaks in abundance of both bivalve and polychaete larvae tended to be quite short. For example, bivalve larvae at station 5 went from 10,000/m^3 on 8/23/76 to 258,000/m^3 on 8/30/76, and they back down to 9,900/m^3 on 9/13/76. This means that any study of larval populations of these groups, such as might be done in order to assess adult stock sizes, should have closely spaced sampling intervals.

Rotifers were present only during the spring, reaching peak numbers of 186,286/m^3 at station 5 on 3/12/76 (Julian Day 72) and 85,801/m^3 at station 1 on 3/22/76 (Julian Day 82). Cladocera (Evadne nordmanni and Podon polyphemoides) reached peak abundances during May and June (Fig. 2g).

While the timing of the major seasonal changes in abundance of the different taxa were similar at the upper and lower bay stations (Figs. 2a to 2g), there were slight differences in the actual time a taxa first appeared, reached population peaks or disappeared. The cladoceron Evadne provides a good example of this where each of the three population peaks was reached a little earlier in the upper bay. The rotifers provide another clear example of this. A. tonsa showed a similar trend with the first cohort which appeared and grew up a little sooner in the upper bay. However, with the second peak in September, while the nauplii and copepodites increased a little sooner in the lower bay, the peak in adults was reached at the same time at the two stations.

Up Bay-Down Bay Differences

Inspection of Table 2 indicates no dramatic differences in the community composition between the upper (station 5) and lower (station 1) bay. All of the taxonomic groups listed in Table 2 were present at each station. However, there were differences in mean abundance between the two stations as will be discussed below. (It should be noted here, however, that some of the taxonomic groups, particularly the temporary plankton, represent a number of species lumped together. This is unfortunate since there are likely to be up-bay down-bay differences in abundance of individual species within these groups.)

In terms of overall mean abundance, the upper bay station was about 40% higher than the lower bay (mean = 162,436/m^3 at station 5 and mean = 114,760/m^3 at station 1). These overall differences in abundance are primarily due to differences in rotifers, polychaete larvae, and bivalve larvae, all of which were several-fold more abundant at station 5. The overall mean numbers of the two dominant copepods, Acartia hudsonica and A. tonsa were quite similar at the two stations; A. hudsonica was slightly more abundant in the lower bay and A. tonsa in the upper bay. None of these differences was significant, however (Table 3).

There were significant differences between the abundance levels of some of the other species or taxonomic groups at the upper and lower bay stations (Table 3). Eurytemora sp., Hemicyclops sp., polychaete larvae, and rotifers were all significantly more abundant in the upper bay than in the lower bay while Parvocalanus crassirostris, Temora longicornis, and Tortanus sp., and the unidentified harpacticoids were all significantly more abundant in the lower bay.

Summary of Other Studies

There are a number of other studies of seasonal changes in zooplankton abundance and community composition (Table 1). Data for these are summarized in Appendix Tables 2a, b; 3a, b; 4a, b; 5a, b, c. These studies include stations which are within Narraganestt Bay (Martin station 1; Hulsizer, station 2, 1972, 1973; Mar. Res. station A, B; Smayda, 1987); stations which are in the transition zone between Narragansett Bay and adjacent coastal waters (Frolander station B, off GSO dock; Faber off GSO dock; MERL at GSO dock; Martin station 3, adjacent to Beavertail); and one station outside of the bay (Frolander station A, south of Point Judith) (Fig. 1). The only station within the bay which was sampled in more than one year is that off Wickford (Durbin station 1; Hulsizer, 1972, 1973; Smayda, 1987). The MERL study, which includes data from 1976-1986, is in the transition zone between the lower bay and Block Island Sound.

In addition to these studies listed above, there is an early, non-quantitative taxonomic description of copepods collected from the Narragansett Bay area (Williams, 1906). This study does not describe methods used or give any numerical data nor is it a complete listing of species. However, it is interesting to note the same species present are the same as those seen today.

Temporal Trends

Based on the data available in these studies there do not appear to have been any significant temporal trends in the overall composition of the permanent members of the zooplankton community (Table 4, Fig. 5). The following group of holoplankters were dominants or subdominants in all of the studies. These include the copepods Acartia hudsonica, A. tonsa, Pseudocalanus minutus, Oithona spp. and Centropages spp, and the cladocera Evadne nordmanni and Podon spp (Table 4). In most cases individual species of meroplankton were not identified and enumerated, and as a result no such similar statement can be made about this component of the zooplankton. This is unfortunate since the abundance and distribution of benthic animals may have changed through time in response to changes in pollution level and their planktonic larvae would have reflected any such changes.

There does, however, appear to be considerable year to year variability in some of the zooplankton taxa. For example, mean numbers of A. tonsa copepodites and adults in Hulsizer's study were 335/m^3 in 1972 and 6235 in 1973. Other species present in the summer and fall (Centropages sp., Oithona sp. Parvocalanus crassirostris and Tortanus discaudatus) were also much lower in 1972.

The differences seen in the relative abundance of some of the dominants between Martin's and the other studies similarly reflects short term interannual variability. In Martin's study Hemicyclops sp. and Parvocalanus sp. were absent, while Oithona rather than one the of the Acartia spp. ws the numerical dominant (Table 4). However, the fact that studies both before (Frolander, 1955), and after (Hulsizer, 1976; Durbin and Durbin, 1981; Smayda, 1987; Mar. Res. 1971, 1972a, b, c, d, 1973a, b, c, 1974), Martin's were similar to each other suggests that his results were not part of a longer term trend.

Some estimate of interannual variations in zooplankton abundance can be obtained from a study by MERL. In this, samples were collected approximately every two weeks with a 30 cm diameter 64 µm mesh net at the GSO dock from integrated and arithmetic mean abundances for the more abundant copepod species are shown in Table 6.. At times annual means calculated by these two methods differed significantly. This is because of the large short term variability in the data and the sometimes unequal sampling interval. The large difference in the 1980 means for A. tonsa is due to the fact that a peak in abundance was followed by a long period in which no samples were collected resulting in an integrated mean estimate which was probably too high. Because of these problems the arithmetic mean is more useful.

Data for Acartia hudsonica and A. tonsa were plotted in Fig. 7. Mean abundances of A. hudsonica did not vary greatly over the 7 year period from 1976-1983 (arithmetic mean range = 564-1094/m^3). However, mean numbers in 1985-86 were considerably lower (mean = 141/m^3). In contrast, mean numbers of A. tonsa were high during the initial two years and were somewhat lower and variable during the remaining period of the study (Fig. 7b). As a result of the initial high values during 1976-77 and 1978 for A. tonsa there appears to be a downward trend in abundance. However, since A. tonsa population size is strongly affected by predators (Durbin and Durbin, 1981; Deason and Smayda, 1982) as well as food availability (Durbin and Durbin, 1983) the causes and significance of these variations cannot be evaluated.

Among the other copepods annual means for Centropages hamatus, Oithona sp. and Pseudocalanus minutus were quite constant during the study period, while Paracalanus crassirostris and Pseudodiaptomis coronatus showed considerable variability (Table 6). P. crassirostris was low during the initial three years, high for two years, and then decreased again in the final year. In one year (1980) it was not recorded at all. P. coronatus was low during the first two years, high the next two, and then low again during the final two years. Reasons for the variability in these two species are not obvious. However, based on data from other studies in Narragansett Bay (Table 4) they do appear quite variable. Means of P. crassirostris in Hulsizer's study were 74/m^3 in 1972 and 823/m^3 in 1973. This species was not recorded at all by Martin in his three year study. Similarly P. coronatus was not recorded by Durbin and Durbin in their study but was relatively abundant in the others (Table 4).

These data do not indicate any trends occurring in the zooplankton but rather represent the considerable seasonal and interannual variability which is sometimes observed. For comparison, Frolander's 1951 data for the same species are shown in Table 6. With the exception of two species (C. hamatus and Oithona) there are no significant differences between means observed by Frolander and MERL. In the case of Oithona, the mean abundance observed by Frolander was unusually low. Mean values for Oithona considerably higher than those observed by MERL were observed by Martin at stations in both the upper and lower bay (Table 4).

Zooplankton Gradients in Narragansett Bay

There is a reduction in numbers of some of the more abundant taxa along a transect from the upper bay (south of Conimicut Point) to outside the bay in Block Island Sound. Species or taxonomic groups which are abundant in the upper bay such as Acartia hudsonica, A. tonsa, Hemicyclops, Eurytemora, Podon sp., bivalve larvae and polychaete larvae became much less abundant or absent at Frolander's station A south of Point Judith. The changes in abundance of Acartia hudsonica and A. tonsa adults along this transect are shown in Table 5 and Fig. 5. (Data from Hulsizer (1976) and Smayda (1987) are not shown on this transect because all of the Acartia copepodites are lumped with the adults.) Above Conimicut Point there is a reduction in numbers and biomass of zooplankton. This was related to the decreased salinities in the Providence River (Smayda, 1987)

At the lower bay stations there is an appearance and an increase in abundance of more coastal species which are absent or not important in the bay (Table 4). These include Acartia longiremis, Calanus finmarchicus, Temora longicornis, Oncea sp. and Penilia avirostris.

In addition to these two groups there is another which shows no clear trends. This includes Pseudocalanus minutus, Oithona, Tortanus discaudatus, Parvocalanus crassirostris and Evadne nordmanni.

Vertical Distribution

Despite its shallow depth Narragansett Bay is frequently not vertically well mixed in terms of temperature, salinity and phytoplankton. Many studies have shown that zooplankton also are not evenly distributed in the water column and that their distribution changes between day and night. However, the only studies which include information on vertical distribution of zooplankton are those by Herman (1962), Sweatt (1980) and Marine Research (1971, 1972a, b, c, d, 1973a, b, c, 1974).

In Herman's study of mysids he showed that these were strong diel vertical migrators. They were on the bottom and absent from the water column during the day but rose up into it at night. Sweatt (1980) collected chaetognaths from different depths during the daytime only in his study. He found that in the summer all chaetognaths were restricted to cooler water found at depth at the mouth of the bay. The older reproducing individuals were restricted to this deeper water at the mouth of the bay throughout the year while younger individuals predominated within the bay.

In their study in lower West Passage Marine Research collected pump samples at two depths at one station and three depths at the other. Each depth was enumerated separately. In addition on one date they collected a sample at night. In general older copepods were lower in abundance at the surface in these daytime collections. Table 7 shows annual means at the different depths at the deeper station of Acartia hudsonica and A. tonsa, the dominant copepod in this study. Mean concentrations at the surface were about one third those found at 30 and 60 ft. Nauplii (of all species lumped together), however, did not show any such marked depth differences. Mean concentrations at the surface were a little higher than those at depth. These data reflect the fact that the older stages migrate vertically and are deeper in the day when these samples were collected while the nauplii do not vertically migrate. Table 8 shows data collected at the different depths at 1100 pm, 500 am and 1100 am. A. tonsa, the dominant zooplankter, was most abundant at the 30 ft at 1100 pm and was absent at 60 ft. By 500 am numbers at the surface were lower while those at 60 ft were increasing. By 1100 am concentrations were highest at 60 ft and lowest at the surface. Highest concentrations of nauplii, in contrast, were found in the upper 30 ft in both the night and day samples.

Mesozooplankton Biomass

Measurements of zooplankton biomass in Narragansett Bay are available from several studies: Kremer and Nixon (1978), Hulsizer (1976), MERL (1980), Durbin and Durbin (1981), and Smayda (1987).

In Kremer and Nixon's study zooplankton were sampled at biweekly intervals from July 1972 to June 1973 at 13 stations within Narragansett Bay. Station locations are shown in Fig. 8. Samples were collected by vertical hauls with a 120 µm mesh net and then dry weights determined by weighing on glass fiber filters.

Hulsizer split the weekly net hauls (150 µm mest net) taken off Wickford (Table 1) during 1972 and 1973 and dried and weighed one half of the split.

In the MERL study 17 stations along a transect from Fox Point to Block Island Sound (Fig. 10) were sampled with vertical tows using a 153 µm mesh 0.7 m diameter plankton net. Durbin and Durbin sampled seven stations (Fig. 1b) throughout Narragansett Bay during 1976 using a pump and collecting samples on a 64 µm mesh net. These were split and one half size-fractionated into 64-153 and > 153 µm size fractions. These subsamples were then weighed.

Seasonal changes in zooplankton biomass during 1976 are shown in Table 9 and Figs. 9a to c. The same major trends can be observed at all of the stations with biomass peaks in the early spring and mid-summer. Biomass was low in the late spring and late summer-fall periods. The 64-153 µm size-fraction constituted about 25-40% of the total (Table 9). However, this smaller size fraction at times contained a significant proportion of resuspended benthic material and thus was not always a good indicator of zooplankton biomass.

Mean dry weight for the two size fractions and the total zooplankton at the seven stations are shown in Table 9. Stations in this table are arranged in order of distance up the bay with station 4 being in the Providence River (Fig. 1b). Values ranged from 199.8 mg dry wt/m^3 at station 1 to 245 mg dry wt/m^3 at station 4. There were no significant differences between any of these stations in terms of dry weight.

Mean zooplankton dry weights measured in the Kremer-Nixon study (Table 11; Appendix Table 6) ranged between 74.7 mg dry wt/m^3 in the lower East Passage to 206.2 mg dry wt/m^3 at a station just south of Warwick Neck. Zooplankton biomass at stations in the mid to lower East Passage (stations 11, 12, 13, 14 and 15) were lower than stations in other parts of the bay. There did not appear to be any trend of increasing biomass from lower and mid West Passage to the upper bay. This bears out the observations made by Durbin and Durbin.

Zooplankton dry weights measured by Kremer-Nixon were somewhat lower than those measured by Durbin and Durbin. For example, mean zooplankton dry weight at station 8 in the Kremer-Nixon study was 162.8 mg/m^3 while at the same location in the Durbin and Durbin study (station 1) the mean was 199.8 mg/m^3. Similarly the Durbin and Durbin station 2 (239.2 mg/m^3) is near the Kremer-Nixon stations 6 and 7 (206.2 and 161.3 mg/m^3) respectively. While it is possible this indicates a trend of increasing biomass, it is probably more likely due to differences in methodology.

Zooplankton biomass in the MERL study (Fig. 11, Table 12) showed the same spatial patterns as observed by Durbin and Durbin and Kremer and Nixon. Throughout most of the length of Narragansett Bay (Field Point to Jamestown Bridge) there were only slight differences in mean annual biomass. At Fox Point and in the transition zone at the mouth of the bay (GSO dock) and outside the bay in Block Island Sound values were lower. However the mean dry weights in the MERL study and in Hulsizer's study (58.2 mg dry wt. / m3 in 1972 and 66.2 mg dry wt. / m3 in 1973) were even lower than those observed at similar stations by Kremer and Nixon or Durbin and Durbin (Fig). Some of these differences might be due to the fact that MERL and Hulsizer used a larger mesh net (150 µm) and thus did not capture the smaller members of the zooplankton. However, this does not entirely explain the reasons for the differences because Durbin and Durbin size-fractionated their samples and the > 153 µm size-fraction at station 1 was 128.8 mg dry wt/m^3, about 2x that measured by MERL and Hulsizer. In all cases the samples were rinsed with deionized water so salt should not have caused the differences. Possibly a 150 μm net being towed through the water extruded a greater number of organisms than when being used as a gentle seive on deck as was done by Durbin and Durbin. However, the presence of differences such as these, particularly between similar stations sampled during the same year is a little disconcerting and points to the need for a careful comparison and intercalibration of methods.

Mesozooplankton Production Rates

The only estimates of zooplankton production in Narragansett Bay are from the study by Durbin and Durbin (1981). In this study they estimated production by the two copepods Acartia hudsonica and A. tonsa. Detailed methods and results are given in their paper. Biomass estimates of these two species were determined from counts of abundance of each developmental stage and the weight of each stage. Production rates were determined from measures of growth rate at different temperatures in the laboratory (duration of each developmental stage), the size increment between each stage and the numbers of each stage observed in the field. These estimates are maximal or "potential" production rates in that they do not take into account any reduction in growth rate in the field due to effects of food limitation.

Mean A. hudsonica biomass (station 1, mean = 82.7 mg dry wt/m^3; station 5, mean = 95.2 mg/m^3) exceeded that of A. tonsa (station 1, mean = 56.7 mg m^3; station 5, mean = 60.0 mg/m^3). However, production rates of the two Acartia spp. were strongly temperature dependent. Thus, despite the higher biomass of A. hudsonica, low temperatures during the period it was present resulted in lower production rates (station 1, mean = 7.25 mg C/m^3/day; station 5, mean = 10.77 mg C/m^3/day) and biomass doubling times of up to 9.6 days. Production rates of A. tonsa at summer temperatures were high (station 1, mean

= 19.0 mg/m^3/day; station 5, mean = 22.9 mg/m^3/day) and biomass doubling times were generally less than one day. More recent studies (Durbin et al., 1983; Durbin et al., in press) have shown that the assumption of maximal growth is reasonable in the spring when A. hudsonica is present but not during the summer when A. tonsa is present. At this time A. tonsa appeared to be significantly food limited.

MACROZOOPLANKTON

This group of organisms includes the mysids and the gelatinous zooplankton.

Mysids in Narragansett Bay

Herman (1962) studied the abundance and vertical migration patterns of the possum shrimp Neomysis americana in Narragansett Bay between February 1960 and February 1961. N. americana was confined to lower Narragansett Bay with greatest abundance near the mouth (Fig. 10). Peak abundance occurred from August through February. It is a strong vertical migrator, coming into the water column at night. It was rarely taken in the plankton during the day. None of the tows was quantitative.

Gelatinous Zooplankton

Members of the gelatinous zooplankton in Narragansett Bay include smaller members such as the medusae and the larger ctenophore Mnemiopsis leidyi. Medusae have been included in studies of mesozooplankton (e.g., Frolander, 1955; Martin, 1965; etc.). They are most abundant in the late spring (e.g., Appendix Table 3a) but do not appear to be significant as predators on zooplankton. The larger ctenophore Mnemiopsis leidyi has been the subject of a number of separate studies.

Mnemiopsis leidyi is present in low numbers in Narragansett Bay throughout the year. During July it undergoes a rapid increase in population size. This coincides with the time when summer temperatures reach their maximum. The ctenophore pulse begins first in the upper bay (Kremer and Nixon, 1976; Durbin and Durbin, 1981; Deason, 1982). Maximum biomass levels and mean abundance levels decrease down the bay. The population peak lasts about one month in the lower bay and about two months in the upper bay. The ctenophore is a voracious predator on zooplankton and appears to have a major impact on zooplankton populations in the bay during its period of peak abundance (Kremer, 1979; Durbin and Durbin, 1981; Deason, 1982; Deason and Smayda, 1982). The predation by ctenophores on zooplankton (Acartia tonsa predominantly) in turn releases the grazing pressure on the larger phytoplankton typically resulting in a bloom of the diatom Skeletonema costatum (Durbin and Durbin, 1981; Deason and Smayda, 1982). Abundance of ctenophores is quite variable from year to year, and appears to be related to the population size of the zooplankton at the time of the initiation of the ctenophore population explosion (Deason and Smayda, 1982).

CONCLUSIONS

The studies described here were carried out by a series of different investigators at different times and using different methods. Each was carried out with a fairly specific objective in mind and most were not really designed to address the major questions being asked in this review. The greatest difficulty which arose in attempting to compare the results from the different studies, however, were the differences in methods used and the level at which the data were reported.

Because of the different mesh sizes used to capture the zooplankton in the different studies, only those organisms which were quantitatively captured in all studies could be used for comparison and evaluation of spatial and temporal trends in the zooplankton community. Intercomparison of the zooplankton biomass data also proved impossible, again because of differences used for capture and processing of the samples. Even similar size fractions of zooplankton biomass (that fraction retained on a 153 µm mesh net) showed large differences in the annual mean values between three studies (Hulsizer, 1976; Durbin and Durbin, 1981; MERL, 1980, see Fig). These differences reflected the way in which the size fractions were generated. In the case of the Hulsizer and MERL studies a 150 µm mesh net towed through the water was used to collect the samples while with the Durbin and Durbin study zooplankton were collected with a pump onto a fine mesh net and then the > 150 µm size fraction generated by sieving the sample through a 150 µm mesh net on deck. The lower biomass values obtained by Hulsizer and MERL probably are due to a greater loss by extrusion through the net.

It can be seen that in order to collect samples which can be intercompared, standardized methods should be used. We think that before any further zooplankton sampling is done in the bay, investigators should meet, evaluate different sampling methods, and decide upon some standardized procedure. Our recommendation would be for a two-step sampling procedure which would include some kind of pumping system where samples would be collected at multiple depths on a 60 µm mesh net, and a larger metered ring or bongo net with a 500 - 1000 µm mesh towed obliquely in the water column to collect gelatinous zooplankton. The number of depths to be sampled with the pumping system would depend on careful evaluation of the vertical variability of the zooplankton distribution and the number of depths required to give a representative pooled sample. The pumping system should have sufficient flow (~ 400 l/min) to collect a sufficient volume to satisfactorily sample the less abundant organisms. Despite being a little more cumbersome than a net, a pumping system has many advantages over a net in estuaries where phytoplankton and zooplankton abundances are high. First, a fine mesh net can be used to collect small zooplankters yet clogging is not a problem because of the vigorous flushing action in the net. Second, a flowmeter can be placed in the pump line to give a much more accurate estimate of volume sampled than a flowmeter in a net. Third, one can be more certain of the depths which are actually sampled than with a net towed behind a boat, and, if desired, discrete depths can be sampled. Despite the problems of intercomparing the different studies outlined above they have provided us with a fairly complete picture of the zooplankton in the bay, particularly with regard to the composition of the zooplankton community and the seasonal changes in abundance which are observed.

These studies have shown that there is a distinct community of zooplankton in the bay which has remained basically the same over the period encompassed by the different studies. There are large seasonal changes in the composition of the community and the same general pattern is observed in all of the studies. Finally, the abundance and biomass levels of zooplankton decrease along a transect from the lower bay to Block Island Sound; differences between the upper and lower bay were not great, however.

Factors which affect changes in the zooplankton community in Narragansett Bay include temperature, food availability and predation.

Temperature has a major influence on the zooplankton. The range in Narragansett Bay is very large, 0 to about 24°C, and this results in the strong seasonality in the abundance of different species. This is because a number of species are able to grow and reproduce over only a portion of this annual range. The two copepods, Acartia hudsonica and A. tonsa, which together dominate the zooplankton numerically and in terms of biomass, are good examples of this; A. hudsonica being present at colder temperatures and A. tonsa being present at warmer temperatures. Temperature also affects growth rates of the copepods and hence their production rates.

The dominant zooplankters in the bay are primarily herbivores and thus dependent upon the availability of suitably sized phytoplankton. In general feeding and growth rates of zooplankton increase curvilinearly above some minimum threshold until a "critical" concentration is reached, at which rates become maximal. Below this critical concentration growth and reproductive rates are reduced. At very low phytoplankton concentrations the copepods starve and mortality increases.

Temperature has an interactive effect with the effects of food availability. For example, at low temperatures, not only does temperature reduce metabolism and growth rates and hence food requirements per unit zooplankton biomass, but also the concentration of food below which the copepods become food limited (Durbin and Durbin, in press). This critical food concentration decreases with decreasing temperature.

An important attribute of the phytoplankton as far as the zooplankton are concerned, is their size. The dominant Acartia species are not efficient at capturing particles below 5-7 µm (Nival and Nival, 1976; Bartrum, 1980). This has a significant effect on the zooplankton in the summer when small flagellates dominate. Studies of A. tonsa during 1985 when the picoalgal 'Brown Tide' bloom was present (Durbin and Durbin, in press) indicate that growth and reproduction rates of this copepod were significantly reduced because of the unavailability of suitably sized food. This would suggest that any longer term trend towards a dominance by such picoalgae will have significant effects on the planktonic food chain in Narragansett Bay.

The phytoplankton abundance in the bay has been the subject of another review for the Bay Project (Hinga). In general the phytoplankton food of the zooplankton decreases in concentration along a transect from the upper bay to outside the bay (Kremer and Nixon, 1978; MERL, 1980). Differences between the upper bay and lower bay are most pronounced during summer (MERL, 1980; Durbin and Durbin, 1981). During the winter-spring period when the diatom bloom is occurring up bay-down bay differences are not great.

Recent studies have demonstrated that Acartia tonsa female adults are chronically food limited during the summer in the lower bay (Durbin et al., 1983) while during the winter-spring period A. hudsonica females from the same location are not (Durbin et al., in press). Because of the effects of this chronic food limitation on A. tonsa, mean production rates of A. tonsa during the summer, and of A. hudsonica during the winter-spring, are not significantly different despite the much higher temperatures during the summer and the higher potential production rates of A. tonsa (Durbin et al., in press).

One outcome of these observations is that during the winter-spring we would not expect to see any upper bay-lower bay differences in abundance of Acartia hudsonica due to the presence of a gradient in phytoplankton, while in the summer we would expect to see such differences in A. tonsa. This appears to be the case with A. hudsonica (Durbin and Durbin, 1981) where numbers in the upper and lower bay are quite similar. However, with A. tonsa predation as well as food limitation play a major role in controlling the population and the affects of the gradient in food availability are not always observed.

Major predators on zooplankton in Narragansett Bay are the ctenophore , plankton feeding fishes and adult A. tonsa (through cannibalism on their own young nauplii). The importance of ctenophores as predators on zooplankton was discussed earlier. Major plankton feeding fishes include the Atlantic menhaden Brevoortia tyrannus, the bay anchovy, and the silverside. Only the role of the menhaden, a filter feeding planktivore which feeds on larger phytoplankton and on zooplankton (Durbin and Durbin, 1975) has been evaluated. This work with the menhaden is based on a bioenergetic model developed from laboratory and field observations (Durbin et al. 1981; Durbin and Durbin 1981; Durbin et al. 1983; Durbin and Durbin 1983). The results of this study indicate that the menhaden can be important zooplankton predators during the summer and early fall.

Because of this role of predators in controlling zooplankton abundance in the bay during the summer and fall, differences in abundance of A. tonsa between the upper and lower bay which would be predicted based on up bay - down bay gradients in phytoplankton abundance, are frequently not observed. The only time when the effects of this gradient in food concentration on A. tonsa abundance are readily observed is a brief period during the summer before the ctenophores become abundant (Durbin and Durbin, 1981).

These studies on the effects of predation on zooplankton in Narragansett Bay indicate that year to year variations in predator abundance and the time over which they are present will have a large effect on summer and fall zooplankton populations and causing the large interannual variability seen in these population (Deason and Smayda, 1982).

In the winter-spring period factors controlling the zooplankton population abundance are less obvious. Acartia hudsonica, the dominant copepod present during this period hatches out of resting eggs in the mid to late fall. A population model (Durbin and Durbin, in press) has shown that at least one generation matures during the late fall. Nauplii hatched out in December grow very slowly because of the low temperatures and do not reach maturity until the following spring. Both food limitation (Durbin et al., in press) and predation (Durbin and Durbin, 1981) are not important in regulating the A. hudsonica population size during the winter-spring period. Instead, the population size present during the winter and spring appears to be determined by conditions during the previous fall when A. hudsonica is hatching out of resting eggs and the first fall generation is growing up (Durbin and Durbin, in press). Factors likely to be important at this time include food availability and the presence of predators. These will determine the size of the initial cohort of A. hudsonica and the subsequent population size which matures during the winter-spring period. More research is needed to investigate how populations in different seasons are linked.

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Table 1. Summary of whole community zooplankton studies carried out in Narragansett Bay.

Investigator	Period of Study	Station Location	Methods
Frolander	7/25/50 - 12/27/51	St B 41°29.7'N; 71°24.9'W St A 41°19.8'N; 71°31.4'W	Oblique hauls with Clarke-Bumpus 240 µm mesh net. Approx. weekly
Faber	7/57 - 6/58	41°29'37"N; 71°24'30"W	Surface tows after dark with Clarke-Bumpus 120 µm mesh net. 2x per week in summer and 1x per week in winter
Martin	1/29/59 - 1/9/62	St 1 41°38'08"N; 71°22'17"W St 3 41°26'47"N; 71°25'09"W	Oblique hauls with Clarke-Bumpus. 1 mm mesh until 9/9/59 then 120 µm for remainder of study. Every 2 weeks.
Hulsizer	1/72 - 12/73	St 2 41°34'07"N; 71°23'31"W	Oblique hauls with 0.3 m diameter, 153 µm mesh net. Weekly samples.
Mar. Res.	6/10/71 - 8/9/73	St A 41°34'15"N; 71°23'W St B 41°31'40"N; 71°23'55"W	Pump. St A, surface and bottom; St B, surface, mid and bottom. Counted separately. Collected on 64 µm mesh net. Every 2 weeks until 12/71, then once per month.
Durbin & Durbin	3/1/76 - 11/5/76	St 1 41°34'15"N; 71°23'31"W St 5 41°42'10"N; 71°20'W	Pump. Pooled surface, mid and bottom. Collected on 60 µm mesh. Approx. weekly.
MERL	8/76 - 5/86	GSO Dock	Vertical haul with 30 cm diameter, 64 µm mesh net. Approx. every 2 weeks.

Table 2. Mean abundance of zooplankton (no/m3) during the period 3/1/76-10/22/76 in lower (St 1), and upper (St 5) Narragansett Bay. From Durbin and Durbin (1981). Means were calculated from the integrated area and the number of days in the study period.

	Station 1 Mean,1976 T=235 days J. Day 61 296	Station 5 Mean, 1976 T=235 days J. Day 61-296	Station 1 % of Total	Station 5 % of Total
Copepods				
Acartia spp.				
Acartia hudsonica, nauplii	44034	31640	38.37	19.48
Acartia hudsonica, C1-5	8229	8361	7.17	5.15
Acartia hudsonica, adults	2342	3877	2.04	2.39
Acartia hudsonica, (C+A)	10571	12238	9.21	7.53
Acartia hudsonica, total (N+C+A)	54605	43888	47.58	27.02
Acartia tonsa, nauplii	22274	33876	19.41	20.85
Acartia tonsa, C1-5	6841	6958	5.96	4.28
Acartia tonsa, adults	1900	3241	1.66	1.99
Acartia tonsa, (C+A)	8742	10198	7.62	6.28
Acartia tonsa, total (N+C+A)	31028	44044	27.04	27.11
Total Acartia spp., (C+A)	19313	22436	16.83	13.81
Total Acartia spp., (N+C+A)	85633	87933	74.62	54.13
Other Copepods (copepodites + adults)				
Centropages sp	117	35	0.10	0.02
Eurytemora sp	1	259	0.00	0.16
Hemicyclops sp (Saphirella)	1091	2707	0.95	1.67
Microsetella norvegica	50	35	0.04	0.02
Oithona sp.	375	355	0.33	0.22
Parvocalanus crassirostris	590	196	0.51	0.12
Pseudocalanus sp.	633	541	0.55	0.33
Temora longicornis	67	9	0.06	0.01
Tortanus sp	17	3	0.01	0.00
Harpacticoid sp	64	43	0.06	0.03
Total Copepods, (copepodites only)	22141	26538	19.29	16.34
Cladocera				
Evadne nordmanni	587	848	0.51	0.52
Podon polyphemoides	3322	2292	2.89	1.41
Other Holoplankton				
Medusae	7	10	0.01	0.01
Rotifers	6599	25323	5.75	15.59
Chaetognaths	6	13	0.00	0.01
Temporary Plankton				
Balanus larvae	128	101	0.11	0.06
Bivalve larvae	11007	24633	9.59	15.16
Bryazoan larvae	13	2	0.01	0.00
Decapod larvae	121	81	0.11	0.05
Gastropod larvae	235	644	0.20	0.40
Polychaete larvae	4288	16435	3.74	10.12
Total Mean Zooplankton	114760	162436		

Table 3 . Mean abundance of zooplankton (no/m3) during the period 3/1/76-10/22/76 in lower (St 1), and upper (St 5) Narragansett Bay. From Durbin and Durbin (1981). Means were calculated from the integrated area and the number of days in the study period. Species whose abundances differ significantly between the two stations (Wilcoxon 2-sample test) are marked with an asterisk.

	Station 1 Mean,1976 T=235 days J. Day 61-296	Station 5 Mean, 1976 T=235 days J. Day 61-296	Station 5 % of Station 1
Copepods			
Acartia spp.			
Acartia hudsonica, nauplii	44034	31640	72
Acartia hudsonica, C1-5	8229	8361	102
Acartia hudsonica, adults	2342	3877	166
Acartia hudsonica, (C+A)	10571	12238	116
Acartia hudsonica, total (N+C+A)	54605	43888	80
Acartia tonsa, nauplii	22274	33876	152
Acartia tonsa, C1-5	6841	6958	102
Acartia tonsa, adults	1900	3241	171
Acartia tonsa, (C+A)	8742	10198	117
Acartia tonsa, total (N+C+A)	31028	44044	142
Total Acartia spp., (C+A)	19313	22436	116
Other Copepods (copepodites + adults)			
Centropages sp	117	35	30
Eurytemora sp	1	259	25999 *
Hemicyclops sp (Saphirella)	1091	2707	248 *
Microsetella norvegica	50	35	68
Oithona sp.	375	355	95
Parvocalanus crassirostris	590	196	33 *
Pseudocalanus sp.	633	541	85
Temora longicornis	67	9	14 *
Tortanus sp	17	3	20 *
Harpacticoid sp	64	43	68 *
Total Copepods, (copepodites only)	22141	26538	120
Cladocera			
Evadne nordmanni	587	848	144
Podon polyphemoides	3322	2292	69
Other Holoplankton			
Medusae	7	10	137
Rotifers	6599	25323	384 *
Chaetognaths	6	13	229
Temporary Plankton			
Balanus larvae	128	101	79
Bivalve larvae	11007	24633	224
Bryazoan larvae	13	2	15
Decapod larvae	121	81	67
Gastropod larvae	235	644	275
Polychaete larvae	4288	16435	383 *
Total Mean Zooplankton	114760	162436	142

Table 4. Mean abundance (no/m3) of Copepods and Cladocera in Narragansett Bay. Means are calculated for the same time period as that used in the study by Durbin and Durbin (1981). Data from Durbin include copepodites as well as adults for all species but Acartia hudsonica and A. tonsa, While that of Hulsizer includes copepodites for all species. Stations are listed from upper (St 5) to lower (St A) bay.

	Durbin St 5 1976	Martin St 1 1959-62	Durbin St 1 1976	Hulsizer St 2 1972	Hulsizer St 2 1973	Frol. St B 1951	Martin St 3 1959-62	Frol. St A 1951
Copepods								
Acartia hudsonica	3876.6	707.8	2342.0	8435.7	12088.4	1356.0	1047.8	469.4
Acartia tonsa	3240.5	2612.2	1900.5	334.7	6235.0	749.4	413.5	326.3
Acartia longiremis	0.0	0.0	0.0	0.0	0.0	0.2	0.0	5.1
Calanus finmarchicus	0.0	0.0	0.0	0.0	0.0	0.3	0.0	23.8
Centropages sp	34.9	57.4	116.8	139.5	404.7	196.8	260.7	353.8
Eurytemora sp.	258.9	29.8	1.0	0.0	0.0	59.3	47.4	46.0
Hemicyclops sp (Saphirella)	2707.4	0.0	1090.8	23.2	216.7	0.0	0.0	0.0
Labidocera aestiva	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.8
Microsetella norvegica	34.5	72.2	50.4	0.0	0.0	0.0	443.7	0.0
Metridia lucens	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
Oithona sp.	355.4	4548.5	374.6	486.5	1276.5	55.1	5674.9	86.7
Oncea sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.9
Pseudocalanus minutus	540.8	125.3	632.7	795.9	1022.9	242.2	1098.8	363.9
Pseudodiaptomus coronatus	0.0	34.0	0.0	196.3	277.9	154.4	64.3	0.0
Parvocalanus crassirostris	195.9	0.0	590.1	74.0	823.1	87.6	0.0	94.9
Paracalanus parvus	0.0	0.0	0.0	0.0	0.0	0.8	94.1	0.0
Rhincalanus nasutus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Temora longicornis	9.2	16.2	66.9	126.0	128.0	48.6	167.7	237.7
Tortanus discaudatus	3.3	22.4	16.8	50.5	145.6	12.1	194.7	16.2
Harpacticoid spp.	43.3	0.0	63.6	12.1	40.5	19.7	0.0	0.0
Cladocera								
Evadne nordmanni	847.8	340.5	587.1	259.7	924.1	209.9	216.4	410.0
Evadne spinifera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.8
Penilia avirostris	0.0	1.2	0.0	0.0	0.0	402.0	21.1	815.0
Podon sp.	2292.4	1248.2	3321.6	406.6	2995.9	248.1	223.3	143.7
Temporary Plankton								
Balanus larvae	101.44	37.55	127.79	67.15	42.26	14.2	31.53	3.83
Bivalve larvae	24632.58	0.00	11006.88	219.81	940.70	0	138.78	0
Bryazoan larvae	1.88	0.00	12.85	0	0.00	0	0.00	0
Decapod larvae	81.47	54.08	120.74	5.8	1.76	1091.31	92.08	19.38
Gastropod larvae	644.34	537.55	234.63	20.53	104.54	422.14	423.67	68.67
Polychaete larvae	16434.72	204.49	4288.31	929.73	1082.89	11.14	90.71	0.78
Other Holoplankton								
Medusae	9.83	24.80	7.19	17.32	87.82	8.85	24.92	35.91
Rotifers	25322.76	2188.57	6599.27	1011.94	1868.31	0	455.51	0
Chaetognaths	12.77	6.56	5.57	0.46	3.86	1.42	16.31	17.83

Table 5. Comparison of mean numbers of adult Acartia hudsonica and A tonsa (no/m3), from studies by Durbin, Martin and Frolander. Stations are arranged along a transect from the upper to lower bay. Means from Martin's and Frolander's studies were calculated for a similar period as that used in the study by Durbin and Durbin.

		Durbin Station 5	Martin St 1 D	Durbin Station 1	Frol. St B D	Martin St 3 D	Frol. St A D
Acartia hudsonica	A	3876.56	707.76	2342.04	1355.97	1047.76	469.38
Acartia tonsa	A	3240.55	2612.24	1900.45	749.43	413.47	326.27
Distance from St 5 (miles)		0	4	8.6	13.5	17	24

Table 6. Integrated and arithmetic mean abundance (no/m3) of adult copepods collected at the G.S.O. dock by MERL.

Year	Time Period (Julian Date)	A. hudsonica	A. tonsa	C hamatus	C. typicus	Oithona spp	P. crassir	P. minutus	P. coronatus	T. longicornis
Integrated Mean										
1976-1977	76251-77255	961	696							
1978	78017-78361	558	465	25	5	312	55	100	55	63
1979	79002-79360	639	247							
1980	80001-80365	821	418	34	5	575	0	98	80	20
1981	81015-81348	838	338	67	1	305	14	59	261	6
1982	82011-82362	722	91	49	1	272	308	101	293	15
1982-1983	82264-83264	760	99	10	1	461	402	91	5	24
1985-1986	85162-86161	184	154							
Arithmetic Mean										
1976-1977	76251-77255	1094	720							
1978	78017-78361	564	551	27	5	398	53	59	78	10
1979	79002-79360	625	254							
1980	80001-80365	892	179	26	6	303	0	170	52	40
1981	81015-81348	741	392	25	2	310	28	40	166	11
1982	82011-82362	604	106	31	0	178	94	149	232	25
1982-1983	82264-83264	676	122	16	0	462	246	106	6	38
1985-1986	85162-86161	141	184							
Frolander, St B,1951		1356	749	196.8		55.1	87.6	242	154	48.6

Table 7. Diel changes in abundance of marine zooplankton at different depths (no/m^3) at Station B. (From Mar. Res., 1972a)

	9/22/71 11:00 p.m. Station B			9/23/71 5:00 a.m. Station B			9/23/71 11:00 a.m. Station B		
	0	30'	60'	0	30'	60'	0	30'	60'
Arthropoda									
Acartia clausii									
Acartia tonsa	4,950	23,800		350	15,250	3,830	1,780	16,800	25,300
Barnacle larvae	396				1,337			980	505
Centropages hematus									
Cladocera									
Evadne									
Podon	198	1,840	221		267	142	593	1,570	
Harpacticoids									
Labidocera aestiva									
Nauplii	46,000	32,500	1,105	42,400	35,700	31,700	65,000	67,600	38,800
Oithona brevicornis									
Oithona similis		410				142		392	
Oithona sp.							297	196	126
Pseudodiaptomus coronatus	198								
Saphirella sp.		2,250	1,545	1,250	2,280	566		1,570	758
Tortanus sp.									
Unknown	4,750	4,310		62	3,210	142	593	8,220	5,800
Annelida									
Polychaete larvae				1,250	802			784	252
Chordata									
Tunicate larvae								196	126
Chaetognatha									
Sagitta			221	250		1,135		392	
Mollusca									
Mytilus edulis	396				267		593		
Teredo navalis				125	267				
Unknown		410				283		196	126
Platyhelminthes									
Stylochus juveniles									

Table 8. Annual mean abundance (no/m^3) of *Acartia hudsonica* and *A. tonsa* copepodites, and total copepod nauplii at different depths at Station B. Data are for the period June 1971 - June 1972. (From Mar. Res. 1971; 1972a, b, c, d)

	0 ft	30 ft	60 ft
Acartia hudsonica	4,133	13,257	10,659
Acartia tonsa	2,579	9,415	9,661
Total Nauplii	55,732	46,969	40,011

Table 9.

Table . Zooplankton dry weights (mg dry wt./m3) from different stations in Narragansett Bay. The integrated area of dry wt. vs time and the overall mean dry weight during the period of study are shown for each station. From Durbin and Durbin (1981).

Date	Julian Date	St 1 64-153	St 1 > 153	St 1 Total	St 2 64-153	St 2 > 153	St 2 Total	St 3 64-153	St 3 > 153	St 3 Total
3/1/76	61			136			192			212
3/12/76	72	38.4	106.1	144.6	376.8	214.4	591.6	64.4	355.4	419.8
3/22/76	82	65.5	261.8	327.3	213.0	208.9	421.9	95.4	124.2	219.6
3/29/76	89	45.5	168.1	213.6	106.3	186.5	292.8	42.4	192.6	235.0
4/9/76	100	52.6	171.3	223.9	127.1	229.6	356.7	73.7	176.1	249.8
4/23/76	114	47.1	214.0	261.1	51.9	230.0	281.9	41.8	132.7	174.5
5/3/76	124	71.5	170.3	241.8	275.9	131.5	407.4	40.3	145.7	186.0
5/10/76	131	30.3	83.6	113.9	75.6	131.2	206.8	38.3	373.9	412.7
5/19/76	140	52.1	76.6	128.7	102.4	68.0	170.4			
5/24/76	145	39.5	87.9	117.4	33.5	161.3	194.8	31.2	209.7	240.9
6/1/76	153	88.1	120.7	208.8	41.1	93.3	134.4	35.0	76.0	111.0
6/9/76	161	10.4	35.5	45.9	13.7	39.6	53.3	7.7	92.4	100.1
6/19/76	171	5.7	63.1	68.8	17.6	140.3	157.9	10.4	84.5	94.9
6/28/76	180	49.3	81.3	130.6	33.0	106.3	139.3	29.1	139.1	168.2
7/12/76	194	114.1	319.5	433.6	64.9	292.3	357.2	70.3	206.4	276.7
7/19/76	201	244	187	431	160	233	393	105	238	343
7/26/76	208	205.4	244.1	449.3	188.1	321.1	509.2	162.0	265.7	427.7
8/2/76	215	137.8	87.0	224.8	125.1	93.3	218.4	212.4	52.0	264.4
8/11/76	224	116.6	346.5	463.1	172.7	232.9	405.6	162.3	78.0	240.3
8/16/76	229	57.2	108.8	166.0	87.7	77.7	165.4	144.8	51.4	196.2
8/23/76	236	32.8	56.7	89.5	43.7	23.1	66.8			
8/30/76	243	162.3	52.6	214.9	66.6	45.7	112.3	312.7	103.7	416.3
9/13/76	257	23.3	70.2	93.5	3.1	167.5	170.6	58.1	73.8	131.9
9/17/76	261									
9/24/76	268	169.8	173.5	343.3	159.0	63.1	222.2	413.8	98.1	511.9
10/1/76	275	114.2	31.3	145.5	37.5	32.1	69.6	120.1	71.9	192.0
10/8/76	282	40.6	68.7	109.3	26.2	16.1	42.3	10.4	23.2	33.7
10/15/76	289	64.4	51.3	115.7	160.2	27.6	187.8	52.1	16.7	68.8
10/22/76	296	46.9	61.8	108.7	189.3	44.6	233.9	57.5	10.6	68.1
10/29/76	303	12.2	59.9	72.1	29.5	36.9	66.4	8.9	40.1	49.0
11/5/76	310	10.1	51.7	61.8	39.4	70.4	109.8	8.0	40.0	48.0
Area		17614	30648	49740	23312	31948	59572	22225	31351	57056
Mean		74.0	128.8	199.8	97.9	134.2	239.2	93.4	131.7	229.1

Table 9.

Table . Zooplankton dry weights (mg dry wt./m3) from different stations in Narragansett Bay. The integrated area of dry wt. vs time and the overall mean dry weight during the period of study are shown for each station. From Durbin and Durbin (1981).													
		St 4 64-153	St 4 > 153	St 4 Total	St 5 64-153	St 5 > 153	St 5 Total	St 6 64-153	St 6 > 153	St 6 Total	St 7 64-153	St 7 > 153	St 7 Total
Date	Julian Date												
3/1/76	61			156			104			186			64
3/12/76	72	45.4	44.3	89.7	72.4	161.8	234.2	40.9	177.7	218.6	17.2	23.9	41.1
3/22/76	82	293.6	74.6	368.2	136.1	121.2	257.3	515.9	229.7	745.6	77.4	91.9	169.3
3/29/76	89	116.0	79.5	195.5	67.2	111.3	178.4		145.9		48.3	90.6	138.9
4/9/76	100	67.0	122.4	189.4	98.3	367.0	465.3	149.8	274.3	424.1	93.1	145.1	238.2
4/23/76	114	44.1	178.5	222.6	39.8	254.6	294.4	57.4	363.7	421.1	17.8	177.9	196.7
5/3/76	124	53.8	83.2	137.0	35.9	100.0	135.9	57.6	104.4	162.0	47.4	135.9	183.2
5/10/76	131	55.0	116.8	171.8	36.5	94.5	131.0	30.9	38.2	61.9	27.3	51.2	78.6
5/19/76	140				36.1	237.4	270.8						
5/24/76	145	34.8	490.7	525.5	24.2	253.0	277.2	22.6	87.8	109.4	40.6	153.8	194.4
6/1/76	153	103.0	213.2	316.2	33.8	109.9	143.7	41.8	141.1	182.9	34.3	136.8	171.1
6/9/76	161	27.1	142.4	169.5	3.7	62.1	65.7	9.4	76.8	86.2	7.4	104.8	122.1
6/19/76	171	30.6	459.6	490.2	6.7	196.7	203.4	6.4	181.1	187.5	2.0	99.8	101.8
6/28/76	180	78.1	468.9	547.0	45.3	447.3	492.6	24.2	376.2	400.4	87.1	240.6	327.7
7/12/76	194	121.4	672.3	793.7	68.3	335.2	403.5	65.4	249.8	315.2	400.4	225.8	626.2
7/19/76	201	58.0	414	472	33	413	446	59	292	351	276	217	493
7/26/76	208	66.3	150.4	216.7	107.3	278.6	385.9	109.3	319.4	428.7	112.6	283.9	396.5
8/2/76	215	125.1	54.1	179.2	45.2	110.0	155.2	66.4	156.4	222.8	123.9	144.4	268.3
8/11/76	224	55.3	39.2	94.5	123.1	142.5	265.6	65.2	69.7	134.9	67.8	124.3	192.1
8/16/76	229	164.2	36.9	201.1	128.8	41.2	170.0	84.0	219.8	303.8	43.3	78.8	122.1
8/23/76	236				46.3	42.5	88.8						
8/30/76	243	104.8	29.7	134.5	65.2	41.3	106.5	58.6	48.7	107.2	37.2	113.5	150.7
9/13/76	257	44.0	105.2	149.2	41.3	45.8	87.1	19.5	107.9	127.2	13.1	258.2	271.2
9/17/76	261												
9/24/76	268	125.9	87.8	213.7	51.6	52.0	103.6	48.8	64.0	112.8	81.0	162.9	243.9
10/1/76	275	42.2	14.9	57.1	34.2	27.3	61.5	24.4	81.0	105.4	16.1	103.9	120.0
10/8/76	282	45.9	14.0	59.5	26.9	24.1	51.0	31.9	20.9	52.6	35.2	112.6	147.8
10/15/76	289	49.4	79.4	128.8									
10/22/76	296	36.1	45.2	81.3	101.0	38.8	139.8	133.4	47.9	181.3	80.8	57.6	138.4
10/29/76	303	11.1	28.2	39.3	22.8	71.6	94.4	12.7	64.6	77.3	13.6	45.2	58.8
11/5/76	310	22.3	30.5	52.8	132.0	40.3	53.5	8.6	50.4	59.0	5.5	32.7	38.2
	Area	18422	41288	61058	13614	37598	52635	19513	38233	59878	16714	32681	50061
	Mean	77.4	173.5	245.2	57.2	158.0	211.4	82.0	160.6	240.5	70.2	137.3	201.0

Table 10. Mean zooplankton dry weights (mg dry wt/m3) during the period 3/1/1976 to 11/5/1976 in Narragansett Bay. Stations are arranged in order of their distance up the Bay from the mouth. From Durbin and Durbin (1981).

Station	Size Class 64-153	> 153	Total
St. 7	70.2	137.3	201.0
St. 1	74.0	128.8	199.8
St. 2	97.9	134.2	239.2
St. 6	82.0	160.6	240.5
St. 3	93.4	131.7	229.1
St. 5	57.2	158.0	211.4
St. 4	77.4	173.5	245.2

Table 11.

Zooplankton dry weights (mg/m3). Fom the Kremer-Nixon 72-73 Bay Survey. Mean is calc. by trapezoidal integration between each sampling date. The first column is the mean over the entire period of the study while the second is over a period similar to that in the study by Durbin and Durbin (1981). Data from 1972 were added on after the 1973 data to give an annual cycle. The dates over which the data were integrated were 2/28/73 to 11/13/72.

Station	Mean, mg/m3	Mean (D), mg/m3
3	107.4	134.5
4	147.9	180.4
5	128.9	148.8
6	167.2	206.2
7	141.7	161.3
8	138.9	162.8
9	116.5	128.9
10	87.7	103.0
11	75.0	92.3
12	66.2	74.7
13	82.7	94.5
14	88.0	98.6
15	81.6	97.3

Table 12. Annual mean zooplankton dry weight (mg/m3) in Narragansett Bay along a transect from Fox Pt (St 1) to Lower Narragansett Bay (St 17). Data from Fig 7, Merl (1980). Samples were collected with vertical hauls of a 153µm mesh net with a 0.7 m opening.

Station	Km	Dry Wt mg/m3
1	.5	25.6
2	4.1	41.9
3	7.6	43.7
6	10.0	37.8
8	13.2	45.6
12	16.9	48.9
10	17.6	50.2
13	22.1	58.2
14	26.9	42.1
15	33.6	50.9
16	40.0	28.0
17	44.0	17.6

Fig. 1A

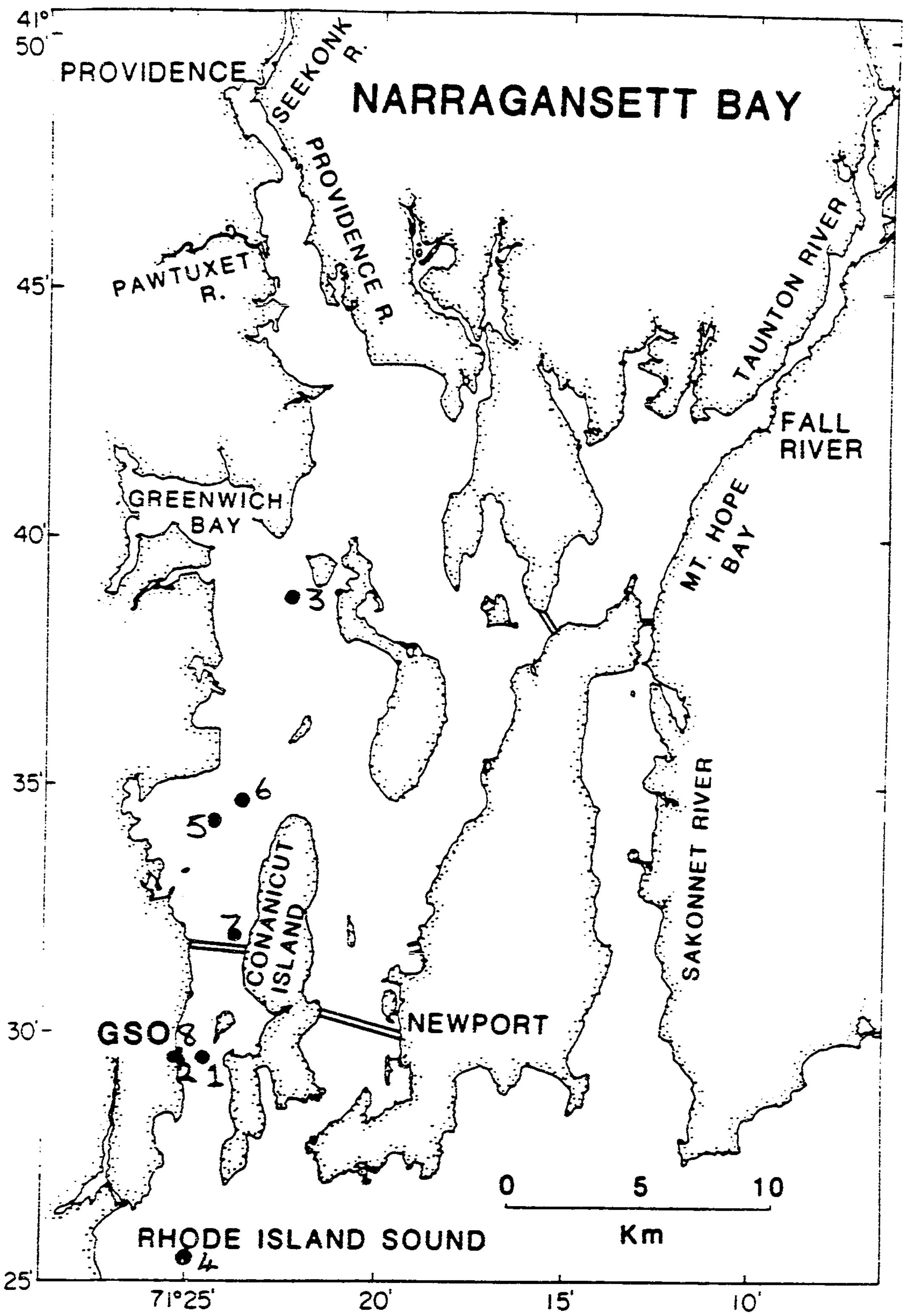

NARRAGANSETT BAY
PROVIDENCE
SEEKONK R.
PROVIDENCE R.
PAWTUXET R.
TAUNTON RIVER
FALL RIVER
GREENWICH BAY
MT. HOPE BAY
SAKONNET RIVER
CONANICUT ISLAND
NEWPORT
GSO
RHODE ISLAND SOUND
0 5 10
Km
41° 50'
45'
40'
35'
30'
25'
71°25'
20'
15'
10'
1
2
3
4
5
6
7
8

Fig. 1A. Station locations of zooplankton studies carried out in Narragansett Bay. Station numbers are as follows. 1, Frolander St. B; 2, Faber; 3, Martin St. 1; 4, Martin St. 3; 5, Hulsizer St. 2; 6, Marine Research St. A; 7, Marine Research St. B; 8, MERL.

Fig. 1B. Station locations of study by Durbin and Durbin, 1981.

Fig. 2a - g. Seasonal changes in the more abundant zooplankton taxa in lower (St. 1), and upper (St. 5) Narragansett Bay. Data for 1976 from Durbin and Durbin, 1981.

Fig. 2a

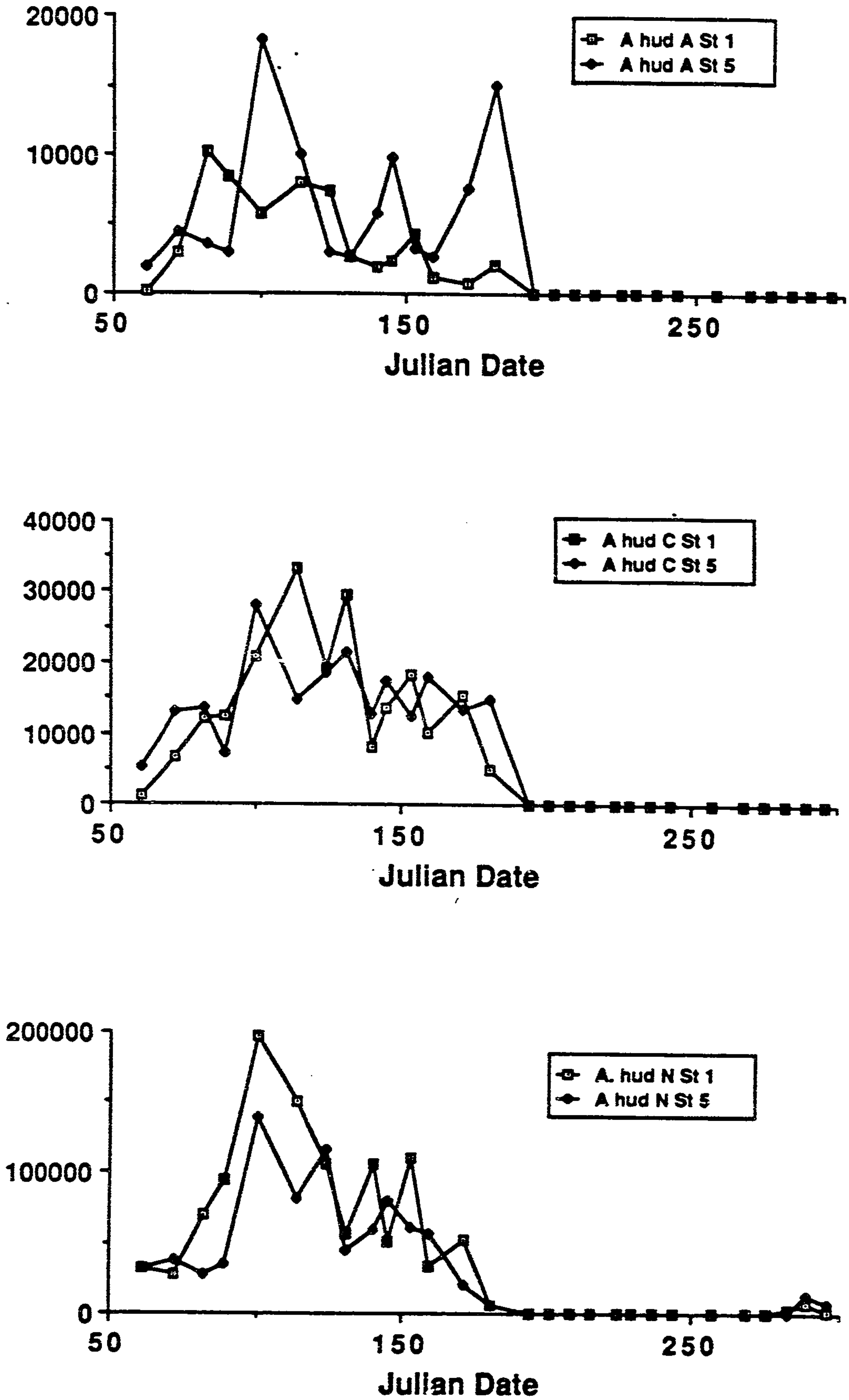
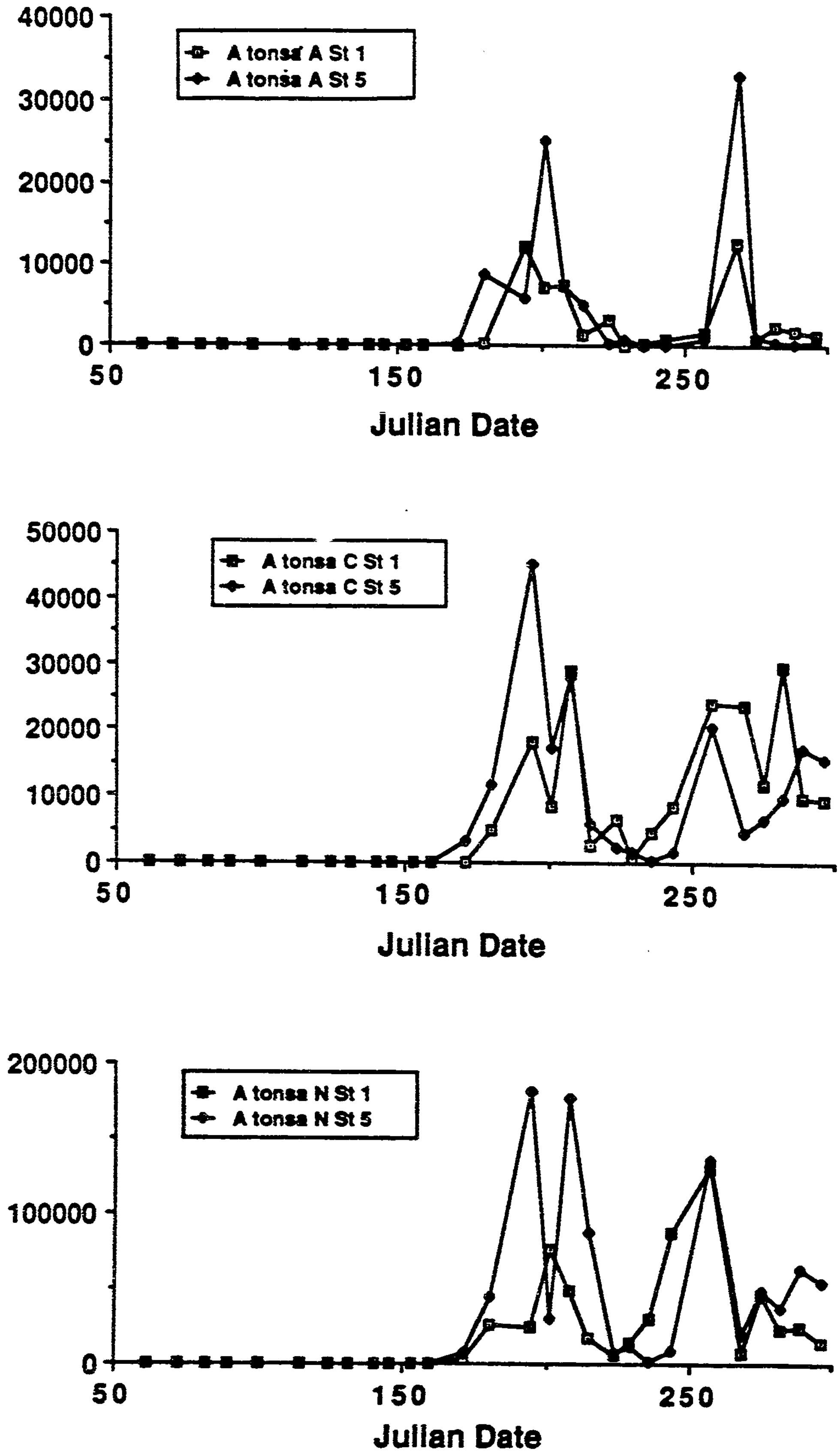

20000
10000
0
50
150
250
Julian Date
A hud A St 1
A hud A St 5
40000
30000
20000
10000
0
50
150
250
Julian Date
A hud C St 1
A hud C St 5
200000
100000
0
50
150
250
Julian Date
A. hud N St 1
A hud N St 5

Fig. 2b



A tonsa A St 1
A tonsa A St 5
40000
30000
20000
10000
0
50
150
250
Julian Date
A tonsa C St 1
A tonsa C St 5
50000
40000
30000
20000
10000
0
50
150
250
Julian Date
A tonsa N St 1
A tonsa N St 5
200000
100000
0
50
150
250
Julian Date

Fig. 2c

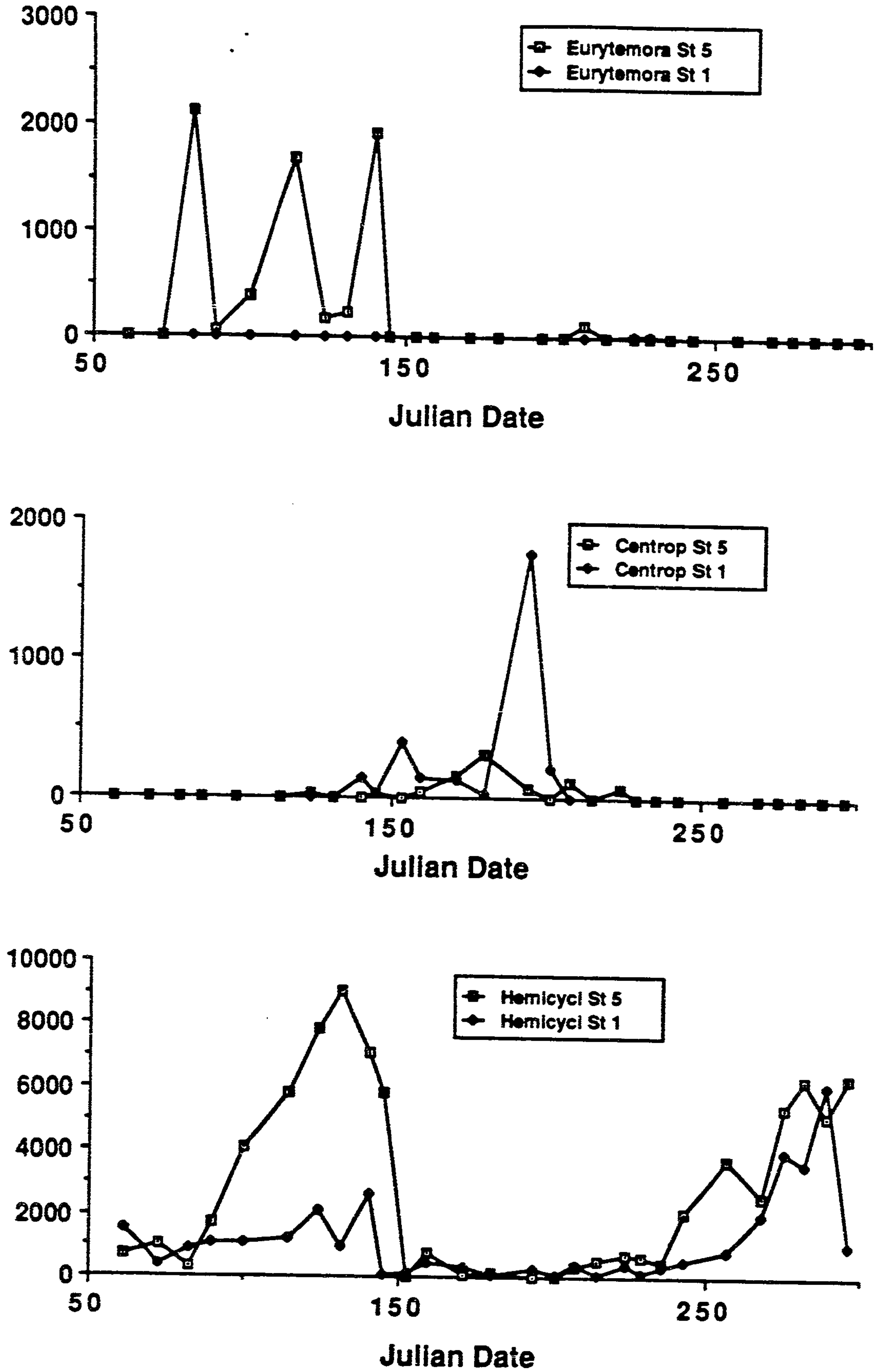

3000
2000
1000
0
50
150
250
Eurytemora St 5
Eurytemora St 1
Julian Date
2000
1000
0
50
150
250
Centrop St 5
Centrop St 1
Julian Date
10000
8000
6000
4000
2000
0
50
150
250
Hemicycl St 5
Hemicycl St 1
Julian Date

Fig. 2d

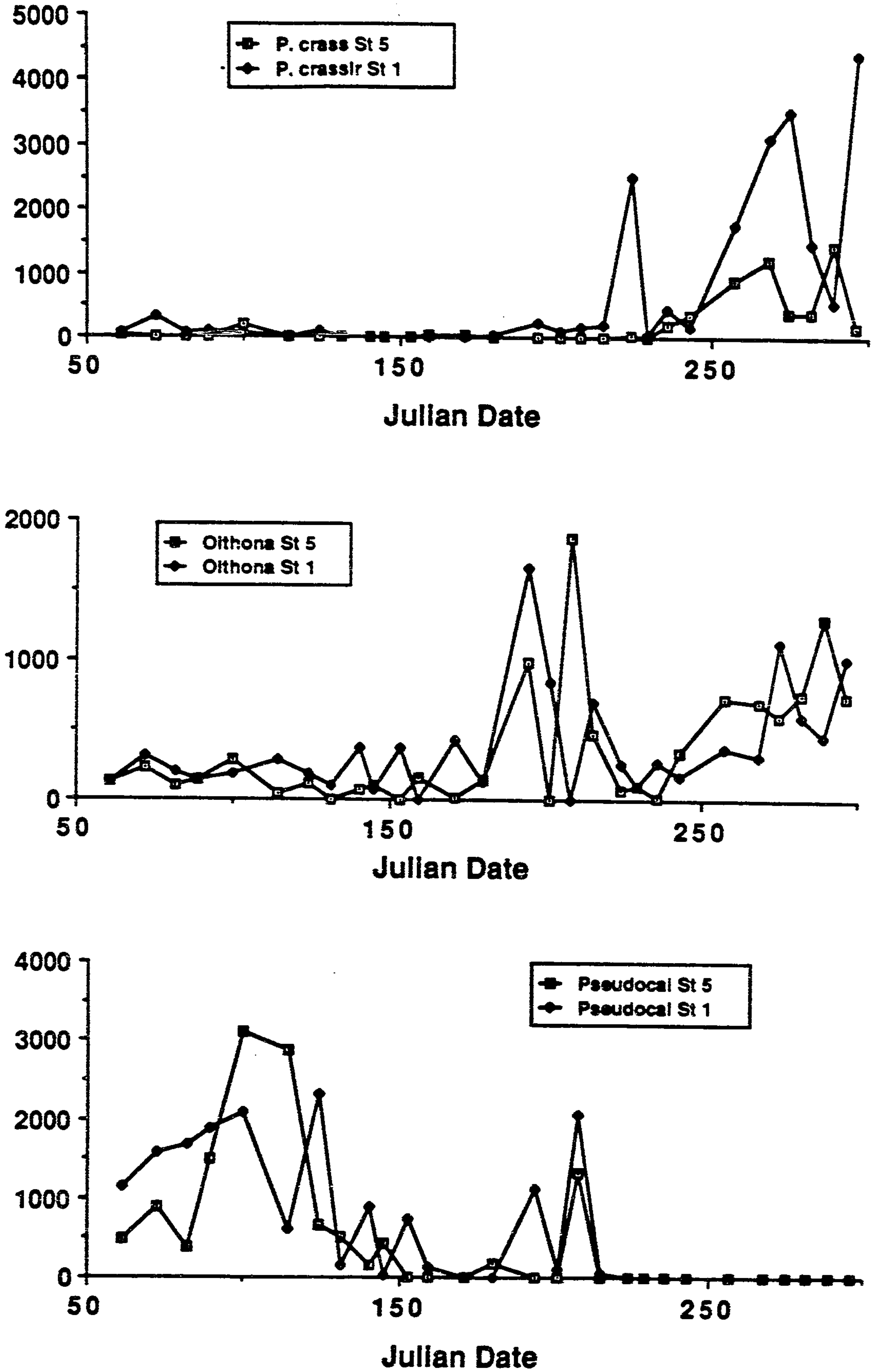
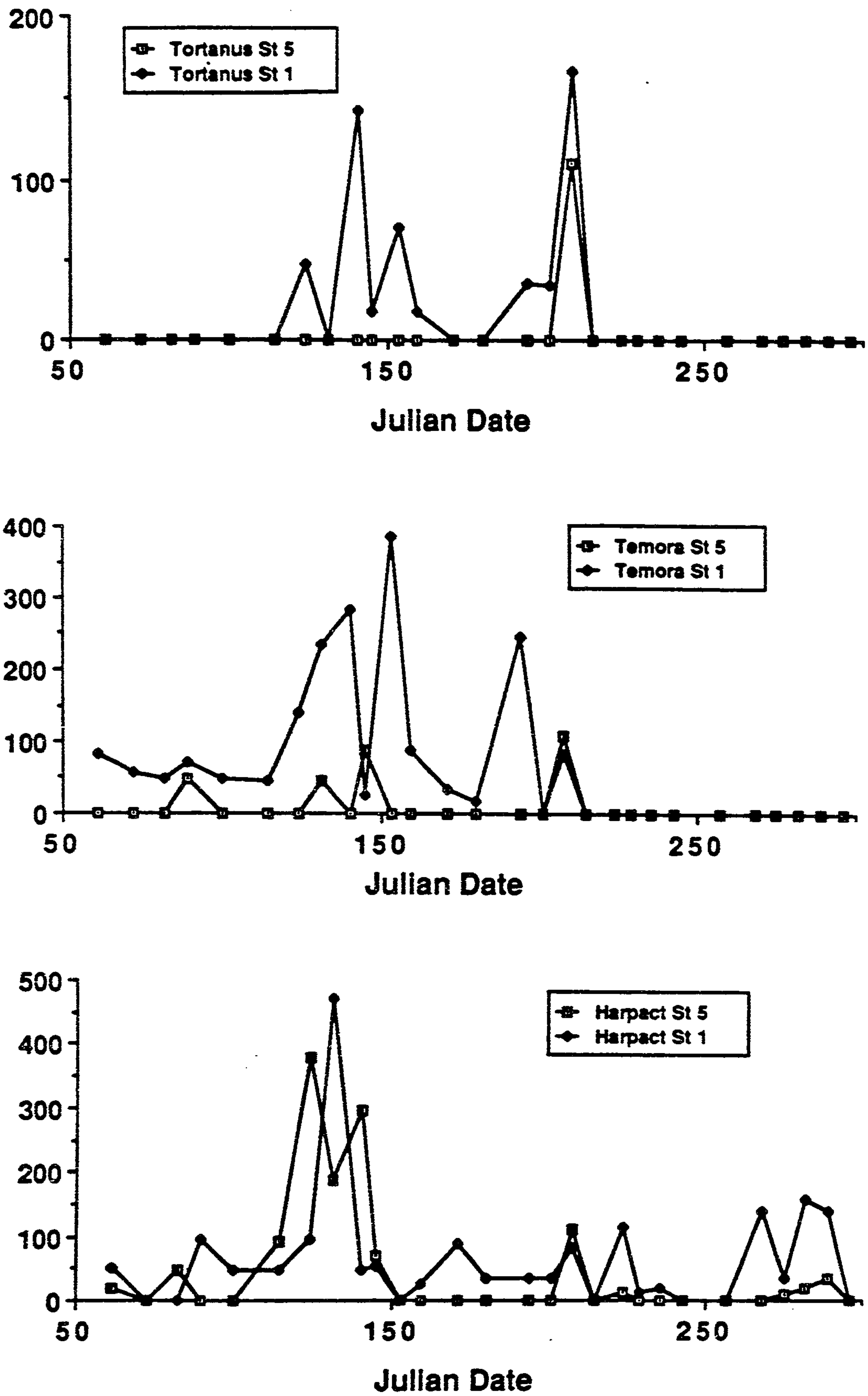
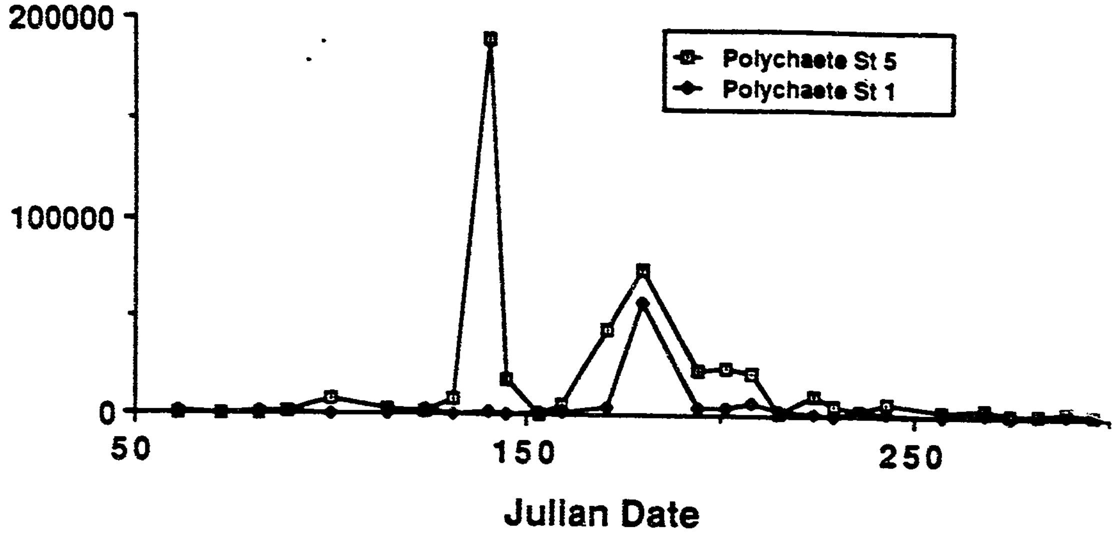

5000
4000
3000
2000
1000
0
50
150
250
Julian Date
P. crass St 5
P. crassir St 1
2000
1000
0
50
150
250
Julian Date
Oithona St 5
Oithona St 1
4000
3000
2000
1000
0
50
150
250
Julian Date
Pseudocal St 5
Pseudocal St 1

Fig. 2e

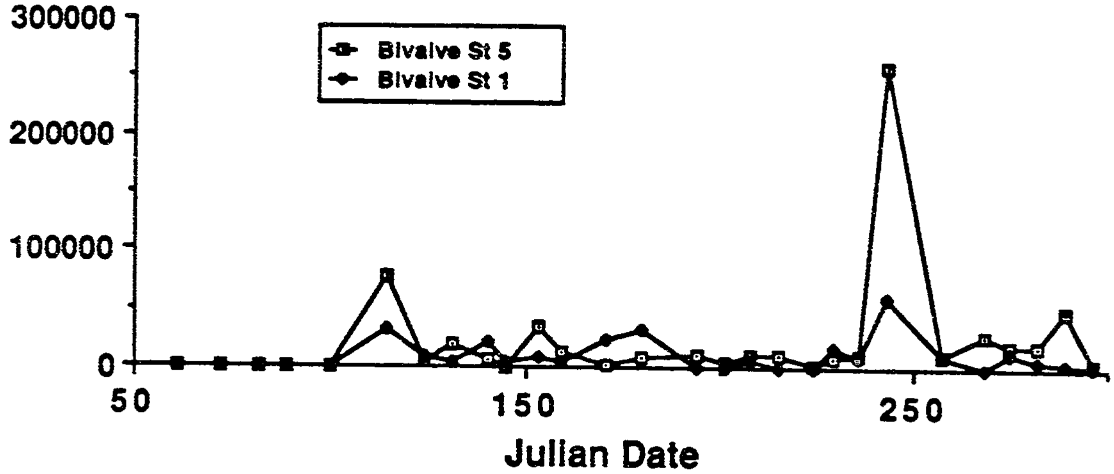


200
100
0
50
150
250
Tortanus St 5
Tortanus St 1
Julian Date
400
300
200
100
0
50
150
250
Temora St 5
Temora St 1
Julian Date
500
400
300
200
100
0
50
150
250
Harpact St 5
Harpact St 1
Julian Date

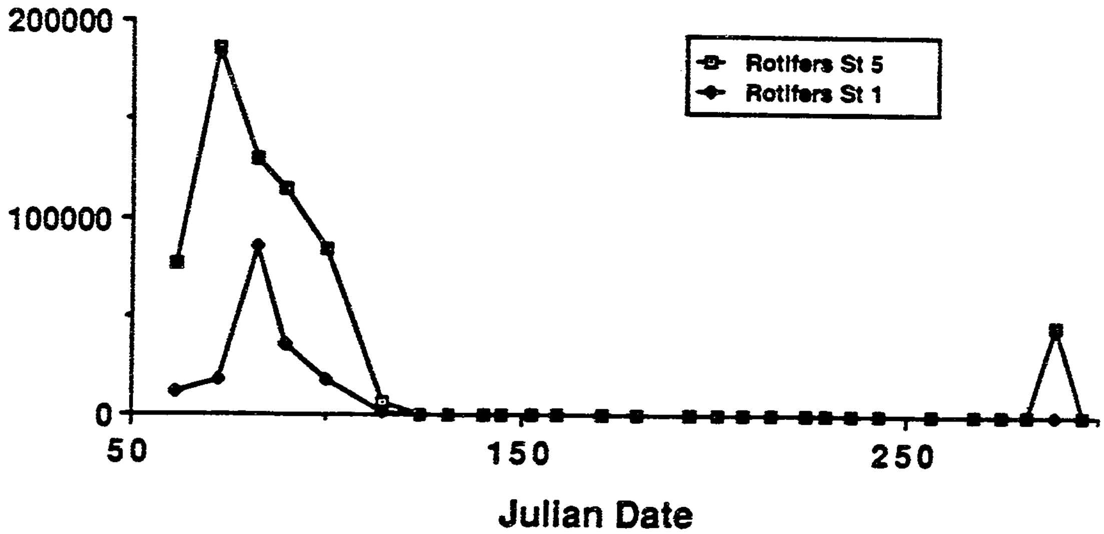
Fig. 2f



200000
100000
0
50
150
250
Julian Date
Polychaete St 5
Polychaete St 1

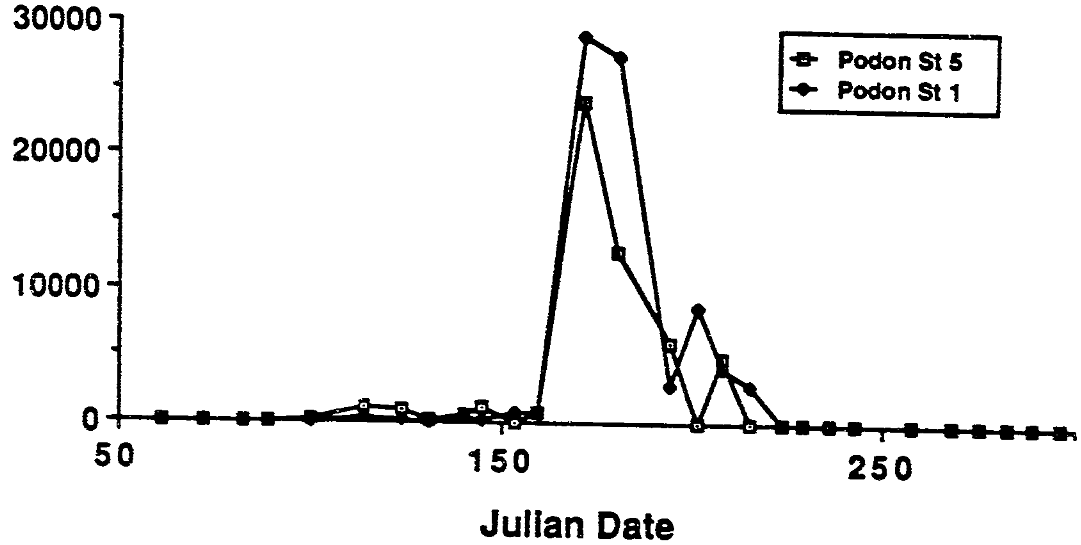


300000
200000
100000
0
50
150
250
Julian Date
Bivalve St 5
Bivalve St 1



200000
100000
0
50
150
250
Julian Date
Rotifers St 5
Rotifers St 1

Fig. 2g


30000
20000
10000
0
50
150
250
Julian Date
Podon St 5
Podon St 1

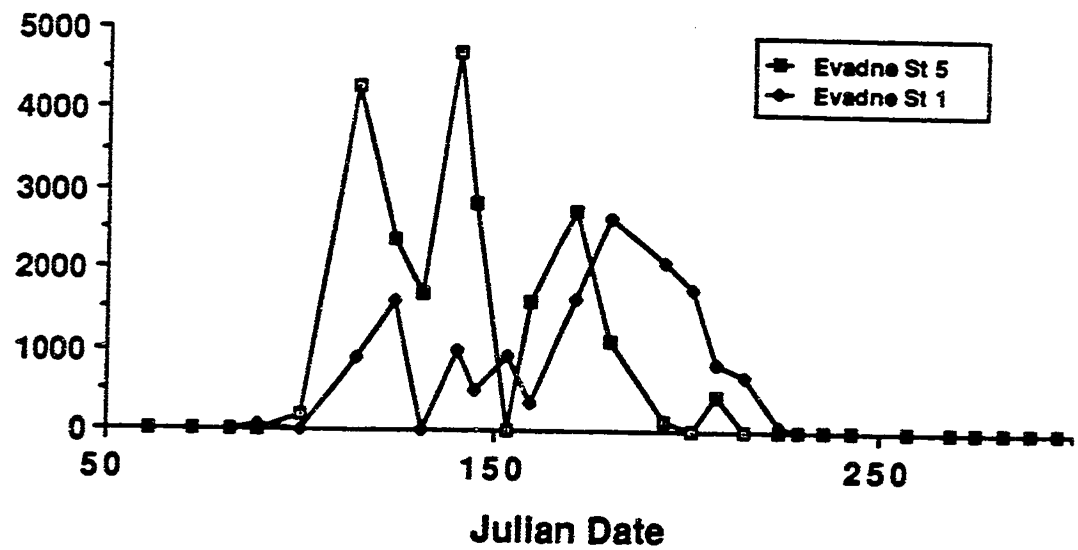
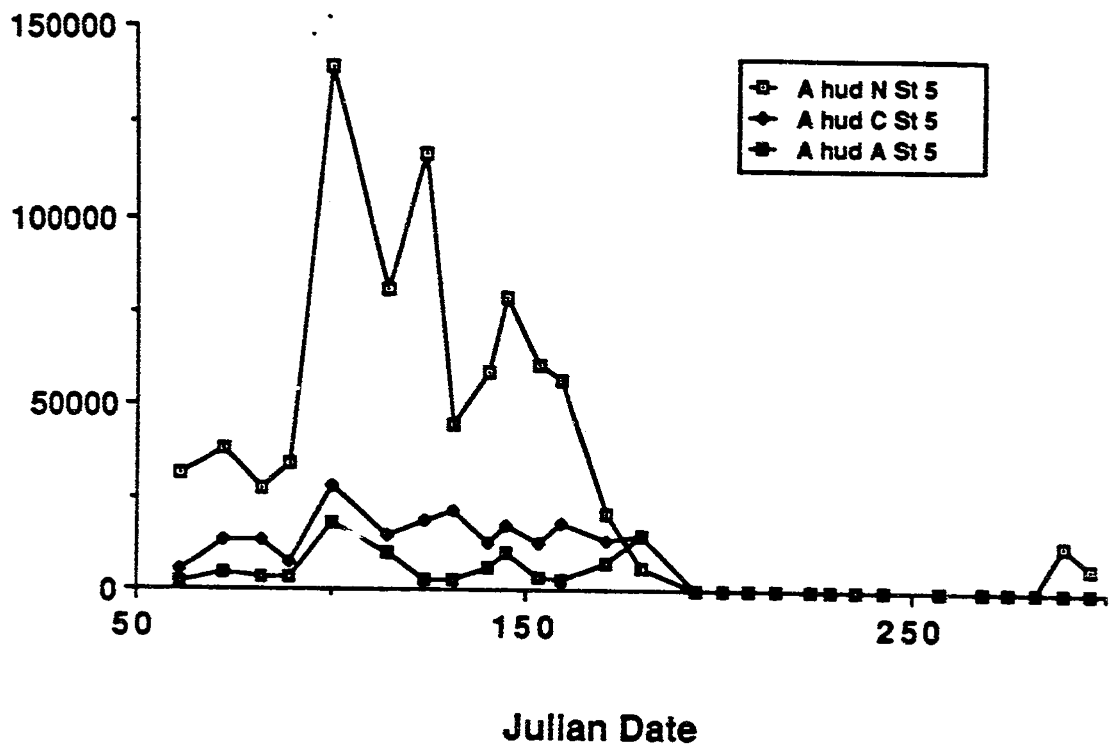

5000
4000
3000
2000
1000
0
50
150
250
Julian Date
Evadne St 5
Evadne St 1

Fig. 3a. Seasonal changes in abundance of total nauplii, copepodites and adults of *Acartia hudsonica* in lower (St. 1) and upper (St. 5) Narragansett Bay from Durbin and Durbin (1981).

Fig. 3b. Seasonal changes in abundance of total nauplii, copepodites and adults of *A. tonsa* (Durbin and Durbin, 1981).

Fig. 3a


150000
100000
50000
0
50
150
250
Julian Date
A hud N St 5
A hud C St 5
A hud A St 5

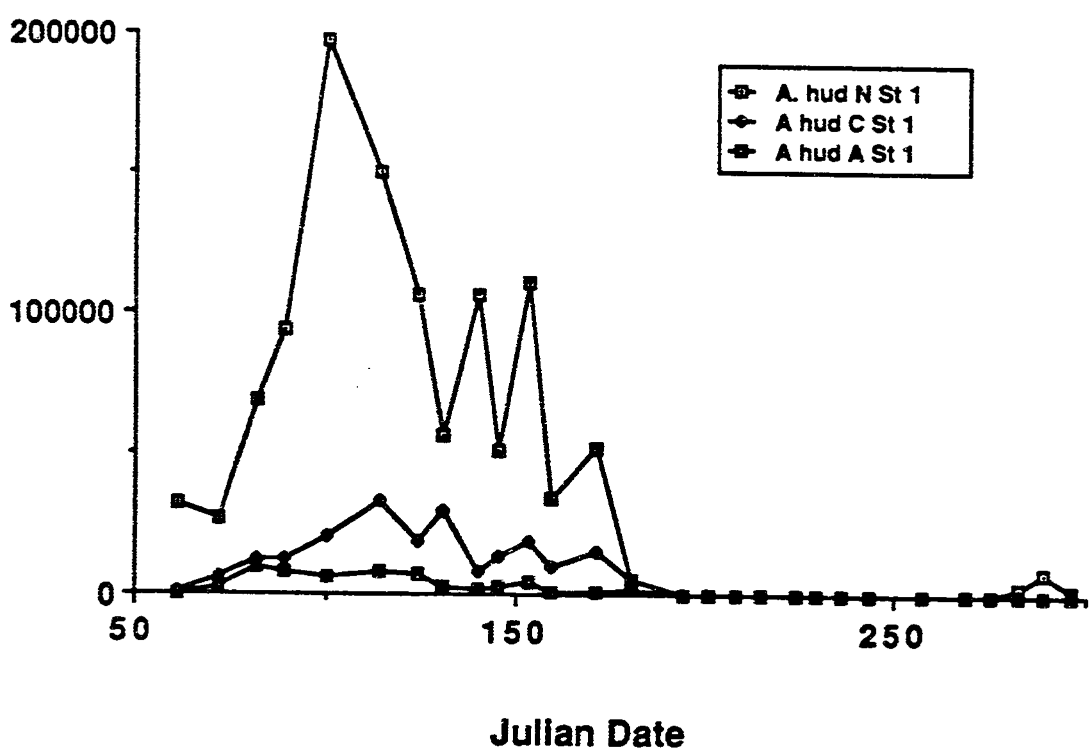
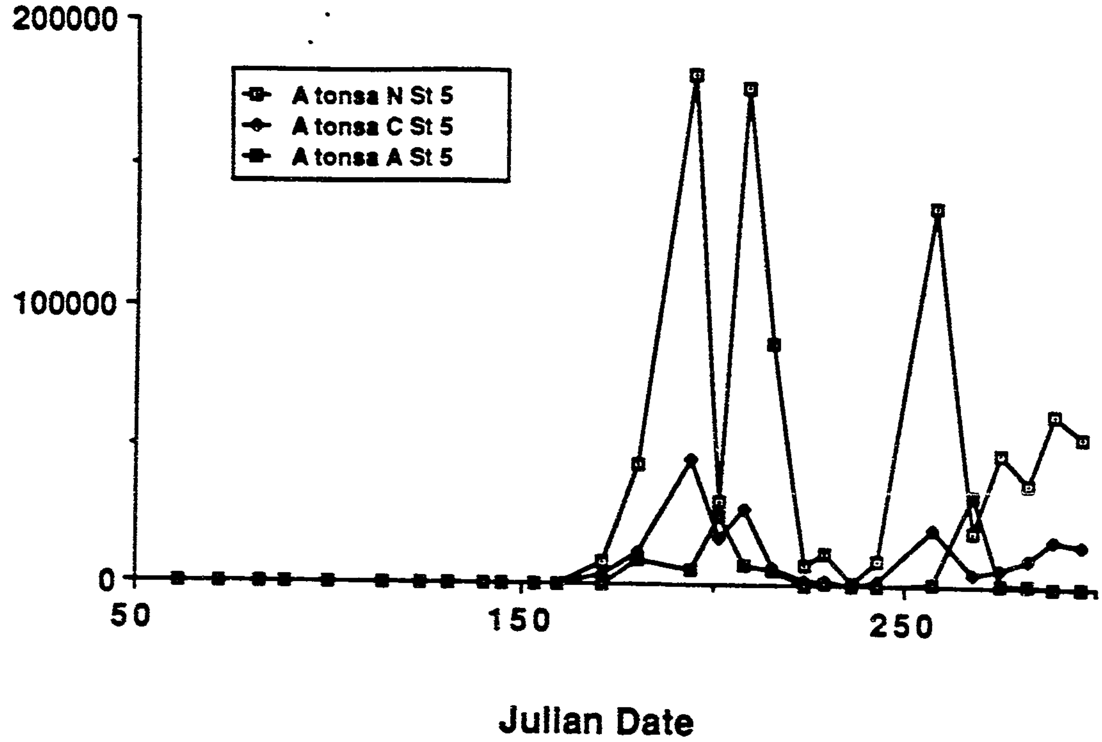
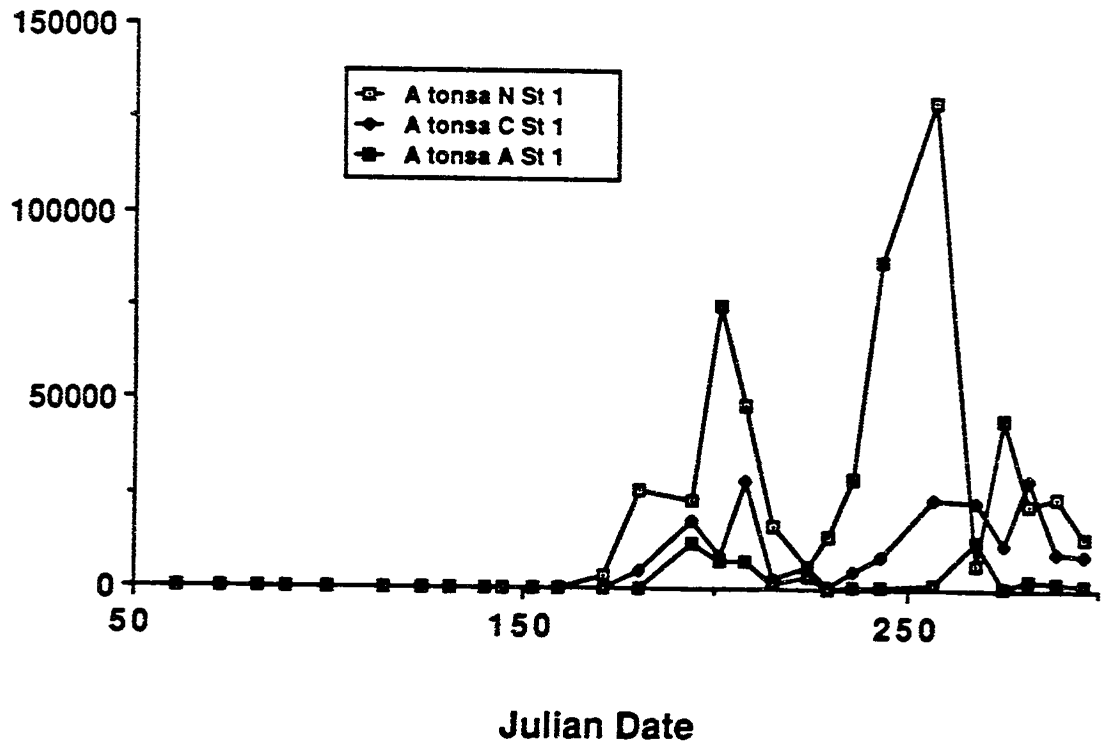

200000
100000
0
50
150
250
Julian Date
A. hud N St 1
A hud C St 1
A hud A St 1

Fig. 3b



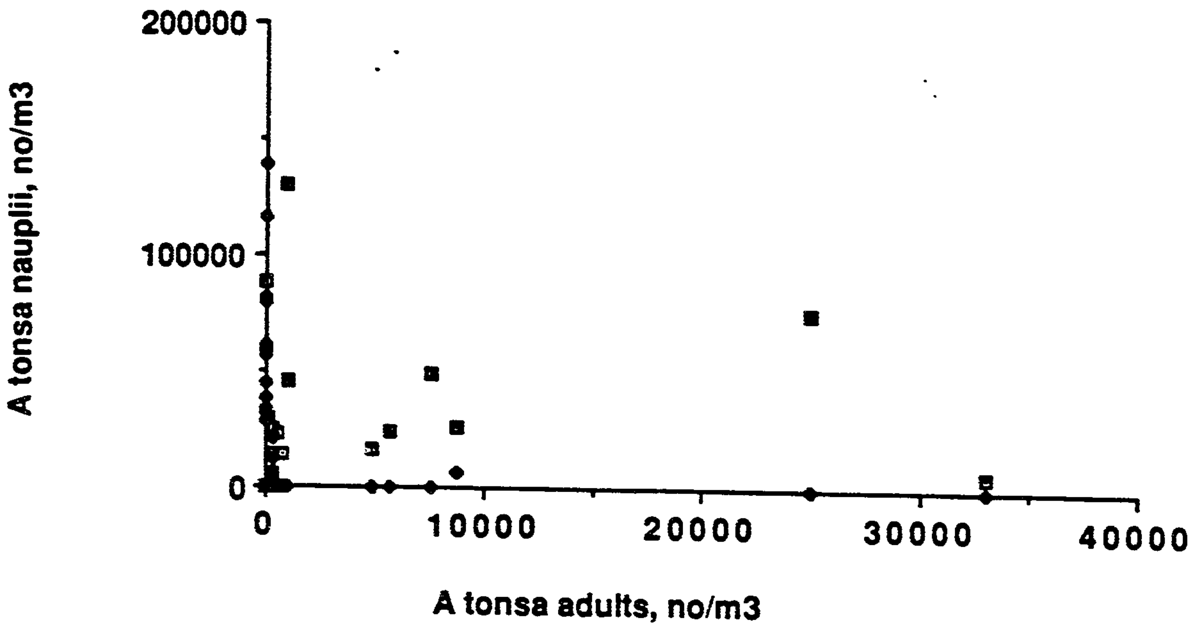
200000
100000
0
50
150
250
Julian Date
A tonsa N St 5
A tonsa C St 5
A tonsa A St 5



150000
100000
50000
0
50
150
250
Julian Date
A tonsa N St 1
A tonsa C St 1
A tonsa A St 1

Fig. 4. Plot of *Acartia hudsonica* and *A. tonsa* total nauplii recorded on a given sampling date against numbers of adults recorded on the same date. Data from Durbin and Durbin (1981. Squares St. 1, diamonds St. 5.

Fig. 4


200000
100000
0
A tonsa nauplii, no/m3
0
10000
20000
30000
40000
A tonsa adults, no/m3

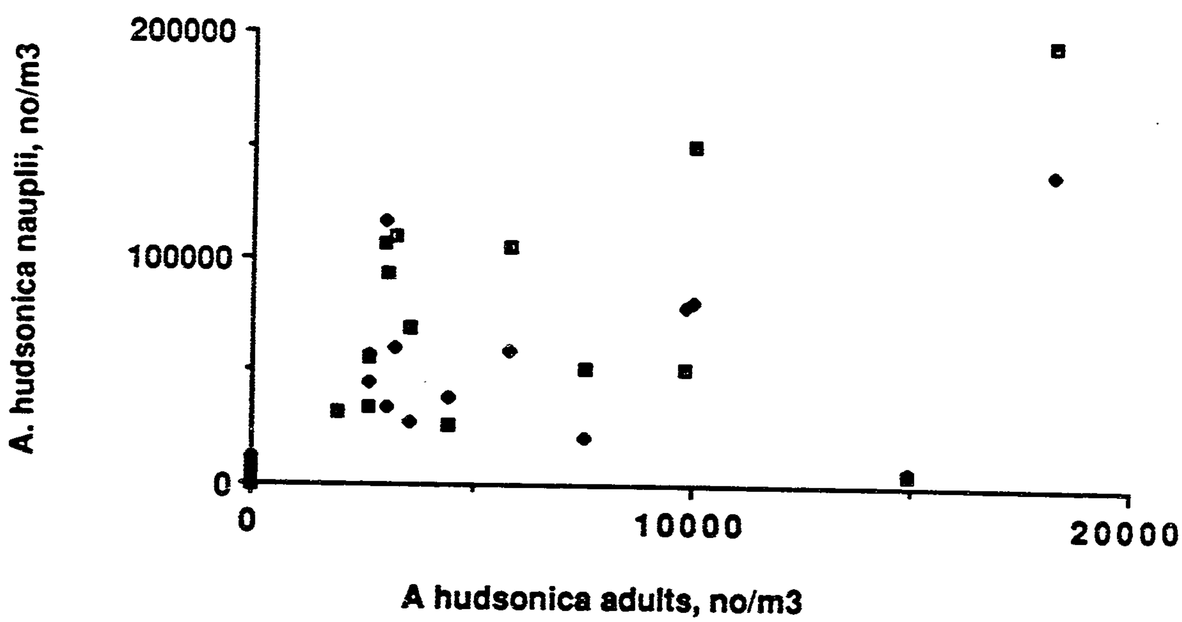
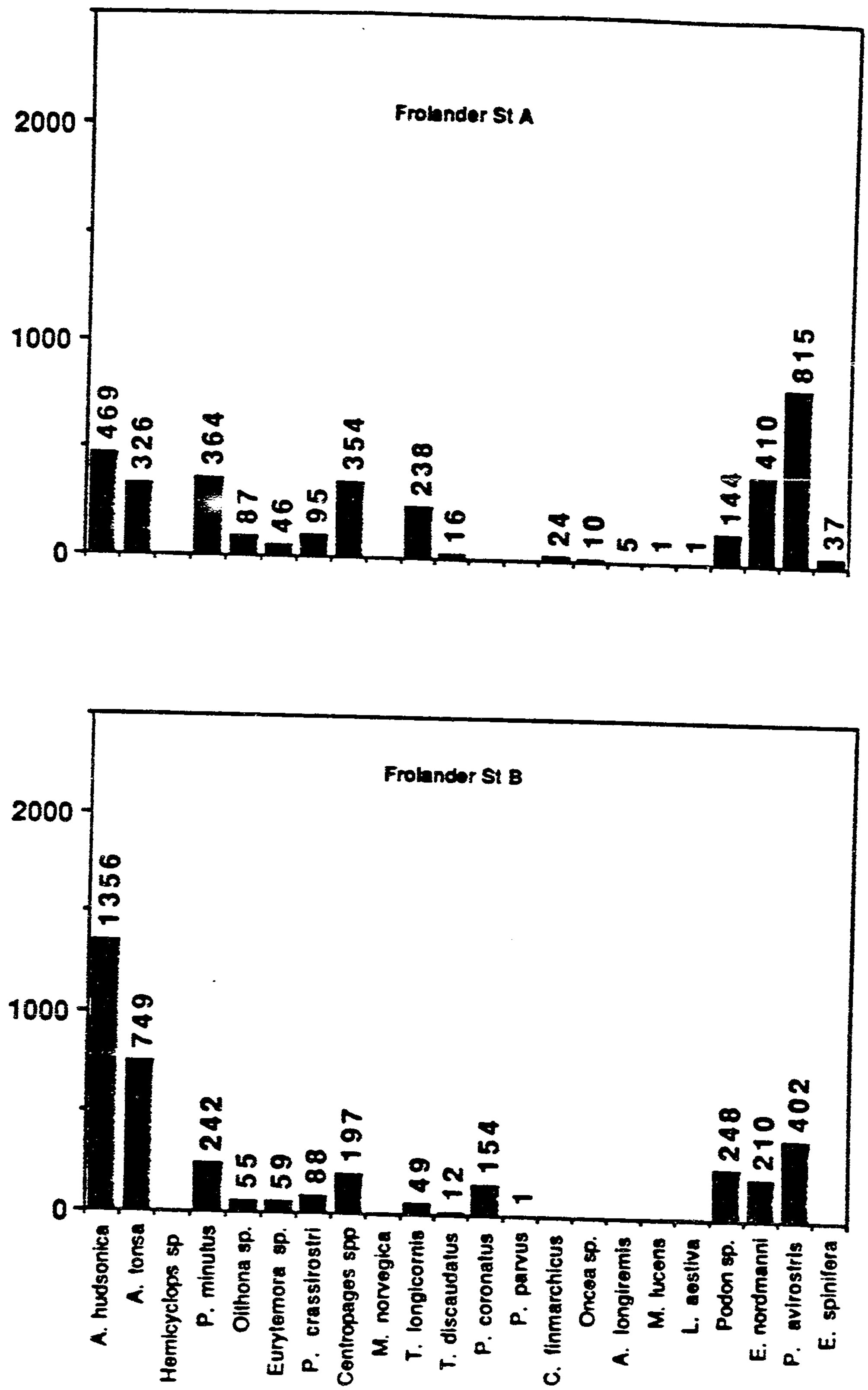

200000
100000
0
A. hudsonica nauplii, no/m3
0
10000
20000
A hudsonica adults, no/m3

Fig. 5a - d. Plot of annual mean abundance of major species of copepods and cladocera.
(a) Frolander; (b) Martin; (c) Hulsizer;
(d) Durbin and Durbin.

Fig. 5a



Frolander St A
Frolander St B
2000
1000
0
469
326
364
87
46
95
354
238
16
24
10
5
1
1
144
410
815
37
1356
749
242
55
59
88
197
49
12
154
1
248
210
402
A. hudsonica
A. tonsa
Hemicyclops sp
P. minutus
Oithona sp.
Eurytemora sp.
P. crassirostri
Centropages spp
M. norvegica
T. longicornis
T. discaudatus
P. coronatus
P. parvus
C. finmarchicus
Oncea sp.
A. longiremis
M. lucens
L. aestiva
Podon sp.
E. nordmanni
P. avirostris
E. spinifera

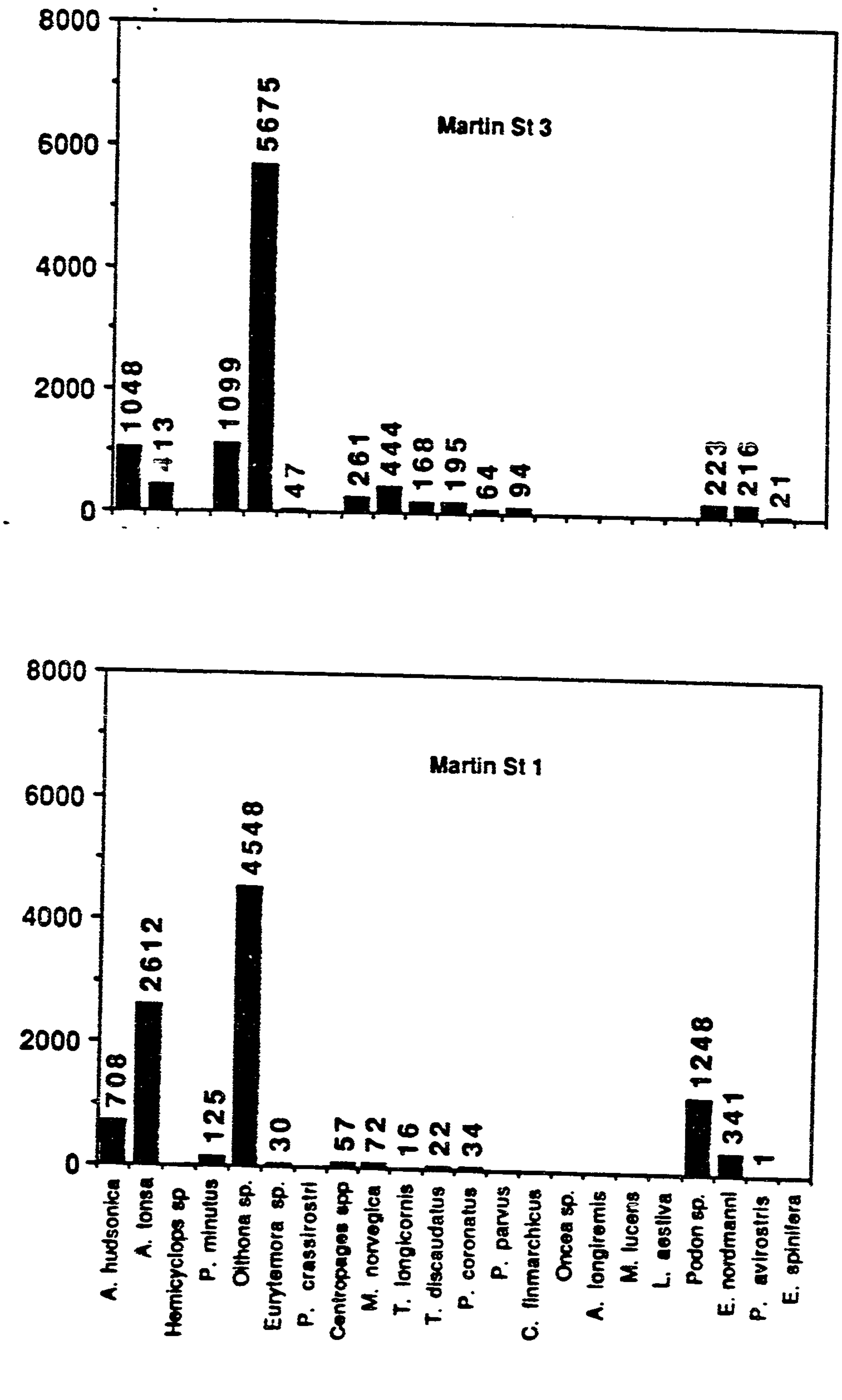
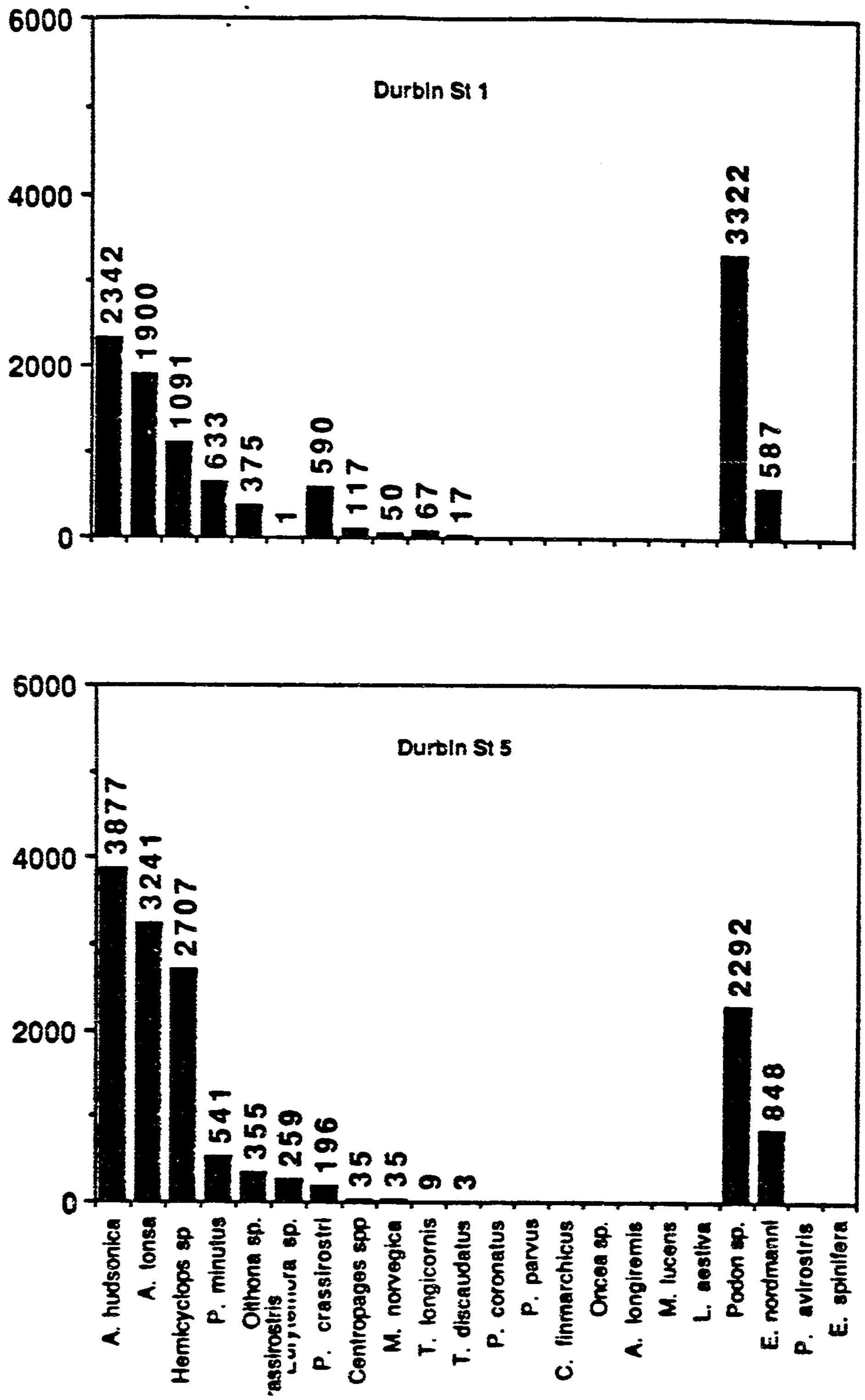

Martin St 3
8000
6000
4000
2000
0
1048
413
1099
5675
47
261
444
168
195
64
94
223
216
21
Martin St 1
8000
6000
4000
2000
0
708
2612
125
4548
30
57
72
16
22
34
1248
341
1
A. hudsonica
A. tonsa
Hemicyclops sp
P. minutus
Oithona sp.
Eurytemora sp.
P. crassirostri
Centropages spp
M. norvegica
T. longicornis
T. discaudatus
P. coronatus
P. parvus
C. finmarchicus
Oncea sp.
A. longiremis
M. lucens
L. aestiva
Podon sp.
E. nordmanni
P. avirostris
E. spinifera

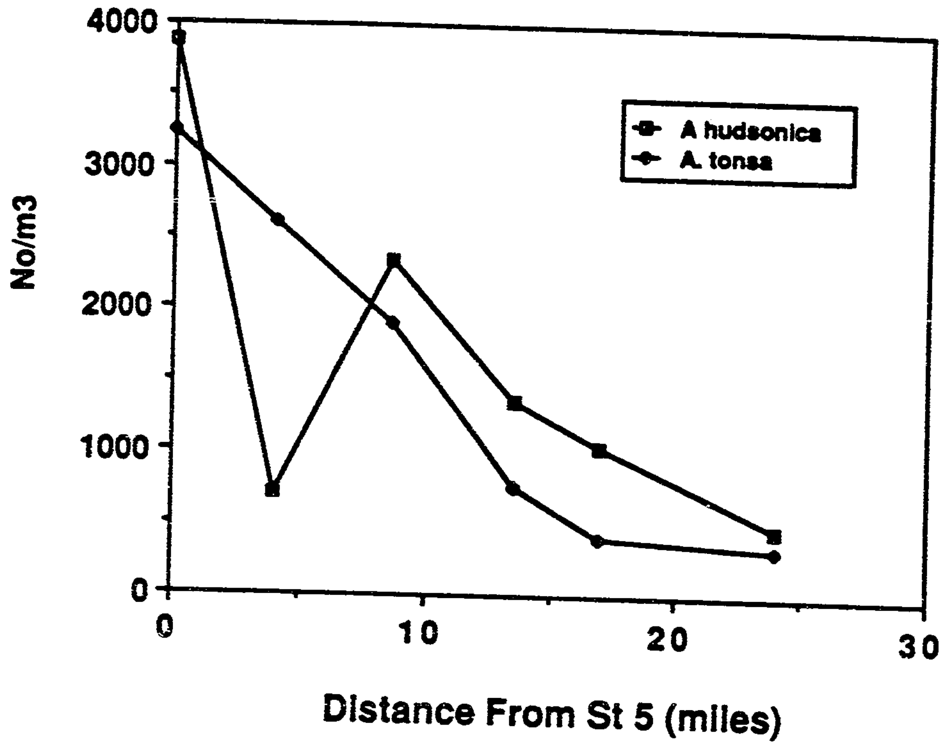
Fig. 5d



Durbin St 1
6000
4000
2000
0
2342
1900
1091
633
375
1
590
117
50
67
17
3322
587
Durbin St 5
3877
3241
2707
541
355
259
196
35
35
9
3
2292
848
A. hudsonica
A. tonsa
Hemicyclops sp
P. minutus
Oithona sp.
P. crassirostri
Centropages spp
M. norvegica
T. longicornis
T. discaudatus
P. coronatus
P. parvus
C. finmarchicus
Oncea sp.
A. longiremis
M. lucens
L. aestiva
Podon sp.
E. nordmanni
P. avirostris
E. spinifera

Fig. 6. Plot of integrated mean annual numbers of adult *Acartia hudsonica* and *A. tonsa* along a transect from upper (St. 5) to lower Narragansett Bay. Data from Table 5.

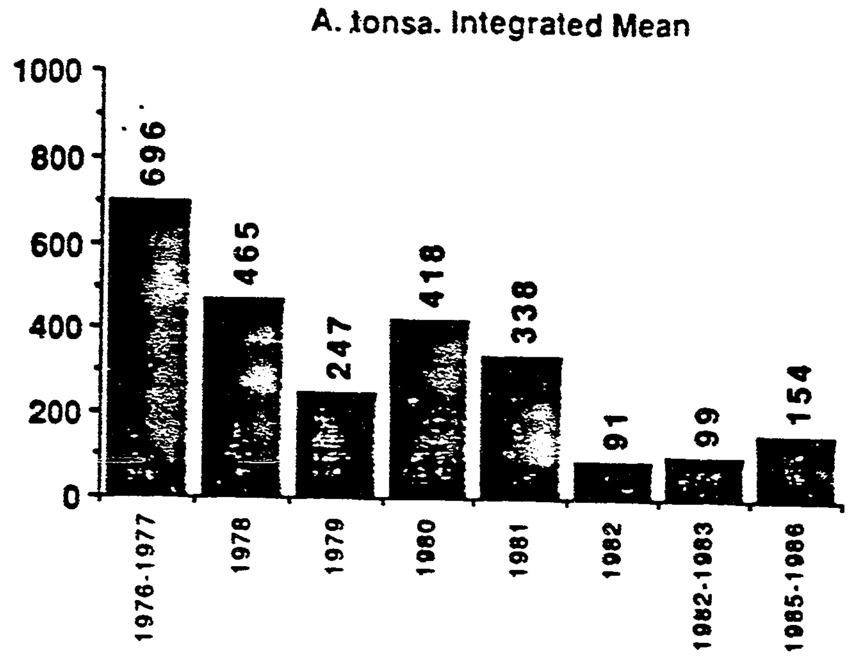
Fig. 6



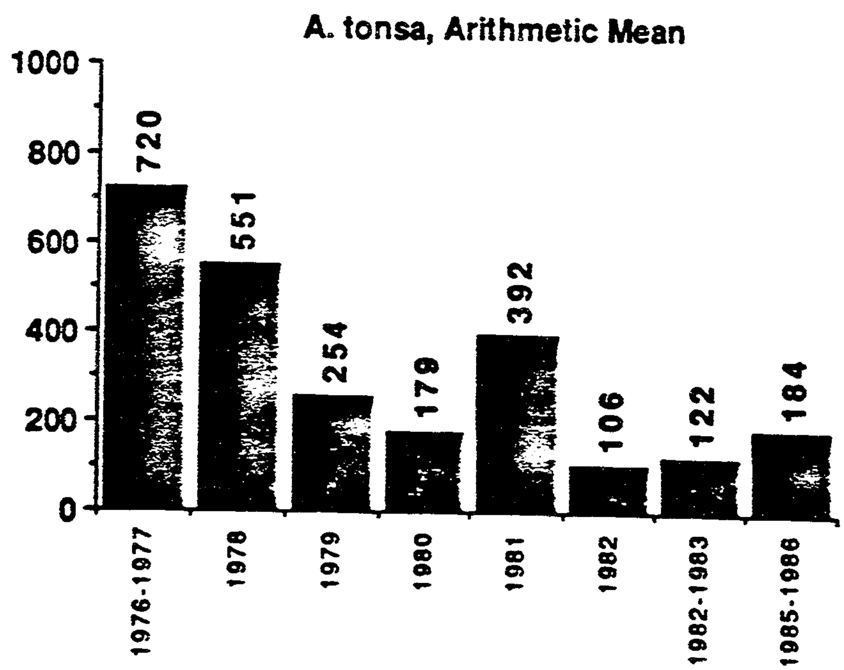
4000
3000
2000
1000
0
No/m3
A hudsonica
A. tonsa
0
10
20
30
Distance From St 5 (miles)

Fig. 7a, b. Integrated and arithmetic annual mean abundance (no/m^3) of *Acartia hudsonica* and *A. tonsa* at G.S.O. dock. Data from MERL.

Fig. 7b



A. tonsa. Integrated Mean
1000
800
600
400
200
0
696
465
247
418
338
91
99
154
1976-1977
1978
1979
1980
1981
1982
1982-1983
1985-1986



A. tonsa, Arithmetic Mean
1000
800
600
400
200
0
720
551
254
179
392
106
122
184
1976-1977
1978
1979
1980
1981
1982
1982-1983
1985-1986

Fig. 8. Map of Narragansett Bay showing sampling locations used in the Kremer-Nixon study of zooplankton biomass in Narragansett Bay.

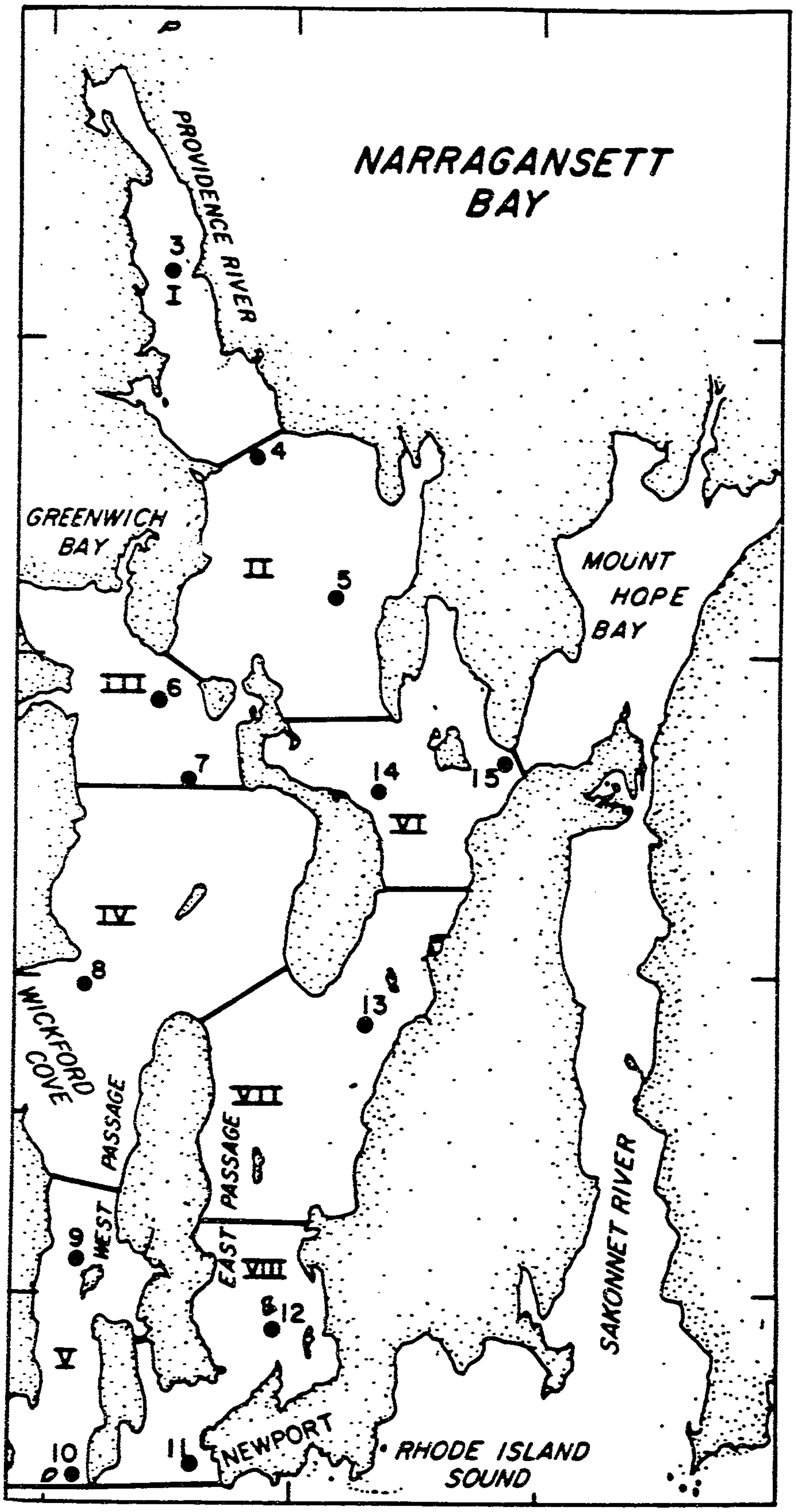
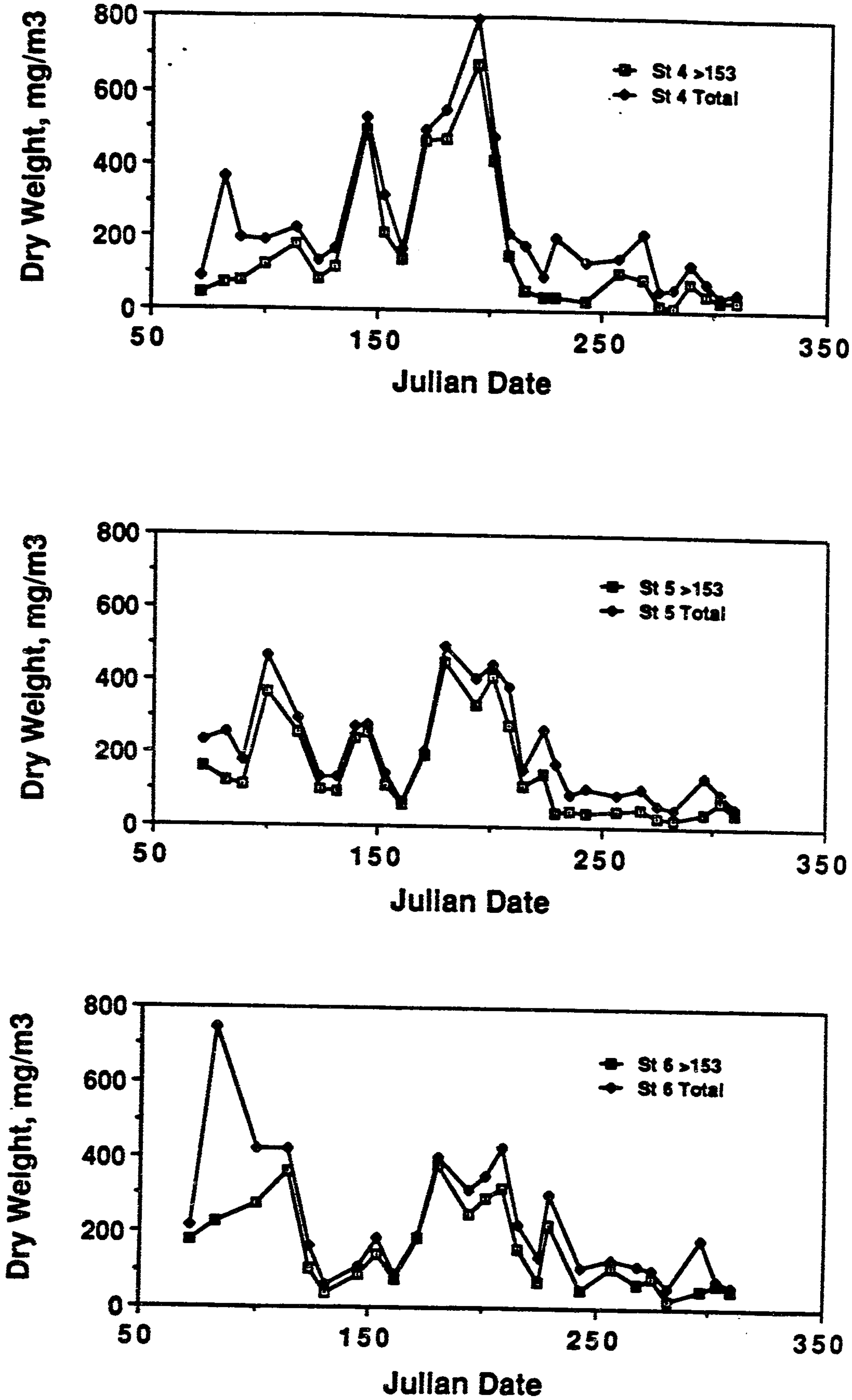
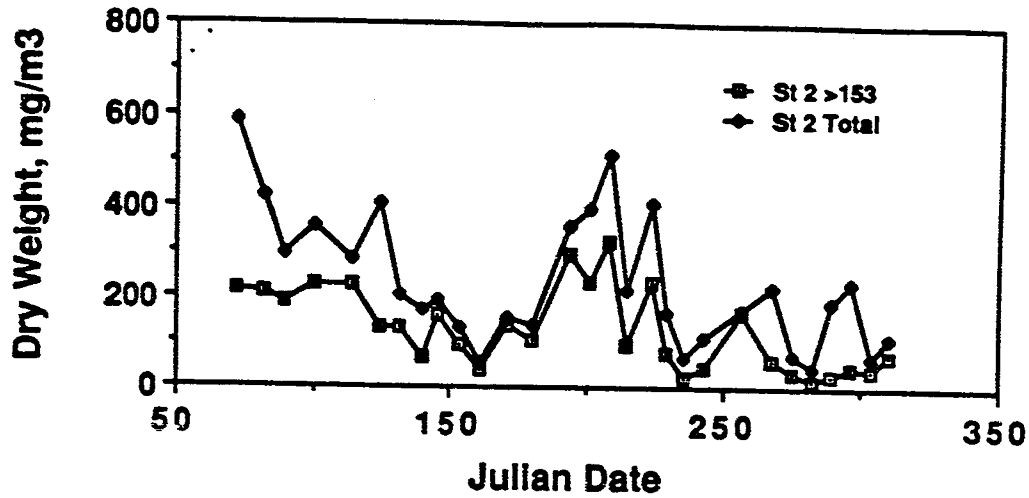

NARRAGANSETT BAY
PROVIDENCE RIVER
GREENWICH BAY
MOUNT HOPE BAY
WICKFORD COVE
WEST PASSAGE
EAST PASSAGE
SAKONNET RIVER
NEWPORT
RHODE ISLAND SOUND
I
II
III
IV
V
VI
VII
VIII
3
4
5
6
7
8
9
10
11
12
13
14
15

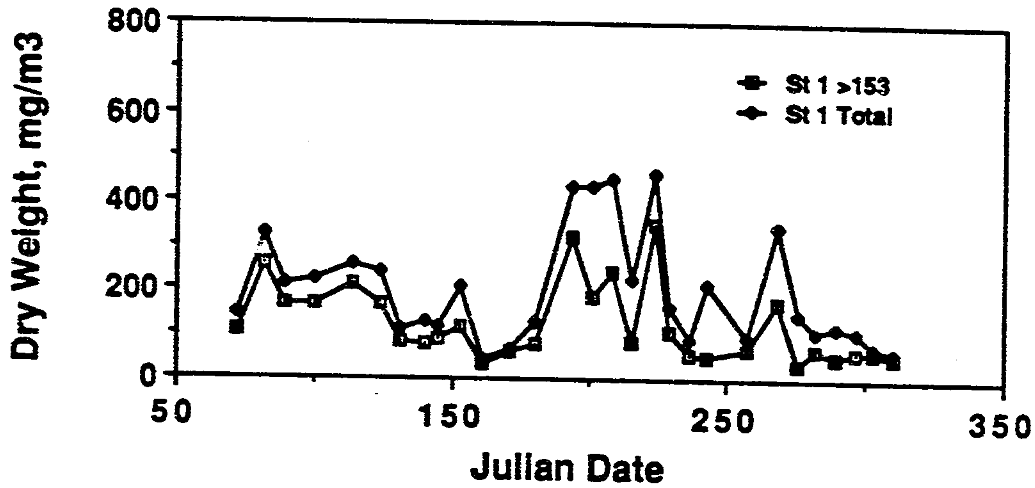
Fig. 9a - c. Seasonal changes in zooplankton biomass (total and >153 μm size-fractions) in Narragansett Bay. Data from Durbin and Durbin (1981).

Fig. 9a



800
600
400
200
0
Dry Weight, mg/m3
50
150
250
350
Julian Date
St 4 >153
St 4 Total
800
600
400
200
0
Dry Weight, mg/m3
50
150
250
350
Julian Date
St 5 >153
St 5 Total
800
600
400
200
0
Dry Weight, mg/m3
50
150
250
350
Julian Date
St 6 >153
St 6 Total


800
600
400
200
0
Dry Weight, mg/m3
St 2 >153
St 2 Total
50
150
250
350
Julian Date


800
600
400
200
0
Dry Weight, mg/m3
St 1 >153
St 1 Total
50
150
250
350
Julian Date

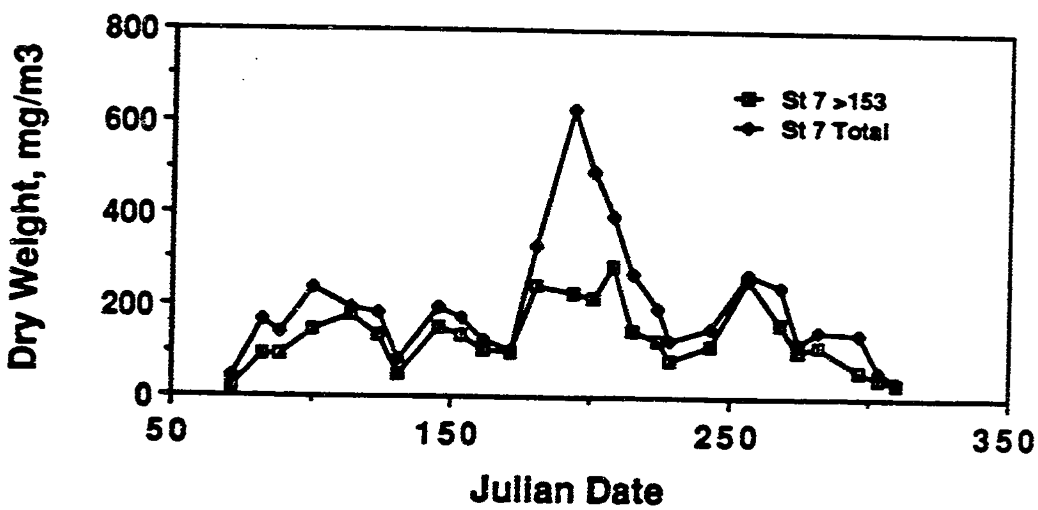
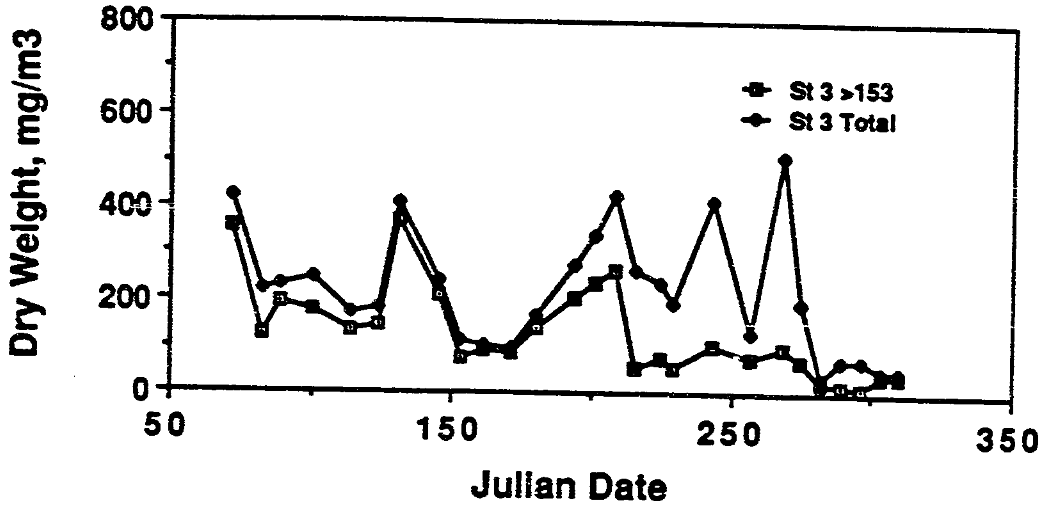

800
600
400
200
0
Dry Weight, mg/m3
St 7 >153
St 7 Total
50
150
250
350
Julian Date

Fig. 9c



Dry Weight, mg/m3
800
600
400
200
0
50
150
250
350
Julian Date
St 3 >153
St 3 Total

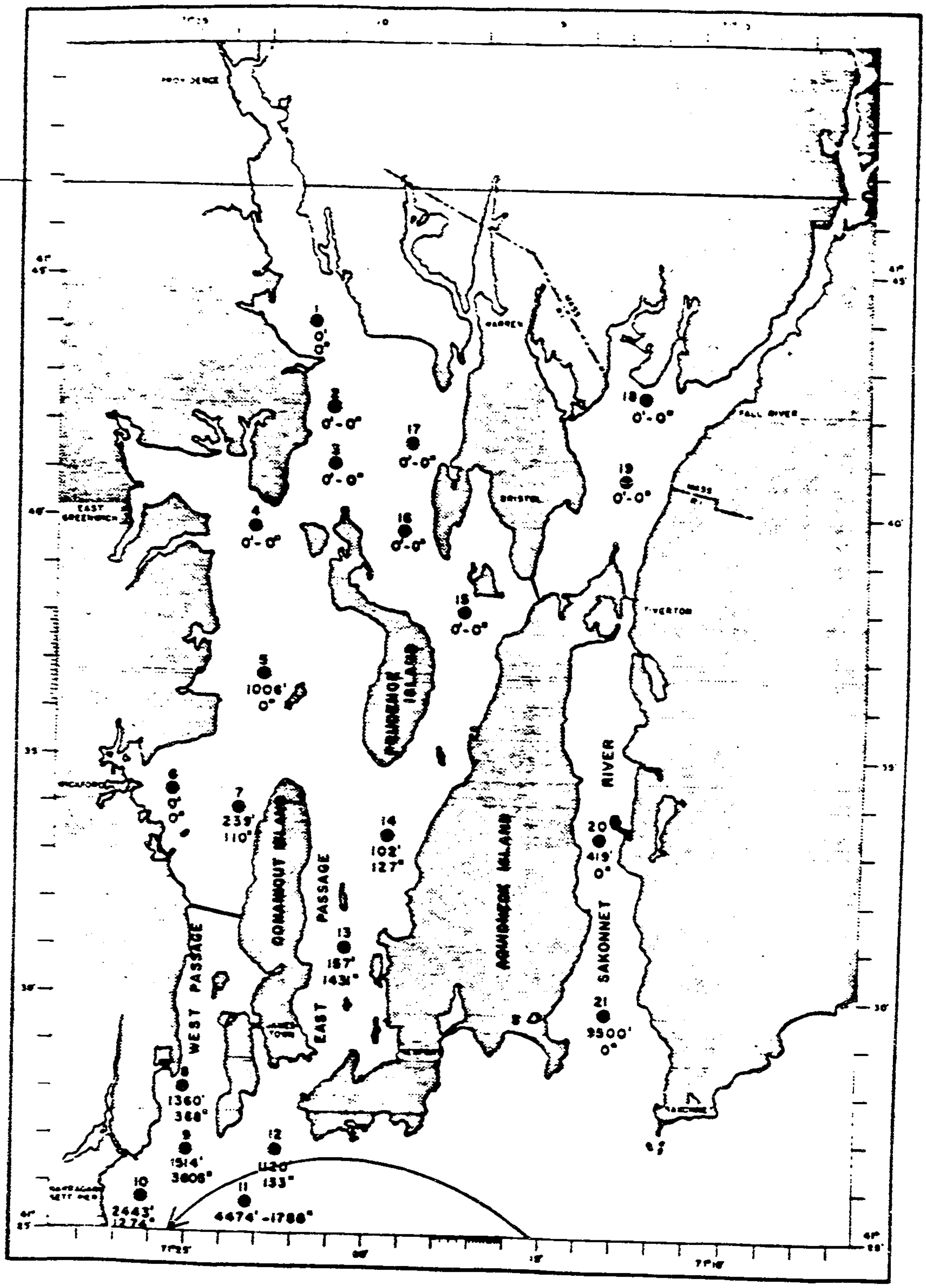


Fig. 10. Station locations for epifaunal survey in Narragansett Bay. Figures below stations represent actual numbers of mysids taken by dredge during the May (') and August (") surveys. Arrow indicates approximate direction of the non-tidal cyclonic flow near the mouth of the Bay. (From Herman, 1962).

Figure 11. Station locations for MERL 1979-80 Narragansett Bay transect studies (MERL, 1980).

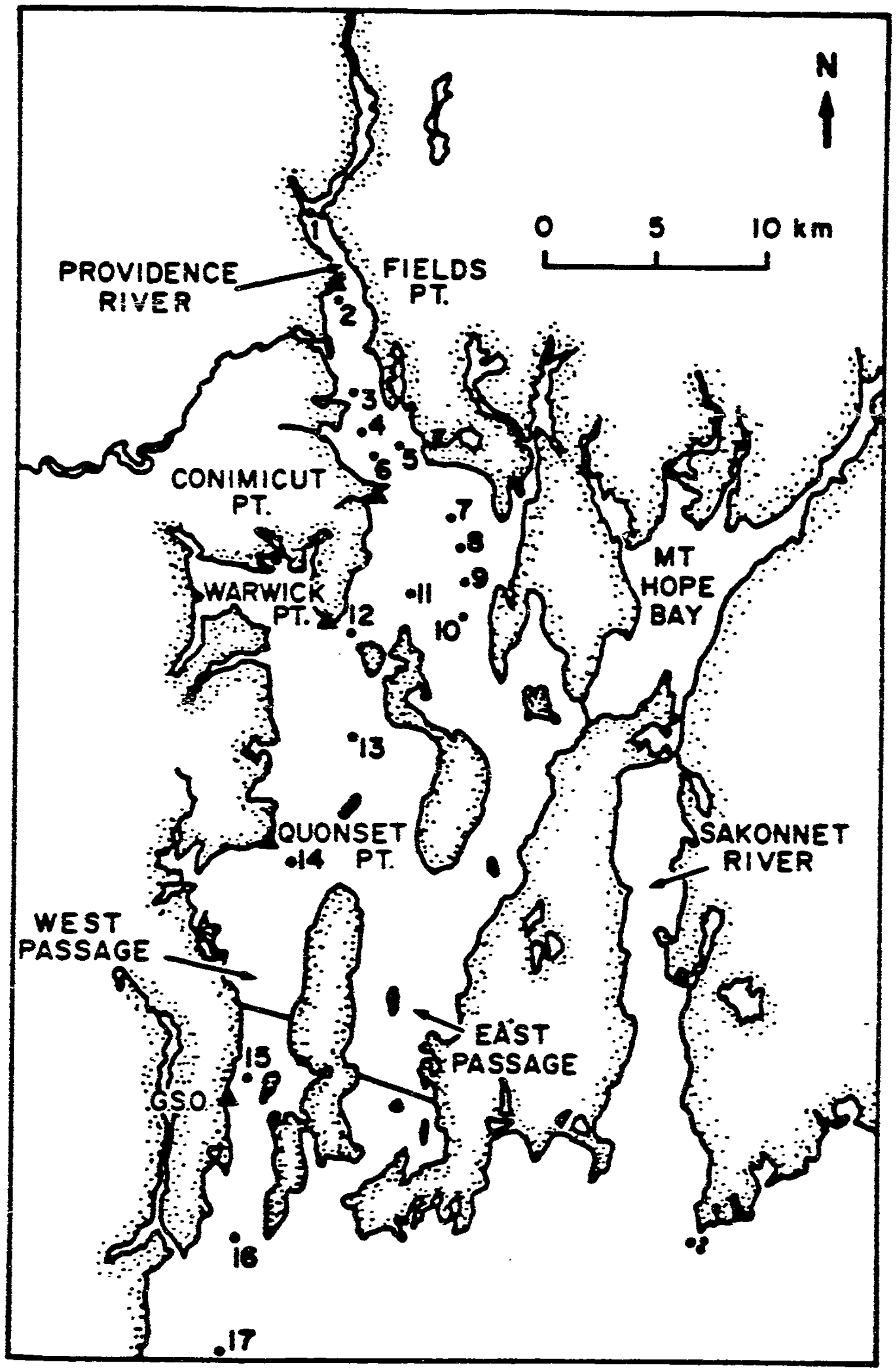
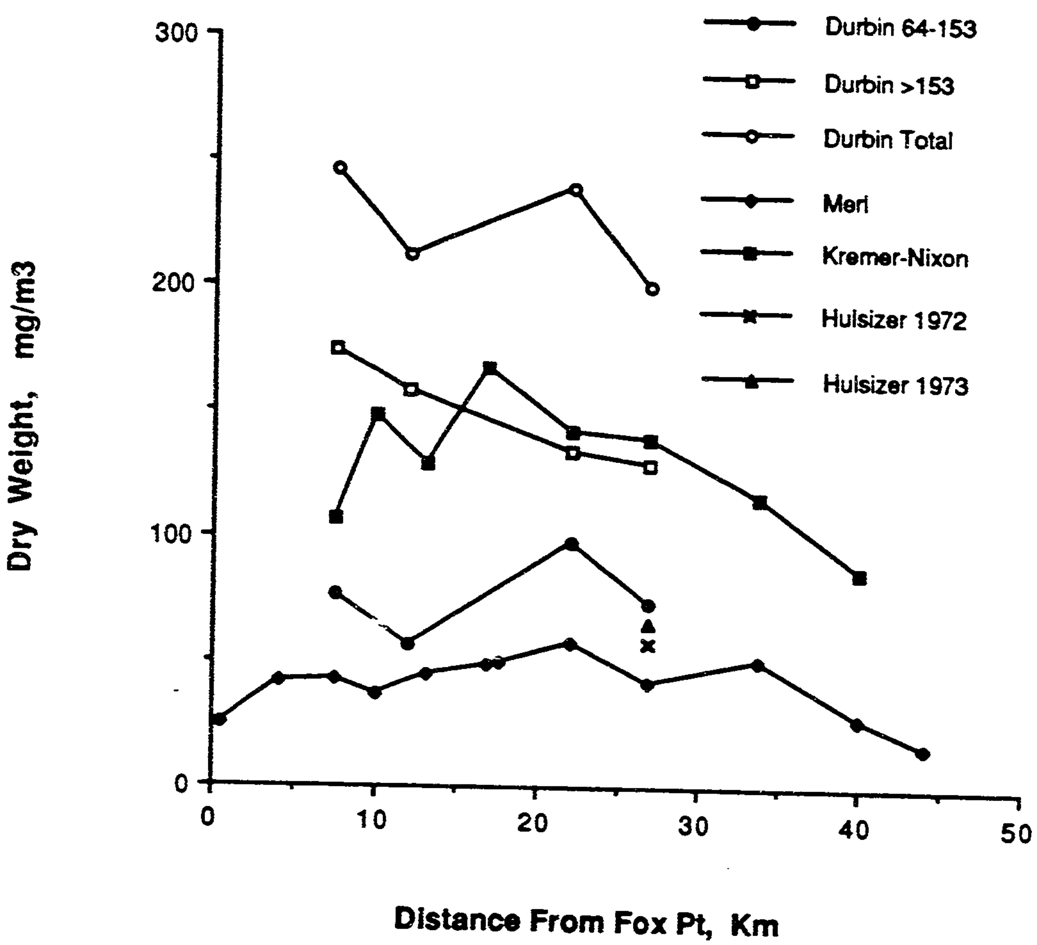

N
0 5 10 km
PROVIDENCE RIVER
FIELDS PT.
CONIMICUT PT.
WARWICK PT.
MT HOPE BAY
QUONSET PT.
SAKONNET RIVER
WEST PASSAGE
EAST PASSAGE
GSO
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

Figure 12. Mean annual zooplankton dry weights from different studies in Narragansett Bay. Data are arranged along a transect from Upper Narragansett Bay (Fox Pt., 0 km) to Block Island.


Durbin 64-153
Durbin >153
Durbin Total
Merl
Kremer-Nixon
Hulsizer 1972
Hulsizer 1973
300
200
100
0
0
10
20
30
40
50
Dry Weight, mg/m3
Distance From Fox Pt, Km

Appendix Table 1a. Seasonal changes in zooplankton abundance (no/m^3) at Station 1 (Durbin and Durbin, 1981).

Appendix Table 1a. Seasonal changes in zooplankton abundance (no/m3) at Station 1 (Durbin and Durbin, 1981).

		3/1/76	3/12/76	3/22/76	3/29/76	4/9/76	4/23/76	5/3/76	5/10/76	5/19/76	5/24/76
Julian Date		61	72	82	89	100	114	124	131	140	145
Copepods											
Acartia hudsonica	N	31900	26878	68973	93807	197245	150368	106250	56388	105990	51333
Acartia hudsonica	C	1238	6628	12116	12483	20857	33271	19177	29422	8159	13519
Acartia hudsonica	A	198	2968	10165	8410	5826	7952	7388	2731	1989	2430
Acartia hudsonica	T	33336	36474	91254	114703	223928	191591	132815	88541	116138	67282
Acartia tonsa	N	0	0	0	0	0	0	0	0	0	0
Acartia tonsa	C	0	0	0	0	0	0	0	0	0	0
Acartia tonsa	A	0	0	0	0	0	0	0	0	0	0
Acartia tonsa	T	0	0	0	0	0	0	0	0	0	0
Centropages hamatus	C, A	0	0	0	0	0	0	47	0	0	0
Centropages typicus	C, A	0	0	0	0	0	0	0	0	0	31
Centropages sp	I	0	0	0	0	0	0	0	0	94	0
Coryceaus sp		0	0	0	0	0	0	0	0	47	0
Cyclops sp		0	0	0	0	0	0	0	0	0	0
Eurytemora sp	C, A	0	0	0	0	0	0	0	0	0	0
Hemicyclops sp (Saphirella)		1510	366	918	1102	1102	1223	2119	942	2591	89
Microsettela norvegica		52	85	0	48	120	0	424	94	188	22
Oithona colcarva	A	20	197	0	24	72	47	94	94	94	71
Oithona similis	A	114	56	145	48	72	94	94	0	0	0
Oithona sp	I	0	56	48	72	48	141	0	0	282	0
Parvocalanus crassirostris		52	310	48	96	72	0	94	0	0	13
Pseudocalanus sp.	C	1010	1325	1594	1725	1870	518	1978	0	0	0
Pseudocalanus sp.	A	136	254	97	168	216	94	329	0	0	0
Pseudocalanus sp.	T	1146	1579	1691	1893	2086	612	2307	141	894	26
Temora longicornis		84	56	48	72	48	47	141	235	282	26
Tortanus sp		0	0	0	0	0	0	47	0	142	18
Harpacticoid sp		52	0	0	96	48	47	94	471	47	53
Unidentified	C	32	0	0	0	0	0	0	0	0	0
Unidentified	N	1628	3194	2943	2638	4596	5822	5882	4699	5888	9564
Temporary Plankton											
Balanus larvae		1322	790	676	335	144	0	188	47	0	0
Bivalve larvae		72	0	48	120	0	33088	9191	4405	21788	5085
Bryazoan larvae		64	141	48	24	0	47	0	0	0	0
Decapod larvae		0	0	0	0	0	0	47	0	0	22
Gastropod larvae		32	85	97	24	48	0	800	188	1600	22
Polychaete larvae		1240	56	1642	1629	240	94	3061	612	1460	194
Other Holoplankton											
Medusae		0	0	97	0	24	47	0	0	0	0
Ctenophores		0	0	0	0	0	0	0	0	0	0
Rotifers		12084	17712	85801	35928	17964	1765	0	0	0	0
Evadne nordmanni		0	0	0	48	0	894	1601	0	989	493
Podon polyphemoides		0	0	0	0	0	424	235	0	424	110
Chaetognaths		20	0	0	0	0	0	141	0	0	0
Other											
Miscellaneous zp.		374	113	435	120	0	141	0	0	0	0

Appendix Table 1a. Seasonal changes in zooplankton abundance (no/m3) at Station 1 (Durbin and Durbin, 1981).

		6/1/76 153	6/7/76 159	6/19/76 171	6/28/76 180	7/12/76 194	7/19/76 201	7/26/76 208	8/2/76 215	8/11/76 224	8/16/76 229	8/23/76 236	8/30/76 243
Copepods													
Acartia hudsonica	N	110412	33517	51558	5366	0	0	0	0	0	0	0	0
Acartia hudsonica	C	18404	10224	15295	4984	0	0	0	0	0	0	0	0
Acartia hudsonica	A	4306	1233	731	2131	0	0	0	0	0	0	0	0
Acartia hudsonica	T	133122	44974	67584	12481	0	0	0	0	0	0	0	0
Acartia tonsa	N	0	0	3306	25861	23706	75882	48680	16680	5947	14242	29723	87700
Acartia tonsa	C	0	0	0	4967	18306	8455	28902	2740	6351	731	4503	8516
Acartia tonsa	A	0	0	0	211	11976	7044	7349	1233	3233	106	392	713
Acartia tonsa	T	0	0	3553	31039	53988	91381	84931	20653	15521	15079	34618	96929
Centropages hamatus	C, A	0	0	0	0	0	0	0	0	0	0	0	0
Centropages typicus	C, A	405	0	0	0	1762	211	0	0	70	0	0	0
Centropages sp	I	0	141	123	35	0	0	0	0	0	0	0	0
Coryceaus sp		0	0	0	0	0	0	0	0	0	0	0	0
Cyclops sp		0	0	0	0	0	0	0	0	0	0	0	0
Eurytemora sp	C, A	0	0	0	0	0	0	0	0	18	18	0	0
Hemicyclops sp (Saphirella)		141	476	317	53	248	70	414	62	379	101	321	525
Microsetlela norvegica		35	0	0	0	36	0	83	9	0	0	70	0
Oithona colcarva	A	370	0	0	0	458	211	0	555	238	97	150	175
Oithona similis	A	0	0	0	0	1198	352	0	150	26	0	123	0
Oithona sp	I	0	0	423	123	0	282	0	0	0	0	0	0
Parvocalanus crassirostris		0	0	0	18	212	106	165	176	2492	35	445	175
Pseudocalanus sp.	C	0	0	0	0	0	0	0	0	0	0	0	0
Pseudocalanus sp.	A	0	0	0	0	0	0	0	0	0	0	0	0
Pseudocalanus sp.	T	740	123	0	0	1128	106	2064	53	0	0	9	0
Temora longicornis		387	88	35	18	246	0	83	0	0	0	0	0
Tortanus sp		70	18	0	0	36	35	165	0	0	0	0	0
Harpacticoid sp		0	26	88	35	36	35	83	0	115	13	18	0
Unidentified	C	159	88	0	18	458	1021	0	0	229	0	0	0
Unidentified	N	1138	2661	11468	4402	9468	21145	16666	15194	8590	14173	17206	16146
Temporary Plankton													
Balanus larvae		0	35	18	0	110	0	0	26	0	0	9	0
Bivalve larvae		9443	3857	23691	33025	110	0	6275	79	220	16237	9216	60546
Bryazoan larvae		0	0	0	0	0	0	0	0	0	0	0	0
Decapod larvae		18	35	18	0	440	441	0	255	2378	62	13	0
Gastropod larvae		0	0	405	0	770	0	0	1268	661	0	0	275
Polychaete larvae		1040	643	3839	57464	3854	3965	6436	3073	1321	550	2338	1100
Other Holoplankton													
Medusae		0	0	0	0	0	0	0	0	0	0	0	0
Ctenophores		0	0	0	0	0	0	0	0	0	0	0	0
Rotifers		0	0	0	0	0	0	0	0	0	0	0	0
Evadne nordmanni		933	326	1642	2642	2092	1762	825	678	70	0	0	0
Podon polyphemoides		704	669	28883	27411	2752	8590	4125	2765	0	9	0	0
Chaetognaths		0	0	0	0	0	0	0	0	0	0	0	0
Other													
Miscellaneous zp.		0	0	23353	16513	4182	5286	7921	3320	11784	11008	2338	1926

Appendix Table 1a. Seasonal changes in zooplankton abundance (no/m3) at Station 1 (Durbin and Durbin, 1981).

		9/13/76	9/24/76	10/1/76	10/8/76	10/15/76	10/22/76
		257	268	275	282	289	296
Copepods							
Acartia hudsonica	N	0	0	0	2793	7917	2102
Acartia hudsonica	C	0	0	0	0	0	0
Acartia hudsonica	A	0	0	0	0	0	0
Acartia hudsonica	T	0	0	0	2793	7917	2102
Acartia tonsa	N	130312	6854	45295	22934	24821	14272
Acartia tonsa	C	24183	23654	11792	29423	9819	9370
Acartia tonsa	A	1673	12699	718	2386	1779	1410
Acartia tonsa	T	156168	43207	57805	54743	36419	25052
Centropages hamatus	C, A	0	0	0	0	0	0
Centropages typicus	C, A	0	0	0	0	0	0
Centropages sp	I	0	0	0	0	0	0
Coryceaus sp		0	0	0	0	0	0
Cyclops sp		0	0	0	0	0	0
Eurytemora sp	C, A	0	0	0	0	0	0
Hemicyclops sp (Saphirella)		845	1990	3963	3558	6055	1009
Microsettela norvegica		0	88	35	0	0	35
Oithona colcarva	A	370	299	1127	0	0	0
Oithona similis	A	0	18	0	0	0	0
Oithona sp	I	0	0	0	599	458	1013
Parvocalanus crassirostris		1761	3082	3514	1462	537	4395
Pseudocalanus sp.	C	0	0	0	0	0	0
Pseudocalanus sp.	A	0	0	0	0	0	0
Pseudocalanus sp.	T	0	0	0	0	0	0
Temora longicornis		0	0	0	0	0	0
Tortanus sp		0	0	0	0	0	0
Harpacticoid sp		0	141	35	159	141	0
Unidentified	C	106	687	537	916	229	1427
Unidentified	N	35227	3715	16100	16278	14173	6788
Temporary Plankton							
Balanus larvae		0	0	0	0	0	0
Bivalve larvae		10458	991	11834	7155	5229	1514
Bryazoan larvae		0	0	0	0	0	0
Decapod larvae		0	35	0	0	0	9
Gastropod larvae		0	159	0	154	0	79
Polychaete larvae		493	1004	97	1285	793	642
Other Holoplankton							
Medusae		0	0	0	0	0	0
Ctenophores		0	0	0	0	0	0
Rotifers		0	0	0	0	0	0
Evadne nordmanni		0	0	0	0	0	0
Podon polyphemoides		0	0	0	0	0	79
Chaetognaths		0	0	0	0	0	0
Other							
Miscellaneous zp.		511	0	0	0	0	62

Appendix Table 1b. Seasonal changes in zooplankton abundance (no/m^3) at Station 5 (Durbin and Durbin, 1981).

Appendix Table 1b. Seasonal changes in zooplankton abundance (no/m3) at Station 5 (Durbin and Durbin, 1981).

		3/1/76	3/12/76	3/22/76	3/29/76	4/9/76	4/23/76	5/3/76	5/10/76	5/19/76	5/24/76
Julian Date		61	72	82	89	100	114	124	131	140	145
Copepods											
Acartia hudsonica	N	31412	37992	27773	34069	139094	81008	116360	44713	58883	79176
Acartia hudsonica	C	5118	13103	13635	7156	28235	14721	18528	21306	12612	17506
Acartia hudsonica	A	1980	4426	3553	3033	18211	10000	2990	2660	5789	9845
Acartia hudsonica	T	38580	55521	44961	44258	185540	105729	137838	68679	77284	106527
Acartia tonsa	N	0	0	0	0	0	0	0	0	0	0
Acartia tonsa	C	0	0	0	0	0	0	0	0	0	0
Acartia tonsa	A	0	0	0	0	0	0	0	0	0	0
Acartia tonsa	T	0	0	0	0	0	0	0	0	0	0
Centropages hamatus	C, A	0	0	0	0	0	0	0	0	0	0
Centropages typicus	C, A	0	0	0	0	0	0	0	0	0	0
Centropages sp	I	0	0	0	0	0	0	24	0	0	35
Coryceaus sp		0	0	0	0	0	0	0	0	0	0
Cyclops sp		0	0	0	0	0	0	0	0	0	0
Eurytemora sp	C, A	0	0	2119	49	388	1674	165	235	1913	0
Hemicyclops sp (Saphirella)		686	1036	334	1698	4078	5814	7840	9040	7061	5777
Microsetella norvegica		20	94	95	49	194	140	118	0	0	0
Oithona colcarva	A	0	94	0	0	94	0	0	0	0	106
Oithona similis	A	124	141	95	97	97	0	47	0	74	0
Oithona sp	I	0	0	0	49	97	47	71	0	0	0
Parvocalanus crassirostris		20	0	0	0	194	0	0	0	0	0
Pseudocalanus sp.	C	370	753	382	1407	3010	2651	636	0	0	0
Pseudocalanus sp.	A	104	141	0	97	97	233	24	0	0	0
Pseudocalanus sp.	T	474	894	382	1504	3107	2884	660	518	147	423
Temora longicornis		0	0	0	49	0	0	0	47	0	88
Tortanus sp		0	0	0	0	0	0	0	0	0	0
Harpacticoid sp		20	0	48	0	0	93	378	188	295	70
Unidentified	C	0	0	0	0	0	0	0	0	0	476
Unidentified	N	977	4046	2576	1961	6373	11047	11029	21366	10010	17801
Temporary Plankton											
Balanus larvae		104	753	143	485	485	140	0	47	221	18
Bivalve larvae		0	47	0	0	0	77326	4779	19824	6281	25908
Bryazoan larvae		0	0	0	49	0	0	0	0	0	0
Decapod larvae		0	0	0	0	0	47	24	0	0	53
Gastropod larvae		0	0	0	49	0	93	188	47	3164	5460
Polychaete larvae		230	471	430	922	7087	3163	1530	7769	188429	17260
Other Holoplankton											
Medusae		0	0	0	0	0	0	0	0	0	0
Ctenophores		0	0	0	0	0	0	0	0	0	0
Rotifers		76042	186286	129851	114545	83636	6395	0	0	0	0
Evadne nordmanni		0	0	0	0	194	4279	2378	1695	4708	2853
Podon polyphemoides		0	0	0	0	194	1163	942	188	515	1039
Chaetognaths		20	0	0	0	0	0	24	47	0	0
Other											
Miscellaneous zp.		124	94	143	340	485	0	0	0	0	0

Appendix Table 1b. Seasonal changes in zooplankton abundance (no/m3) at Station 5 (Durbin and Durbin, 1981).

		6/1/76 153	6/7/76 159	6/19/76 171	6/28/76 180	7/12/76 194	7/19/76 201	7/26/76 208	8/2/76 215	8/11/76 224	8/16/76 229
Copepods											
Acartia hudsonica	N	60613	56935	20907	6059	0	0	0	0	0	0
Acartia hudsonica	C	12559	17839	13439	14758	0	0	0	0	0	0
Acartia hudsonica	A	3232	2616	7520	14970	0	0	0	0	0	0
Acartia hudsonica	T	76404	77390	41866	35787	220	0	0	0	0	0
Acartia tonsa	N	0	0	7703	43802	180994	30714	176625	87838	7049	11283
Acartia tonsa	C	0	0	3253	11800	45122	17083	27973	5864	2122	1647
Acartia tonsa	A	0	0	341	8700	5722	24974	7489	4914	299	770
Acartia tonsa	T	0	23	11297	64302	231838	72771	212114	98616	9470	13700
Centropages hamatus	C, A	0	0	0	0	0	0	0	0	0	0
Centropages typicus	C, A	0	0	0	0	0	211	110	0	70	0
Centropages sp	I	0	47	159	317	73	0	0	0	0	0
Corycaeus sp		0	0	0	0	0	0	0	0	0	0
Cyclops sp		0	0	0	0	0	0	0	0	0	0
Eurytemora sp	C, A	0	0	0	0	0	0	110	0	0	0
Hemicyclops sp (Saphirella)		0	774	70	141	0	281	330	493	682	652
Microsetella norvegica		0	0	0	0	0	0	0	0	13	0
Oithona colcarva	A	0	0	0	0	110	423	1322	123	44	88
Oithona similis	A	0	0	0	0	0	282	551	352	26	9
Oithona sp	I	0	164	18	141	881	0	0	0	0	0
Parvocalanus crassirostris		0	23	35	0	0	0	0	0	40	9
Pseudocalanus sp.	C	0	0	0	0	0	0	0	0	0	0
Pseudocalanus sp.	A	0	0	0	0	0	0	0	0	0	0
Pseudocalanus sp.	T	0	0	0	176	0	0	1322	0	4	4
Temora longicornis		0	0	0	0	0	141	110	0	0	0
Tortanus sp		0	0	0	0	0	211	110	0	0	0
Harpacticoid sp		0	0	0	0	0	0	110	0	13	0
Unidentified	C	0	164	88	0	220	775	0	0	4	13
Unidentified	N	5569	3978	1238	4683	992	6110	11454	11221	5617	4059
Temporary Plankton											
Balanus larvae		0	0	0	0	0	0	0	0	0	0
Bivalve larvae		33898	12258	1101	8264	10242	5119	11233	10891	2753	7706
Bryazoan larvae		0	0	0	0	0	0	0	0	0	0
Decapod larvae		0	23	0	0	991	0	0	599	330	13
Gastropod larvae		0	211	0	0	0	2972	5286	423	881	0
Polychaete larvae		0	5422	42700	74196	22357	24770	21145	1110	10462	4679
Other Holoplankton											
Medusae		0	0	0	0	0	330	0	0	0	0
Ctenophores		0	0	0	0	0	0	0	0	0	0
Rotifers		0	0	0	0	0	0	0	0	0	0
Evadne nordmanni		0	1595	2755	1101	110	0	441	0	0	0
Podon polyphemoides		0	798	23967	12770	5947	0	4846	35	0	0
Chaetognaths		0	0	0	0	220	0	0	0	0	0
Other											
Miscellaneous zp.		0	0	31129	0	881	8587	29075	2730	25099	6743

Appendix Table 1b. Seasonal changes in zooplankton abundance (no/m3) at Station 5 (Durbin and Durbin, 1981).

		8/23/76 236	8/30/76 243	9/13/76 257	9/24/76 268	10/1/76 275	10/8/76 282	10/15/76 289	10/22/76 296
Copepods									
Acartia hudsonica	N	0	0	0	0	0	0	12493	6689
Acartia hudsonica	C	0	0	0	0	0	0	0	0
Acartia hudsonica	A	0	0	0	0	0	0	0	0
Acartia hudsonica	T	0	0	0	0	0	0	12493	6689
Acartia tonsa	N	1030	9152	135540	19953	47931	37497	62686	54479
Acartia tonsa	C	295	1524	20571	4545	6367	9894	17190	15477
Acartia tonsa	A	84	48	916	33020	1009	616	291	405
Acartia tonsa	T	1409	10724	157027	56692	55307	48007	80167	70361
Centropages hamatus	C, A	0	0	0	0	0	0	0	0
Centropages typicus	C, A	0	0	0	0	0	0	0	0
Centropages sp	I	0	0	0	0	0	0	0	0
Coryceaus sp		0	0	0	0	0	0	0	0
Cyclops sp		0	0	0	0	0	0	0	0
Eurytemora sp	C, A	0	0	0	0	0	0	0	0
Hemicyclops sp (Saphirella)		458	2034	3699	2554	5321	6244	5091	6330
Microsetella norvegica		0	0	0	35	0	18	18	0
Oithona colcarva	A	13	338	723	687	594	0	0	0
Oithona similis	A	4	0	0	18	0	0		0
Oithona sp	I	0	0	0	0	0	757	1303	737
Parvocalanus crassirostris		185	338	881	1198	392	387	1427	144
Pseudocalanus sp.	C	0	0	0	0	0	0	0	0
Pseudocalanus sp.	A	0	0	0	0	0	0	0	0
Pseudocalanus sp.	T	0	0	0	0	0	0	0	0
Temora longicornis		0	0	0	0	0	0	0	0
Tortanus sp		0	0	0	0	0	0	0	0
Harpacticoid sp		0	0	0	0	9	18	35	0
Unidentified	C	0	0	0	53	48	123	317	246
Unidentified	N	4129	20916	13063	19127	20090	12934	21329	5779
Temporary Plankton									
Balanus larvae		0	0	0	0	0	0	0	0
Bivalve larvae		10041	258421	9908	28071	18989	19265	49813	3303
Bryazoan larvae		0	0	0	0	0	0	0	0
Decapod larvae		26	0	0	0	0	0	0	17
Gastropod larvae		0	0	176	775	75	1356	247	21
Polychaete larvae		2200	6880	2431	4174	1079	1444	2219	1592
Other Holoplankton									
Medusae		0	0	0	0	0	0	0	0
Ctenophores		0	0	0	0	0	0	0	0
Rotifers		0	0	0	0	0	0	45684	0
Evadne nordmanni		0	0	0	0	0	0	0	0
Podon polyphemoides		0	0	0	0	0	0	0	34
Chaetognaths		0	0	0	0	0	0	0	0
Other									
Miscellaneous zp.		17888	1926	211	0	22	0	0	0

Appendix Table 2a. Abundance of zooplankton (no/m³) in Block Island Sound, Station A (Frolander, 1955).

Appendix Table 2a. Abundance of zooplankton (no/m3) in Block Island Sound, Frolander's St A (Frolander, 1955).
Copepod data are for adults only.

	7/25/50	7/31/50	8/7/50	8/13/50	8/22/50	8/28/50	9/7/50	9/18/50	9/25/50	10/2/50	10/11/50	10/16/50
Julian Date	206	212	219	225	234	240	250	261	268	275	284	289
Copepods (adults only)												
Acartia hudsonica	102	94	66	29	9	8	0	0	0	0	0	0
Acartia tonsa	46	101	60	266	611	1468	541	587	1189	1707	839	478
Acartia longiremis	0	0	0	0	0	0	0	0	0	0	0	0
Calanus finmarchicus	0	0	0	0	0	0	0	0	0	0	0	0
Candacia armata	0	0	0	0	0	0	0	0	0	0	0	0
Centropages hamatus	1285	859	307	104	92	82	0	4	13	10	0	0
Centropages typicus	213	154	36	22	15	59	8	100	13	10	56	9
Eurytemora sp.	18	0	0	0	0	0	0	0	0	0	0	0
Labidocera aestiva	0	0	0	4	0	0	0	16	0	15	0	0
Metridia lucens	0	0	0	0	0	0	0	0	0	0	0	0
Oithona sp.	9	94	12	151	3	8	48	8	0	10	0	0
Oncea sp.	0	0	0	0	0	0	0	0	0	0	0	0
Pseudocalanus minutus	176	255	30	83	0	4	0	0	0	0	11	5
Pseudodiaptomus coronatus	0	0	0	0	0	0	0	0	0	0	0	0
Parategastes sphaericus	0	0	0	0	0	0	0	0	0	0	0	0
Paracalanus crassirostris	0	0	0	0	0	0	0	0	0	10	22	54
Paracalanus parvus	0	0	0	0	0	0	0	0	0	0	0	0
Rhincalanus nasutus	0	0	0	0	0	0	0	0	0	0	0	0
Temora longicornis	222	457	139	65	12	8	0	4	0	0	0	0
Tortanus discaudatus	18	67	0	0	0	0	0	4	0	0	0	0
Coryceaus sp.	0	0	0	0	0	0	0	0	0	0	0	0
Harpacticiod	0	0	0	0	0	0	0	0	0	0	0	0
Cladocera												
Evadne nordmanni	74	54	175	471	332	137	1227	0	0	0	950	18
Evadne spinifera	0	0	0	0	0	235	153	0	0	0	0	0
Penilia avirostris	0	0	0	0	0	0	517	12	80	45	2785	162
Podon sp.	9	107	199	395	136	114	186	16	13	30	369	54
Temporary Plankton												
Decapod larvae	27	20	6	27	51	39	40	24	7	45	0	10
Balanus larvae	0	0	0	0	0	0	0	0	0	0	0	0
Gastropod larvae	37	20	102	127	101	180	121	40	26	196	0	32
Polychaete larvae	0	0	6	0	0	0	0	0	0	0	0	0
Other Holoplankton												
Oikopleura sp.	102	34	54	7	12	24	194	20	66	45	124	36
Fritillaria borealis	0	0	0	0	0	0	0	0	0	0	0	0
Dolioletta gegenbauri	0	0	0	0	0	0	0	0	0	0	0	0
Doliolium nationalis	0	0	0	0	0	0	0	8	40	45	111	5
Chaetognaths	0	7	0	0	0	0	0	0	0	0	0	0
Obelia sp	0	7	0	0	0	4	0	0	0	0	11	0
Sarsia tubulosa	0	0	0	0	0	0	0	0	0	0	0	0
Rathkea octopunctata	0	0	0	0	0	0	0	0	0	0	0	0
Hydromedusae sp	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 2a Abundance of zooplankton (no/m3) in Block Island Sound, Frolander's St A (Frolander, 1955).
Copepod data are for adults only.

	10/26/50	10/31/50	11/13/50	11/17/50	12/1/50	12/13/50	12/17/50	1/5/51	1/11/51	1/26/51	2/5/51	2/14/51
Julian Date	299	304	317	321	335	347	351	5	11	26	36	45
Copepods (adults only)												
Acartia hudsonica	0	0	0	0	0	4	3	0	2	15	3	0
Acartia tonsa	273	430	294	401	120	343	107	30	22	19	17	2
Acartia longiremis	0	0	0	0	0	0	0	0	0	0	0	0
Calanus finmarchicus	0	0	0	5	0	0	2	0	0	0	0	0
Candacia armata	0	0	0	0	0	0	2	0	0	0	0	0
Centropages hamatus	0	0	0	0	0	4	8	2	0	0	0	6
Centropages typicus	6	2	61	42	38	13	8	6	9	3	0	4
Eurytemora sp.	0	0	0	0	0	0	0	0	0	0	0	0
Labidocera aestiva	0	0	0	0	0	0	0	0	0	0	0	0
Metridia lucens	0	0	0	0	0	0	0	0	0	0	0	0
Oithona sp.	0	44	30	32	4	2	0	1	1	2	15	8
Oncea sp.	0	0	0	0	2	0	0	0	0	0	0	0
Pseudocalanus minutus	2	12	61	28	55	72	167	213	94	118	144	208
Pseudodiaptomus coronatus	2	0	0	0	0	2	0	0	0	0	0	0
Parategastes sphaericus	0	0	0	0	0	0	0	0	0	0	0	0
Paracalanus crassirostris	0	15	9	28	2	2	0	0	1	0	0	0
Paracalanus parvus	0	0	4	0	0	7	2	11	7	3	3	0
Rhincalanus nasutus	0	0	0	0	0	0	0	0	0	0	0	0
Temora longicornis	0	0	4	0	0	0	3	4	2	2	9	6
Tortanus discaudatus	0	0	0	0	0	0	0	0	0	0	0	0
Coryceaus sp.	0	0	0	0	0	0	0	0	0	0	0	0
Harpacticiod	0	0	0	0	0	0	0	0	0	0	0	0
Cladocera												
Evadne nordmanni	0	0	0	0	2	0	0	0	0	0	0	0
Evadne spinifera	0	0	0	0	0	0	0	0	0	0	0	0
Penilia avirostris	60	20	74	120	0	0	0	0	0	0	0	0
Podon sp.	4	0	0	0	0	0	0	0	0	0	0	0
Temporary Plankton												
Decapod larvae	2	2	0	0	0	0	0	0	0	0	0	0
Balanus larvae	0	0	0	0	0	0	0	0	5	22	15	2
Gastropod larvae	16	2	9	5	2	2	0	2	2	29	12	11
Polychaete larvae	0	0	0	0	0	0	0	0	0	0	6	2
Other Holoplankton												
Oikopleura sp.	8	5	43	31	0	0	0	0	0	0	0	0
Fritillaria borealis	0	0	0	0	0	0	0	0	0	0	0	0
Dolioletta gegenbauri	0	0	0	0	0	0	0	0	0	0	0	0
Doliolium nationalis	0	0	13	0	0	0	0	0	0	0	0	0
Chaetognaths	2	7	0	5	4	9	7	0	12	21	46	38
Obelia sp	2	0	26	23	11	4	0	0	0	0	0	0
Sarsia tubulosa	0	0	0	0	0	0	0	0	0	0	0	0
Rathkea octopunctata	0	0	0	0	0	0	0	0	0	0	0	2
Hydromedusae sp	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 2a. Abundance of zooplankton (no/m3) in Block Island Sound, Frolander's St A (Frolander, 1955).
Copepod data are for adults only.

	2/19/51	3/6/51	4/12/51	4/16/51	4/24/51	5/2/51	5/7/51	5/14/51	5/21/51	5/28/51	6/4/51	6/13/51
Julian Date	50	65	102	106	114	122	127	134	141	148	155	164
Copepods (adults only)												
Acartia hudsonica	0	4	196	87	534	625	786	279	674	448	979	1071
Acartia tonsa	2	0	0	0	0	0	0	0	0	0	0	0
Acartia longiremis	0	0	0	10	22	28	0	55	42	0	0	0
Calanus finmarchicus	0	0	0	22	38	0	9	48	50	149	364	43
Candacia armata	0	0	0	0	0	0	0	0	0	0	0	0
Centropages hamatus	0	3	149	173	439	329	473	518	141	498	1298	1014
Centropages typicus	6	0	0	0	29	11	9	32	0	50	0	14
Eurytemora sp.	0	0	0	0	10	0	0	0	0	17	68	200
Labidocera aestiva	0	0	0	0	0	0	0	0	0	0	0	0
Metridia lucens	0	0	0	0	0	11	0	0	8	23	0	0
Oithona sp.	47	1	86	152	152	186	57	88	17	33	0	43
Oncea sp.	0	0	0	0	0	0	0	0	0	0	0	0
Pseudocalanus minutus	212	127	908	2468	724	537	199	694	715	647	250	486
Pseudodiaptomus coronatus	0	0	0	0	0	0	0	0	0	0	0	0
Paralegastes sphaericus	0	0	0	0	0	0	0	0	0	0	0	0
Paracalanus crassirostris	2	0	0	0	0	0	0	0	0	0	0	0
Paracalanus parvus	0	0	0	0	0	0	0	0	0	0	0	0
Rhincalanus nasutus	0	0	0	0	0	0	0	0	0	0	0	0
Temora longicornis	5	4	423	195	210	274	284	152	216	431	751	743
Tortanus discaudatus	0	0	23	0	10	33	85	48	25	100	23	0
Coryceaus sp.	0	0	0	0	0	0	0	0	0	0	0	0
Harpacticiod	0	0	0	0	0	0	0	0	0	0	0	0
Cladocera												
Evadne nordmanni	0	0	0	0	29	164	208	303	108	33	205	114
Evadne spinifera	0	0	0	0	0	0	0	0	0	0	0	0
Penilia avirostris	0	0	0	0	0	0	0	0	0	0	0	0
Podon sp.	0	0	0	0	0	22	0	56	8	0	0	57
Temporary Plankton												
Decapod larvae	0	0	0	0	0	0	0	32	8	0	0	43
Balanus larvae	19	1	16	22	29	0	0	8	0	0	0	0
Gastropod larvae	19	29	8	22	77	22	56	207	84	0	46	0
Polychaete larvae	3	0	8	0	0	0	0	0	0	0	0	0
Other Holoplankton												
Oikopleura sp.	0	0	0	0	0	0	0	0	0	0	0	0
Fritillaria borealis	0	0	0	260	0	0	0	0	0	0	0	0
Dolioletta gegenbauri	0	0	0	0	0	0	0	0	0	0	0	0
Doliolium nationalis	0	0	0	0	0	0	0	0	0	0	0	0
Chaetognaths	28	19	31	0	10	88	0	16	33	116	68	14
Obelia sp	2	0	16	22	19	0	0	8	42	581	91	43
Sarsia tubulosa	0	0	0	0	0	0	0	0	0	0	0	0
Rathkea octopunctata	0	0	8	65	0	0	0	32	0	0	0	0
Hydromedusae sp	0	0	31	108	0	0	0	0	0	0	0	0

Appendix Table 2a. Abundance of zooplankton (no/m3) in Block Island Sound, Frolander's St A (Frolander, 1955). Copepod data are for adults only.

	6/19/51	6/25/51	7/2/51	7/9/51	7/16/51	7/25/51	7/30/51	8/6/51	8/13/51	8/20/51	8/27/51	9/7/51
Julian Date	170	176	183	190	197	206	211	218	225	232	239	250
Copepods (adults only)												
Acartia hudsonica	2740	1616	1810	306	2266	526	288	187	255	49	0	0
Acartia tonsa	22	0	11	0	346	451	354	374	1714	2036	998	1605
Acartia longiremis	0	0	0	16	0	0	0	0	0	0	0	0
Calanus finmarchicus	0	17	11	8	0	0	0	0	0	0	0	0
Candacia armata	0	0	0	0	0	0	0	0	0	0	0	0
Centropages hamatus	2673	1531	709	306	823	144	131	0	12	12	17	0
Centropages typicus	0	17	74	169	0	0	24	0	0	12	0	0
Eurytemora sp.	314	221	434	24	87	188	36	0	0	0	0	0
Labidocera aestiva	0	0	0	0	14	6	6	0	0	0	0	0
Metridia lucens	0	0	0	0	0	0	0	0	0	0	0	0
Oithona sp.	67	51	0	8	279	57	168	164	194	159	68	0
Oncea sp.	0	0	0	0	0	0	0	0	0	0	0	0
Pseudocalanus minutus	359	289	95	418	1082	69	85	0	61	25	0	0
Pseudodiaptomus coronatus	0	0	0	0	0	0	0	0	0	0	0	0
Parategastes sphaericus	0	0	0	0	0	0	0	0	0	0	0	0
Paracalanus crassirostris	22	0	0	0	0	19	60	94	122	258	118	36
Paracalanus parvus	0	0	0	0	0	0	0	0	0	0	0	0
Rhincalanus nasutus	0	0	0	0	0	0	0	0	0	0	0	0
Temora longicornis	247	1888	286	788	303	63	30	0	12	0	0	9
Tortanus discaudatus	22	17	64	56	14	0	0	0	0	0	0	0
Coryceaus sp.	0	0	0	0	0	0	0	0	0	0	0	0
Harpacticiod	0	0	0	0	0	0	0	0	0	0	0	0
Cladocera												
Evadne nordmanni	157	204	783	88	1371	777	294	2176	1142	2183	660	27
Evadne spinifera	0	0	0	0	0	0	0	94	280	527	169	0
Penilia avirostris	0	0	0	0	14	582	522	10179	3027	2073	3435	870
Podon sp.	224	17	317	0	72	38	66	468	1374	1484	457	9
Temporary Plankton												
Decapod larvae	22	68	42	16	86	38	36	47	36	98	68	0
Balanus larvae	0	0	0	0	0	0	0	0	0	0	0	0
Gastropod larvae	22	0	32	8	14	13	84	47	146	258	711	0
Polychaete larvae	0	0	0	0	0	0	0	0	0	0	0	0
Other Holoplankton												
Oikopleura sp.	0	0	0	0	14	62	156	94	73	184	169	63
Fritillaria borealis	0	0	0	0	0	0	0	0	0	0	0	0
Dolioletta gegenbauri	0	0	0	0	0	0	0	0	0	0	0	0
Doliolium nationalis	0	0	0	0	0	0	6	0	0	0	0	0
Chaetognaths	22	17	0	16	14	0	0	0	0	0	0	0
Obelia sp	22	0	0	0	0	0	0	0	0	0	0	0
Sarsia tubulosa	0	0	0	0	0	0	0	0	0	0	0	0
Rathkea octopunctata	0	0	0	0	0	0	0	0	0	0	0	0
Hydromedusae sp	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 2a. Abundance of zooplankton (no/m3) in Block Island Sound, Frolander's St A (Frolander, 1955). Copepod data are for adults only.

	9/13/51	9/19/51	10/31/51	12/12/51	12/27/51
Julian Date	256	262	304	346	361
Copepods (adults only)					
Acartia hudsonica	0	0	4	7	11
Acartia tonsa	536	407	249	266	76
Acartia longiremis	0	0	0	0	0
Calanus finmarchicus	0	0	0	0	0
Candacia armata	0	0	0	0	0
Centropages hamatus	7	0	0	0	0
Centropages typicus	7	30	4	9	37
Eurytemora sp.	0	0	0	0	0
Labidocera aestiva	0	0	0	0	0
Metridia lucens	0	0	0	0	1
Oithona sp.	7	60	165	53	148
Oncea sp.	0	99	0	0	0
Pseudocalanus minutus	7	10	0	7	6
Pseudodiaptomus coronatus	0	0	0	0	0
Parategastes sphaericus	0	0	0	0	0
Paracalanus crassirostris	7	169	631	52	58
Paracalanus parvus	0	0	0	0	0
Rhincalanus nasutus	0	0	0	0	1
Temora longicornis	0	0	0	0	0
Tortanus discaudatus	0	0	0	0	0
Coryceaus sp.	0	0	0	0	0
Harpacticiod	0	0	0	0	0
Cladocera					
Evadne nordmanni	111	724	28	0	1
Evadne spinifera	0	40	0	0	0
Penilia avirostris	647	1597	0	0	0
Podon sp.	22	30	4	0	6
Temporary Plankton					
Decapod larvae	0	0	0	0	0
Balanus larvae	0	0	0	0	0
Gastropod larvae	14	40	0	1	11
Polychaete larvae	0	0	0	0	0
Other Holoplankton					
Oikopleura sp.	29	516	68	0	0
Fritillaria borealis	0	0	0	0	0
Doliolelta gegenbauri	0	0	0	0	0
Doliolium nationalis	0	0	0	0	0
Chaetognaths	0	0	0	0	0
Obelia sp	7	0	12	0	0
Sarsia tubulosa	0	0	0	0	0
Rathkea octopunctata	0	0	0	0	0
Hydromedusae sp	0	0	0	0	0

Appendix Table 2b. Abundance of zooplankton (no/m^3) in Block Island Sound, Station B (Frolander, 1955).

Appendix Table 2b. Abundance of zooplankton (no/m3) in lower West Passage, Frolander's St B (Frolander, 1955). Copepod data are for adults only.

Julian Date	7/25/50 206	7/31/50 212	8/8/50 220	8/14/50 226	8/21/50 233	8/28/50 240	9/8/50 251	9/18/50 261	9/25/50 268	10/2/50 275	10/11/50 284	10/16/50 289
Copepods												
Acartia clausii	3314	496	9	57	32	25	0	0	0	2	22	25
Acartia tonsa	1250	3345	656	1278	7316	5064	292	882	1794	154	2174	2801
Acartia longiremis	0	0	0	0	0	0	0	0	0	0	0	0
Calanus finmarchicus	0	0	0	0	0	0	0	0	0	0	0	0
Centropages hamatus	800	267	9	133	64	25	0	12	6	0	11	0
Centropages typicus	0	13	0	0	0	0	0	12	0	0	0	0
Eurytemora sp	44	0	0	0	0	0	0	0	0	0	0	0
Labidocera aestiva	0	13	4	6	16	12	0	0	0	0	0	0
Metridia lucens	0	0	0	0	0	0	0	0	0	0	0	0
Oithona sp.	0	0	0	32	80	0	0	6	0	3	0	0
Pseudocalanus minutus	538	0	0	120	0	0	0	0	0	0	0	0
Pseudodiaptomis coronatus	29	0	0	0	16	0	0	0	11	2	11	25
Paracalanus crassirostris	0	0	0	0	0	0	0	0	0	0	0	0
Paracalanus parvus	0	0	0	13	0	0	0	0	0	0	0	0
Temora longicornis	44	13	0	38	0	0	0	0	0	0	0	0
Tortanus discaudatus	44	0	0	0	0	0	0	0	0	0	0	0
Harpacticoid sp	0	0	0	0	0	0	0	0	0	0	0	0
Cladocera												
Evadne nordmanni	625	102	31	127	80	173	22	0	0	15	123	50
Penilia avirostris	0	0	0	0	0	0	0	0	0	2	0	0
Podon sp.	102	13	457	88	80	272	434	91	45	80	870	186
Temporary Plankton												
Crab larvae	1004	319	514	342	1299	928	489	115	133	145	1004	236
Balanus larvae	0	0	0	0	0	0	0	0	0	0	0	0
Gastropod larvae	1337	64	71	285	433	161	18	24	56	45	0	0
Polychaete larvae	0	38	13	0	0	0	0	0	0	0	0	0
Other Holoplankton												
Oikopleura sp.	88	77	9	50	48	37	15	30	44	5	0	37
Chaetognaths		0	0	0	0	0	0	0	0	0	0	0
Obelia sp	0	0		0	0	0	0	0	0	0	0	0
Sarsia tubulosa	0	0	0	0	0	0	0	0	0	0	0	0
Rathkea octopunctata	0	0	0	0	0	0	0	0	0	0	0	0
Bouganvillia superciliaris	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 2b. Abundance of zooplankton (no/m3) in lower West Passage, Frolander's St B (Frolander, 1955).
Copepod data are for adults only.

	10/25/50	10/31/50	11/10/50	12/1/50	12/7/50	12/13/50	12/19/50	1/3/51	1/6/51	1/11/51	1/26/51	2/2/51
Julian Date	298	304	314	335	341	347	353	3	6	11	26	33
Copepods												
Acartia clausii	16	78	26	284	87	16	1979	508	346	51	455	438
Acartia tonsa	1479	1634	1459	2617	650	381	8690	9640	2524	2004	455	74
Acartia longiremis	0	0	0	0	0	0	0	0	0	0	0	0
Calanus finmarchicus	0	0	0	0	0	0	0	0	0	0	0	0
Centropages hamatus	8	10	35	32	4	16	27	0	0	11	5	0
Centropages typicus	0	0	0	0	0	0	0	0	0	0	0	0
Eurytemora sp	0	0	0	0	0	0	0	0	0	0	0	0
Labidocera aestiva	0	0	0	0	0	0	0	0	0	0	0	0
Metridia lucens	0	0	0	0	0	0	0	0	0	0	0	0
Oithona sp.	8	0	0	0	0	3	0	0	0	11	0	0
Pseudocalanus minutus	0	0	0	0	0	0	27	0	24	102	18	45
Pseudodiaptomis coronatus	57	0	35	32	4	9	0	0	0	0	0	0
Paracalanus crassirostris	0	0	0	0	0	0	0	0	0	0	0	0
Paracalanus parvus	0	0	0	32	0	6	0	0	0	23	0	0
Temora longicornis	0	0	0	0	0	0	0	0	0	0	0	0
Tortanus discaudatus	0	0	0	0	0	0	0	0	0	0	0	0
Harpacticoid sp	0	0	0	0	0	0	0	0	0	0	0	0
Cladocera												
Evadne nordmanni	16	0	0	0	4	0	0	0	0	0	0	0
Penilia avirostris	0	0	0	0	0	0	0	0	0	0	0	0
Podon sp.	98	39	44	63	12	0	0	0	0	0	0	0
Temporary Plankton												
Crab larvae	114	39	44	63	16	0	0	0	0	0	0	0
Balanus larvae	0	0	0	0	0	0	0	0	8	165	1170	264
Gastropod larvae	16	0	0	0	0	0	0	0	0	0	0	0
Polychaete larvae	0	0	0	0	4	0	0	0	0	0	32	0
Other Holoplankton												
Oikopleura sp.	16	10	0	0	0	0	0	0	0	0	0	0
Chaetognaths	0	0	0	0	0	3	0	0	8	57	18	39
Obelia sp	16	0	0	0	0	0	0	0	0	0	0	0
Sarsia tubulosa	0	0	0	0	0	0	0	0	0	0	0	0
Rathkea octopunctata	0	0	0	0	0	0	0	0	0	0	0	0
Bouganvillia supercillaris	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 2b. Abundance of zooplankton (no/m3) in lower West Passage, Frolander's St B (Frolander, 1955). Copepod data are for adults only.

	2/12/51	2/19/51	2/28/51	3/6/51	3/26/51	3/26/51	3/26/51	4/2/51	4/2/51	4/2/51	4/9/51	4/9/51
Julian Date	43	50	59	65	85	85	85	92	92	92	99	99
Copepods												
Acartia clausii	38	132	54	39	74	40	75	1815	1023	685	3114	2945
Acartia tonsa	12	21	7	8	0	0	0	0	0	0	0	0
Acartia longiremis	0	0	0	0	0	0	0	0	0	0	0	0
Calanus finmarchicus	0	0	0	0	0	0	0	0	0	0	0	0
Centropages hamatus	2	5	24	17	74	28	12	148	112	92	171	339
Centropages typicus	2	0	0	0	0	0	0	0	0	0	0	9
Eurytemora sp	0	0	0	0	0	0	0	0	0	0	85	59
Labidocera aestiva	0	0	0	0	0	0	0	0	0	0	0	0
Metridia lucens	0	0	0	0	0	0	0	0	0	0	0	0
Oithona sp.	5	2	8	0	0	16	12	0	24	31	24	0
Pseudocalanus minutus	50	221	212	114	1311	330	340	528	455	608	684	135
Pseudodiaptomis coronatus	0	0	0	0	0	0	0	0	0	0	0	0
Paracalanus crassirostris	0	0	0	0	0	0	0	0	0	0	0	0
Paracalanus parvus	0	0	0	0	0	0	0	0	0	0	0	0
Temora longicornis	2	19	9	6	59	2	15	130	128	15	134	34
Tortanus discaudatus	0	0	0	0	7	0	0	9	0	14	0	8
Harpacticoid sp	0	0	3	0	0	0	0	0	16	0	0	0
Cladocera												
Evadne nordmanni	0	0	0	0	0	0	0	0	0	0	0	0
Penilia avirostris	0	0	0	0	0	0	0	0	0	0	0	0
Podon sp.	0	0	0	0	0	0	0	0	0	0	0	0
Temporary Plankton												
Crab larvae	0	0	0	0	0	0	0	0	0	0	0	0
Balanus larvae	115	76	22	22	44	10	29	83	144	107	110	76
Gastropod larvae	0	0	0	0	15	6	0	19	16	0	0	8
Polychaete larvae	5	0	8	6	22	15	52	56	8	30	12	8
Other Holoplankton												
Oikopleura sp.	0	0	0	0	0	0	0	0	0	0	0	0
Chaetognaths	20	19	11	10	0	0	0	0	0	0	0	0
Obelia sp	2	0	0	0	0	0	0	19	0	0	24	17
Sarsia tubulosa	0	0	0	0	0	0	0	0	0	0	0	0
Rathkea octopunctata	0	0	0	0	0	0	0	0	0	0	0	0
Bouganvillia supercillaris	0	0	0	0	0	0	0	0	0	0	8	0	0

Appendix Table 2b. Abundance of zooplankton (no/m3) in lower West Passage, Frolander's St B (Frolander, 1955). Copepod data are for adults only.

Julian Date	4/17/51 107	4/23/51 113	5/1/51 121	5/8/51 128	5/14/51 134	5/21/51 141	5/28/51 148	6/4/51 155	6/5/51 156	6/6/51 157	6/7/51 158	6/8/51 159
Copepods												
Acartia clausi	2359	2194	2716	2477	3812	1797	3688	2131	1523	908	1860	1176
Acartia tonsa	0	0	0	0	0	0	0	4	4	3	10	13
Acartia longiremis	0	0	0	0	0	7	0	0	0	0	0	0
Calanus finmarchicus	0	0	0	0	12	0	0	0	0	0	0	0
Centropages hamatus	703	542	254	400	253	165	426	243	14	17	39	10
Centropages typicus	0	12	0	0	0	0	0	0	0	0	0	. 0
Eurytemora sp	78	24	8	54	12	0	67	4	12	0	10	5
Labidocera aestiva	0	0	0	0	0	0	0	0	0	0	0	0
Metridia lucens	0	0	0	0	0	0	)	0	0	0	0	0
Oithona sp.	47	49	15	54	24	0	13	0	6	2	0	0
Pseudocalanus minutus	1828	1158	269	227	240	48	27	43	2	2	3	0
Pseudodiaptomis coronatus	0	0	0	0	0	0	0	0	0	0	0	0
Paracalanus crassirostris	0	0	0	0	0	0	0	0	0	0	0	0
Paracalanus parvus	0	0	0	0	0	0	0	0	0	2	0	0
Temora longicornis	297	222	45	108	144	41	0	0	0	0	0	0
Tortanus discaudatus	0	12	22	54	24	14	27	17	0	0	0	0
Harpacticoid sp	0	0	0	11	0	0	0	0	0	0	0	0
Cladocera												
Evadne nordmanni	0	12	15	43	325	681	1438	371	227	279	202	170
Penilia avirostris	0	0	0	0	0	0	0	0	0	0	0	0
Podon sp.	0	0	0	43	60	96	293	282	312	712	668	949
Temporary Plankton												
Crab larvae	0	12	15	86	397	784	1784	661	539	991	870	1119
Balanus larvae	64	37	30	22	24	0	0	0	0	0	0	0
Gastropod larvae	125	49	15	54	84	156	1531	43	23	38	19	165
Polychaete larvae	31	12	0	0	0	14	0	0	0	0	0	10
Other Holoplankton												
Oikopleura sp.	0	0	0	0	0	0	0	0	0	0	0	0
Chaetognaths	0	0	0	11	0	14	0	4	0	0	0	0
Obelia sp	172	0	0	0	0	0	67	0	2	0	0	3
Sarsia tubulosa	0	0	0	0	0	0	0	0	0	0	0	0
Rathkea octopunctata	0	0	0	0	0	0	0	0	4	0	0	0
Bouganvillia supercillaris	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 2b. Abundance of zooplankton (no/m3) in lower West Passage, Frolander's St B (Frolander, 1955). Copepod data are for adults only.

	6/13/51	6/19/51	6/25/51	7/2/51	7/9/51	7/16/51	7/25/51	7/30/51	8/6/51	8/13/51	8/20/51	8/27/51
Julian Date	164	170	176	183	190	197	206	211	218	225	232	239
Copepods												
Acartia clausii	1564	2720	7723	2970	2137	2368	2338	175	221	38	13	0
Acartia tonsa	84	38	16	85	60	926	2850	9600	3889	2128	1569	1669
Acartia longiremis	0	0	0	0	0	0	0	0	0	0	0	0
Calanus finmarchicus	0	0	0	0	0	0	0	0	0	0	0	0
Centropages hamatus	409	338	908	193	188	162	1169	200	17	0	13	15
Centropages typicus	13	0	0	0	0	0	0	0	0	0	0	.0
Eurytemora sp	91	63	200	39	522	176	658	25	0	0	0	0
Labidocera aestiva	0	0	0	0	7	0	0	0	0	0	0	0
Metridia lucens	0	0	0	0	0	0	0	0	0	0	0	0
Oithona sp.	13	0	46	8	20	44	695	100	102	171	13	29
Pseudocalanus minutus	0	13	31	23	516	44	648	25	17	19	0	0
Pseudodiaptomis coronatus	0	6	0	0	0	15	2850	550	509	418	151	0
Paracalanus crassirostris	0	0	0	0	0	0	110	0	0	19	63	0
Paracalanus parvus	0	6	15	8	0	0	0	0	0	0	0	0
Temora longicornis	84	6	15	8	74	0	365	25	0	38	0	0
Tortanus discaudatus	19	0	108	0	33	15	73	0	0	0	0	0
Harpacticoid sp	0	0	0	0	0	0	0	0	0	0	0	0
Cladocera												
Evadne nordmanni	175	263	369	804	623	1765	183	0	34	57	0	15
Penilia avirostris	0	0	0	0	0	0	73	75	390	6289	2812	3523
Podon sp.	3017	1266	400	2421	141	529	73	50	17	152	75	29
Temporary Plankton												
Crab larvae	3198	1529	846	3379	1179	4721	1279	1400	1239	7391	3489	3699
Balanus larvae	0	0	0	0	0	0	0	0	0	0	0	0
Gastropod larvae	622	1830	1600	711	295	1235	5297	225	306	133	86	44
Polychaete larvae	6	0	0	8	0	0	0	0	34	0	0	0
Other Holoplankton												
Oikopleura sp.	0	0	0	0	0	0	256	75	68	152	38	15
Chaetognaths	0	0	0	0	0	0	0	0	0	0	0	0
Obelia sp	6	0	0	0	0	0	0	0	0	0	0	0
Sarsia tubulosa	0	0	0	0	0	0	0	0	0	0	0	0
Rathkea octopunctata	0	0	0	0	0	0	0	0	0	0	0	0
Bouganvillia superciliaris	0	0	0	0	0	0	0	0	0	0	0	0

2b

Appendix Table . Abundance of zooplankton (no/m3) in lower West Passage, Frolander's St B (Frolander, 1955). Copepod data are for adults only.

	9/6/51	9/13/51	9/19/51	10/31/51	12/12/51	12/27/51
Julian Date	249	256	262	304	346	361
Copepods						
Acartia clausii	0	0	0	101	1370	1283
Acartia tonsa	163	1	341	942	1909	528
Acartia longiremis	0	0	0	0	0	0
Calanus finmarchicus	0	0	0	0	0	0
Centropages hamatus	0	0	0	10	0	21
Centropages typicus	0	0	0	0	0	0
Eurytemora sp	0	0	0	0	0	0
Labidocera aestiva	0	0	0	0	0	0
Metridia lucens	0	0	0	0	0	0
Oithona sp.	0	0	4	149	122	114
Pseudocalanus minutus	1	0	0	0	7	10
Pseudodiaptomis coronatus	14	0	4	317	93	10
Paracalanus crassirostris	1	0	190	740	7	5
Paracalanus parvus	0	0	0	0	0	0
Temora longicornis	0	0	0	0	0	0
Tortanus discaudatus	0	0	0	0	0	0
Harpacticoid sp	0	0	0	226	96	0
Cladocera						
Evadne nordmanni	0	0	4	5	0	0
Penilia avirostris	24	0	39	0	0	0
Podon sp.	0	0	0	0	7	0
Temporary Plankton						
Crab larvae	32	13	68	5	7	0
Balanus larvae	0	0	0	0	0	129
Gastropod larvae	1	0	162	14	22	0
Polychaete larvae	0	0	8	43	0	5
Other Holoplankton						
Oikopleura sp.	0	0	19	10	0	0
Chaetognaths	0	0	0	0	7	2
Obelia sp	0	0	0	5	0	0
Sarsia tubulosa	0	0	0	0	0	0
Rathkea octopunctata	0	0	4	0	0	0
Bouganvillia superciliaris	0	0	0	0	0	0

Appendix Table 3a. Zooplankton abundance in upper West Passage, Station 1 (Martin, 1965)

Appendix Table 3a. Zooplankton abundance in upper West Passage (Station 1, Martin 1965). Data presented by Martin are monthly mean numbers of organisms (no/m3) over the period 1/28/59 to 1/9/62.

DATE	JAN 31	FEB 28	MAR 31	APR 30	MAY 31	JUNE 30	JULY 31	AUG 31	SEPT 30	OCT 31	NOV 30	DEC 31
Copepods (adult only)												
Calanoid												
Acartia hudsonica	3500	1000	700	300	1000	3000	700	0	0	0	100	1100
Acartia tonsa	500	0	0	0	0	200	9500	6000	1500	3500	9500	1100
Centropages hamatus	170	30	20	20	30	150	140	60	20	20	170	100
Centropages typicus												
Eurytemora herdmanni	0	0	0	10	30	120	70	10	0	0	0	0
Harpacticus gracilis	0	0	0	0	0	0	0	0	0	0	0	0
Microsetella norvegica	100	125	300	125	25	0	50		0	75	25	200
Oithona spp.	1000	500	500	400	100	200	5000		8000	22000	8500	5200
Oithona spinirostris	0	0	0	0	25	0	0	0	0	0	0	0
Paracalanus parvus												
Pseudocalanus minutus	300	500	400	300	150	0	100	50	0	0	100	150
Pseudodiaptomus coronatus	30	10	10	10	70	10	100	10	10	50	200	20
Temora longicornis	60	30	50	30	30	20	0	0	0	0	0	20
Tortanus discaudatus	20	10	20	50	60	40	10	0	0	0	10	50
Cladocerans												
Evadni nordmanni	0	0	0	0	30	1200	1150	350	0	0	40	30
Penillia avirostris	0	0	0	0	0	0	0	0	10	0	0	0
Podon polyphemoides	0	0	0	0	0	3700	3500	1300	500	1000	900	0
Total Cladocera	0	0	0	0	30	4900	4650	1650	510	1000	940	30
Temporary plankton												
Balanus larvae	750	300	100	100	100	0	0	0	0	0	25	50
Bivalve larvae	0	0	0	0	0	0	0	0	0	0	400	100
Decapod larvae	0	0	0	0	0	30	250	100	50	0	0	0
Gastropod larvae	0	0	0	0	0	1500	2200	400	100	100	100	0
Polychaete larvae	300	800	400	100	400	150	50	0	25	500	1300	300
Other Holoplankton												
Chaetognaths	0	20	20	25	10	0	0	0	0	0	0	5
Dolioletta gegenbouri												
Obelia spp.	0	0	0	135	80	0	0	0	0	0	0	0
Oikopleura spp.												
Rathkea octopunctata	0	0	5	125	70	0	0	0	0	0	0	0
Rotifers	300	5000	9600	1550	6100	100	0	0	0	0	0	0
Sarsia tubulosa	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 3b. Zooplankton abundance in upper West Passage, Station 3 (Martin, 1965)

Appendix Table 3b. Zooplankton abundance in southern West Passage (Station 3, Martin 1965). Data presented by Martin are monthly mean numbers of organisms (no/m3) over the period 1/28/59 to 1/9/62.

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
	31	28	31	30	31	30	31	31	30	31	30	31
Copepods (adult only)												
Acartia hudsonica	300	200	300	200	400	3500	4000	0	0	0	0	200
Acartia tonsa	0	0	0	0	0	0	300	700	1000	1300	500	100
Centropages hamatus	50	100	0	70	270	310	500	530	200	110	130	50
Centropages typicus	10	0	0	0	0	0	0	0	30	60	260	80
Eurytemora herdmanni	0	0	0	0	0	170	180	30	0	0	0	0
Harpacticus gracilis	0	0	0	0	0	0	0	0	0	0	0	0
Microsetella norvegica	700	900	850	1000	300	250	300		100	750	5200	800
Oithona spp.	1000	1000	300	300	2500	3000	13000		10000	16000	10000	2000
Oithona spinirostris	10	10	0	20	110	5	0	10	15	20	60	40
Paracalanus parvus	0	0	0	0	0	0	0	50	200	500	200	10
Pseudocalanus minutus	500	1700	1300	1900	1700	1300	1900	200	400	100	200	300
Pseudodiaptomus coronatus	0	0	0	0	0	20	100	100	30	260	60	20
Temora longicornis	20	110	160	270	180	80	470	80	100	0	30	20
Tortanus discaudatus	30	100	110	220	600	450	150	30	0	0	0	20
Cladocerans												
Evadni nordmanni	0	0	0	0	0	400	800	230	200	100	0	0
Penillia avirostris	0	0	0	0	0	0	0	10	110	50	5	0
Podon polyphemoides	0	0	0	0	0	100	500	100	1000	100	50	0
Total Cladocera												
Temporary plankton												
Balanus larvae	400	250	200	25	25	0	0	0	0	0	0	100
Bivalve larvae	400	100	0	100	0	0	0	0	0	1000	1400	500
Decapod larvae	0	0	0	0	10	40	400	250	30	0	0	0
Gastropod larvae	0	0	0	0	100	1500	1000	600	100	100	100	0
Polychaete larvae	100	600	300	200	100	25	25	25	25	25	250	50
Other Holoplankton												
Chaetognaths	25	15	20	35	65	0	10	0	0	0	5	15
Dolioletta gegenbouri	0	0	0	0	0	0	0	0	0	0	0	0
Obelia sp.	0	0	20	90	30	5	20	5	0	20	0	0
Oikopleura spp.	0	0	0	0	0	0	300		450	150	75	0
Rathkea octopunctata	0	0	0	0	10	0	0	0	0	0	0	0
Rotifers	0	600	2600	0	1000	0	0	0	0	0	0	0

Appendix Table 4a. Zooplankton abundance off Wickford during 1972 (Hulsizer, 1976)

Appendix Table 4a. Seasonal changes in zooplankton abundance (no/m3) off Wickford during 1972. Data from Hulsizer (1976). Formulae at the bottom of table indicate how total Acartia copepodites 1-3 were apportioned between A. hudsonica and A. tonsa.

	1/3/72	1/10/72	1/17/72	1/24/72	1/31/72	2/7/72	2/14/72	2/21/72	2/28/72	3/7/72	3/13/72
Julian Date	3	10	17	24	31	38	45	52	59	67	73
Copepods											
Acartia hudsonica 1-3,Total	6518	12026	2515	1948	1744	4022	1430	790	2423	1172	977
Acartia hudsonica,4-6 Total	6244	9807	7304	4837	6981	11493	17422	2864	6036	1380	1122
Acartia hudsonica , Total	12762	21833	9819	6785	8725	15515	18852	3654	8459	2552	2099
Acartia tonsa 1-3 Total	0	0	0	0	0	0	0	0	0	0	0
Acartia tonsa 4-6	619	889	193	178	0	0	0	0	0	0	0
Acartia tonsa, Total	619	889	193	178	0	0	0	0	0	0	0
Total Acartia spp.	13381	22722	10012	6963	8725	15515	18852	3654	8459	2552	2099
Centropages hamatus	137	89	0	0	0	0	0	0	0	8	25
Harpacticoid	0	0	0	0	22	30	0	0	0	85	0
Hemicyclops sp (Sophirella)	67	44	0	0	89	0	0	0	0	0	8
Oithona sp.	0	311	119	296	63	85	63	74	72	183	117
Parvocalanus crassirostris	0	0	0	0	0	0	0	0	68	44	89
Pseudocalanus minutus	33	356	96	178	252	389	3111	568	292	406	719
Pseudodiaptomus coronatus	0	0	0	0	0	0	0	0	0	0	0
Temora longicornis	0	0	0	0	0	0	0	25	0	44	15
Tortanus discaudatus	0	0	0	0	0	0	0	0	0	0	0
Total Copepods	13618	23522	10227	7437	9151	16019	22026	4321	8891	3322	3072
Cladocera											
Evadne sp	0	0	0	0	0	0	0	0	0	0	0
Podon spp.	0	0	0	0	0	0	0	0	0	0	0
Cladoceron	137	0	0	0	0	0	0	0	0	0	0
Total Cladocera	137	0	0	0	0	0	0	0	0	0	0
Temporary Plankton											
Barnacle larvae	1785	933	119	237	337	104	126	74	102	154	30
Bivalve larvae	0	0	0	0	0	0	63	0	0	0	0
Crab larvae	0	0	0	0	0	0	0	0	0	0	0
Gastropod larvae	0	0	0	0	0	0	0	0	0	0	0
Polychaete larvae	33	222	0	0	22	85	0	0	0	0	0
Worm	0	0	0	0	0	0	0	0	0	16	0
Polychaete larvae	33	222	0	0	22	85	0	0	0	16	0
Other											
Chaetognath	0.1	0.1	0	0	0.1	0	0.1	0	1	0.1	0.1
Medusae	0	0	0	0	0	0	0	0	0	8	0
Oikopleura	0	0	0	0	0	0	0	0	0	0	0
Rotifer	0	0	0	119	178	1370	315	815	1242	884	360

Z-A. hud 1-3,4-6 est = (Z. A. hud. All)/2
A. hud 1-3 est=(A. hud 4-6)/((A. hud 4-6) + (A. ton 4-6))* (A. spp. 1-3)
A. tonsa 1-3 est = (A. ton. 4-6)/((A. hud 4-6) + (A. ton 4-6))* (A. spp. 1-3)

Appendix Table 4a. Seasonal changes in zooplankton abundance (no/m3) off Wickford during 1972. Data from Hulsizer (1976). Formulae at the bottom of table indicate how total Acartia copepodites 1-3 were apportioned between A. hudsonica and A. tonsa.

	3/20/72	3/27/72	4/3/72	4/10/72	4/17/72	4/24/72	5/1/72	5/8/72	5/15/72	5/22/72	5/30/72
Julian Date	80	87	94	101	108	115	122	129	136	143	151
Copepods											
Acartia hudsonica 1-3,Total	1847	2462	19134	2538	2206	8030	3043	19425	6014	3979	26550
Acartia hudsonica,4-6 Total	2372	2642	9108	3177	4790	9866	4608	16093	5251	2261	18217
Acartia hudsonica , Total	4218	5104	28242	5715	6995	17896	7651	35517	11265	6239	44766
Acartia tonsa 1-3 Total	0	0	0	0	0	0	0	0	0	0	0
Acartia tonsa 4-6	0	0	0	0	0	0	0	0	0	0	0
Acartia tonsa, Total	0	0	0	0	0	0	0	0	0	0	0
Total Acartia spp.	4218	5104	28242	5715	6995	17896	7651	35517	11265	6239	44766
Centropages hamatus	0	0	0	13	16	137	0	0	82	72	0
Harpacticoid	0	0	0	10	0	94	0	0	109	54	0
Hemicyclops sp (Sophirella)	0	40	0	0	0	44	0	0	0	0	0
Oithona sp.	192	245	568	120	145	87	174	318	381	72	980
Parvocalanus crassirostris	52	82	264	108	184	355	116	531	191	0	0
Pseudocalanus minutus	564	416	4032	1582	2857	3430	3768	2010	3105	307	654
Pseudodiaptomus coronatus	0	0	0	0	16	0	0	0	27	0	0
Temora longicornis	26	40	0	21	92	0	0	450	218	176	163
Tortanus discaudatus	0	0	0	0	0	0	0	106	109	46	163
Total Copepods	5052	5927	33106	7569	10305	22043	11709	38932	15487	6966	46726
Cladocera											
Evadne sp	0	0	0	0	0	0	0	42	54	368	1144
Podon spp.	0	0	0	0	0	0	0	0	54	304	327
Cladoceron	0	0	0	0	0	0	0	0	0	0	0
Total Cladocera	0	0	0	0	0	0	0	42	108	672	1471
Temporary Plankton											
Barnacle larvae	141	306	809	153	306	116	124	0	0	0	0
Bivalve larvae	0	0	0	0	0	0	0	0	0	0	1304
Crab larvae	0	0	0	0	0	0	0	0	0	0	0
Gastropod larvae	0	0	0	0	0	0	0	0	0	0	163
Polychaete larvae	0	0	0	0	56	0	290	416	2151	0	0
Worm	0	0	0	0	0	0	0	0	0	256	652
Polychaete larvae	0	0	0	0	56	0	290	416	2151	256	652
Other											
Chaetognath	1	5	0.1	0.1	0.1	0	4	0	1	0.1	3
Medusae	13	20	91	0	16	137	116	0	0	0	0
Oikopleura	0	0	0	0	0	0	0	0	0	0	0
Rotifer	141	82	304	105	571	4239	7942	16520	1443	111	0

Z-A. hud 1-3,4-6 est = (Z. A. hud. All)/2
A. hud 1-3 est=(A. hud 4-6)/((A. hud 4-6) + (A. ton 4-6))* (A. spp. 1-3)
A. tonsa 1-3 est = (A. ton. 4-6)/((A. hud 4-6) + (A. ton 4-6))* (A. spp. 1-3)

Appendix Table 4a. Seasonal changes in zooplankton abundance (no/m3) off Wickford during 1972. Data from Hulsizer (1976). Formulae at the bottom of table indicate how total Acartia copepodites 1-3 were apportioned between A. hudsonica and A. tonsa.

	6/5/72	6/12/72	6/19/72	6/26/72	7/3/72	7/10/72	7/17/72	7/24/72	7/31/72	8/15/72	8/21/72
Julian Date	157	164	171	178	185	192	199	206	213	228	234
Copepods											
Acartia hudsonica 1-3,Total	18564	20261	5041	3540	3377	728	101	0	0	0	0
Acartia hudsonica,4-6 Total	14436	17928	2766	1038	8496	916	152	0	0	0	0
Acartia hudsonica , Total	33000	38188	7807	4577	11873	1644	253	0	0	0	0
Acartia tonsa 1-3 Total	0	0	0	0	0	0	1111	2040	501	135	188
Acartia tonsa 4-6	0	0	0	0	0	228	354	100	794	21	26
Acartia tonsa, Total	0	0	0	0	0	228	1465	2140	1295	156	214
Total Acartia spp.	33000	38188	7807	4577	11873	1872	1718	2140	1295	156	214
Centropages hamatus	1608	699	73	748	599	492	0	0	0	5	0
Harpacticoid	0	0	0	0	0	0	0	0	0	1	0
Hemicyclops sp (Sophirella)	0	0	0	0	0	0	50	60	20	5	34
Oithona sp.	536	972	294	280	2397	770	4949	413	599	124	97
Parvocalanus crassirostris	0	0	0	0	0	0	0	0	0	0	0
Pseudocalanus minutus	516	980	0	131	0	565	50	18	28	2	6
Pseudodiaptomus coronatus	516	980	1616	130	2560	586	0	61	0	3	0
Temora longicornis	1842	426	0	66	436	210	50	0	0	0	2
Tortanus discaudatus	364	572	73	0	109	114	0	18	0	0	0
Total Copepods	38382	42817	9863	5932	17974	4609	6817	2710	1942	296	353
Cladocera											
Evadne sp	1530	683	30	2577	2124	0	101	0	0	0	0
Podon spp.	6524	171	91	94	3050	519	2727	0	0	0	0
Cladoceron	0	0	0	0	0	0	0	0	0	0	12
Total Cladocera	8054	854	121	2671	5174	519	2828	0	0	0	12
Temporary Plankton											
Barnacle larvae	0	0	0	0	0	0	0	0	0	0	0
Bivalve larvae	4219	145	147	719	436	82	152	24	119	21	10
Crab larvae	0	0	0	0	0	0	50	64	8	16	4
Gastropod larvae	0	0	0	0	109	41	0	46	119	47	2
Polychaete larvae	0	0	0	0	0	0	0	0	0	0	0
Worm	364	0	2056	6508	4194	6008	5909	1245	0	87	20
Polychaete larvae	364	0	2056	6508	4194	6008	5909	1245	0	87	20
Other											
Chaetognath	0.1	0	0	0	0	0	0	0	0	0	0
Medusae	0	0	0	0	0	64	0	42	39	1	0
Oikopleura	0	0	0	0	0	0	0	0	0	0	6
Rotifer	0	0	0	0	0	0	0	0	0	0	0

Z-A. hud 1-3,4-6 est = (Z. A. hud. All)/2
A. hud 1-3 est=(A. hud 4-6)/((A. hud 4-6) + (A. ton 4-6))* (A. spp. 1-3)
A. tonsa 1-3 est = (A. ton. 4-6)/((A. hud 4-6) + (A. ton 4-6))* (A. spp. 1-3)

4a
Appendix Table . Seasonal changes in zooplankton abundance (no/m3) off Wickford during 1972. Data from Hulsizer (1976).
Formulae at the bottom of table indicate how total Acartia copepodites 1-3 were apportioned between A. hudsonica and A. tonsa.

	8/28/72	9/5/72	9/11/72	9/18/72	9/25/72	10/10/72	10/16/72	10/24/72	10/30/72	11/6/72	11/13/72
Julian Date	241	249	255	262	269	284	290	298	304	311	318
Copepods											
Acartia hudsonica 1-3,Total	0	0	0	0	0	0	3	0	187	94	74
Acartia hudsonica,4-6 Total	0	0	0	0	0	0	1	0	51	54	54
Acartia hudsonica , Total	0	0	0	0	0	0	4	0	238	148	128
Acartia tonsa 1-3 Total	150	815	32	516	62	166	55	1978	221	201	178
Acartia tonsa 4-6	33	450	14	56	55	70	20	409	60	116	129
Acartia tonsa, Total	183	1265	46	572	117	236	75	2387	281	317	307
Total Acartia spp.	183	1265	46	572	117	236	79	2387	519	465	435
Centropages hamatus	0	0	0	0	0	0	4	228	34	34	25
Harpacticoid	0	0	0	0	3	1	[illegible]	61	8	5	0
Hemicyclops sp (Sophirella)	16	10	7	56	65	48	58	298	213	72	82
Oithona sp.	160	219	7	101	20	46	34	22	102	136	75
Parvocalanus crassirostris	0	0	0	94	60	99	44	22	68	64	16
Pseudocalanus minutus	0	0	0	0	0	0	0	0	0	2	4
Pseudodiaptomus coronatus	4	10	1	0	1	0	0	0	0	0	0
Temora longicornis	0	0	0	0	1	0	0	0	0	0	0
Tortanus discaudatus	0	0	0	0	0	0	0	25	0	0	0
Total Copepods	363	1504	61	823	267	430	219	3043	944	778	637
Cladocera											
Evadne sp	0	0	0	0	0	0	0	0	0	0	0
Podon spp.	0	0	0	0	0	0	0	0	0	0	0
Cladoceron	46	0	1	1	18	2	10	0	42	34	9
Total Cladocera	46	0	1	1	18	2	10	0	42	34	9
Temporary Plankton											
Barnacle larvae	0	0	0	0.1	0	0	0	36	0	0	0
Bivalve larvae	1	6	1	18	8	8	20	50	8	10	0
Crab larvae	4	32	1	0	0	0	0	0	0	0	0
Gastropod larvae	1	28	1	7	5	4	2	11	0	0	4
Polychaete larvae	0	0	0	0	0	0	0	0	0	0	0
Worm	100	86	20	15	37	24	44	94	179	173	52
Polychaete larvae	100	86	20	15	37	24	44	94	179	173	52
Other											
Chaetognath	0	0	0	0	0	0	0	0	0	0	0
Medusae	0	0	1	1	0	0	0	0	0	0	0
Oikopleura	1	0	1	0	0.1	0	1	0	0	0	0
Rotifer	0	0	0	0	0	0	0	0	0	0	0

Z-A. hud 1-3,4-6 est = (Z. A. hud. All)/2
A. hud 1-3 est=(A. hud 4-6)/((A. hud 4-6) + (A. ton 4-6))* (A. spp. 1-3)
A. tonsa 1-3 est = (A. ton. 4-6)/((A. hud 4-6) + (A. ton 4-6))* (A. spp. 1-3)

4a

Appendix Table . Seasonal changes in zooplankton abundance (no/m3) off Wickford during 1972. Data from Hulsizer (1976). Formulae at the bottom of table indicate how total Acartia copepodites 1-3 were apportioned between A. hudsonica and A. tonsa.

Julian Date	11/20/72 325	11/27/72 332	12/4/72 339	12/11/72 346	12/18/72 353	12/26/72 361	1972 Area	1972 Mean	Area D,1972 T=231 days Day 67-298	Mean D,1972 T=231 days Day 67-298
Copepods										
Acartia hudsonica 1-3,Total	269	321	632	3193	706	398	1287627.0	3596.72	1044828.6	4523.07
Acartia hudsonica,4-6 Total	664	408	610	2662	2184	1009	1423658.3	3976.70	903810.8	3912.60
Acartia hudsonica , Total	933	729	1242	5855	2890	1407	2711285.3	7573.42	1948639.3	8435.67
Acartia tonsa 1-3 Total	125	143	284	763	99	66	71819.7	200.61	51581.2	223.30
Acartia tonsa 4-6	310	182	274	636	308	168	48008.5	134.10	20894.0	90.45
Acartia tonsa, Total	435	325	558	1399	407	234	119828.2	334.72	119828.2	334.72
Total Acartia spp.	1368	1054	1800	7254	3297	1641	2831113.5	7908.14	2021114.5	8749.41
Centropages hamatus	56	18	8	28	34	10	35701.[illegible]	99.72	32216.0	139.46
Harpacticoid	2	9	2	11	3	4	3629.5	10.14	2789.0	12.07
Hemicyclops sp (Sophirella)	201	248	138	490	52	45	17979.0	50.22	5348.0	23.15
Oithona sp.	128	125	98	228	114	98	127219.5	355.36	112384.5	486.51
Parvocalanus crassirostris	0	0	0	0	0	0	18399.0	51.39	17093.0	74.00
Pseudocalanus minutus	4	4	25	238	112	292	223576.5	624.52	183842.0	795.85
Pseudodiaptomus coronatus	0	0	0	0	0	0	45335.0	126.63	45335.0	196.26
Temora longicornis	0	0	0	6	0	0	29325.5	81.91	29108.5	126.01
Tortanus discaudatus	0	0	0	0	0	0	11734.0	32.78	11659.0	50.47
Total Copepods	1759	1458	2071	8255	3612	2090	3344013.0	9340.82	2460889.5	10653.20
Cladocera										
Evadne sp	0	0	0	0	0	0	59990.0	167.57	59990.0	259.70
Podon spp.	0	0	0	0	0	0	93917.0	262.34	93917.0	406.57
Cladoceron	6	6	2	6	0	0	1919.0	5.36	725.5	3.14
Total Cladocera	6	6	2	6	0	0	155826.0	435.27	154632.5	669.40
Temporary Plankton										
Barnacle larvae	0	0	7	22	0	16	36000.2	100.56	15510.7	67.15
Bivalve larvae	4	0	2	0	0	0	51530.0	143.94	50775.0	219.81
Crab larvae	0	0	0	0	0	0	1340.5	3.74	1340.5	5.80
Gastropod larvae	4	6	3	0	0	0	4894.5	13.67	4742.5	20.53
Polychaete larvae	0	0	0	0	0	0	22809.5	63.71	20391.0	88.27
Worm	90	56	11	92	10	28	199326.0	556.78	194375.5	841.45
Polychaete larvae	90	56	11	92	10	28	222135.5	620.49	214766.5	929.73
Other										
Chaetognath	0	0	0	0	1	0.1	120.7	0.34	106.9	0.46
Medusae	0	0	0	0	0	0	4002.0	11.18	4002.0	17.32
Oikopleura	0	0	0	0	0	0	61.1	0.17	61.1	0.26
Rotifer	0	0	0	16	0	4	257811.5	720.14	233757.5	1011.94

Z-A. hud 1-3,4-6 est = (Z. A. hud. All)/2

A. hud 1-3 est=(A. hud 4-6)/((A. hud 4-6) + (A. ton 4-6))* (A. spp. 1-3)

A. tonsa 1-3 est = (A. ton. 4-6)/((A. hud 4-6) + (A. ton 4-6))* (A. spp. 1-3)

Appendix Table 4b. Zooplankton abundance off Wickford during 1973 (Hulsizer, 1976)

Appendix Table 4b. Seasonal changes in zooplankton abundance (no/m3) off Wickford during 1973. Data from Hulsizer (1976). Formulae at the bottom of table indicate how total Acartia copepodites 1-3 were apportioned between A. hudsonica and A. tonsa.

	1/2/73	1/8/73	1/15/73	1/23/73	1/29/73	2/5/73	2/12/73	2/19/73	2/26/73	3/5/73	3/12/73	3/19/73
Julian Date	2	8	15	23	29	36	43	50	57	64	71	78
Copepods												
Acartia hudsonica 1-3, Total	1592	484	776	1046	1274	15717	1792	4363	930	6888	5101	2130.5
Acartia hudsonica 4-6, Total	4562	1436	2630	610	727	6448	1720	5230	3551	8397	5065	1644.5
Acartia hudsonica Total	6154	1920	3406	1656	2001	22165	3512	9593	4481	15285	10166	3775
Acartia tonsa 1-3, Total	0	0	0	0	0	0	0	0	0	0	0	0
Acartia tonsa 4-6, Total	264	120	200	32	5	0	0	0	0	0	0	0
Acartia tonsa, Total	264	120	200	32	5	0	0	0	0	0	0	0
Total Acartia spp.	6418	2040	3606	1688	2006	22165	3512	9593	4481	15285	10166	3775
Centropages hamatus	28	10	0	31	0	0	0	0	0	0	0	0
Harpacticoid	4	0	0	0	0	0	0	0	24	0	0	0
Hemicyclops (Saphirella)	176	15	36	0	4	0	0	0	0	0	0	0
Oithona sp.	632	175	881	93	82	382	164	411	258	446	352	40
Parvocalanus crassirostrus	16	0	0	0	4	0	0	0	52	85	109	162
Pseudocalanus minutus	2312	533	4753	654	707	2367	324	1807	1482	2721	744	2187
Pseudodiaptomis coronatus	16	0	0	0	0	0	0	0	11	0	0	0
Temora longicornis	0	0	0	0	0	0	0	0	26	0	0	0
Tortanus discaudatus	0	0	0	0	0	0	0	0	0	0	0	0
Cladocerans												
Evadne sp	0	0	0	0	0	0	0	0	0	0	0	0
Podon sp.	0	0	0	0	0	0	0	0	0	0	0	0
Cladoceran	0	0	0	0	0	0	0	0	82	0	22	0
Total Cladocera	0	0	0	0	0	0	0	0	82	0	22	0
Temporary Plankton												
Barnacle nauplii	150	31	535	1779	1588	242	1885	806	504	324	105	161
Bivalve larvae	0	0	0	0	0	0	0	0	22	0	0	0
Crab zoea	0	0	0	0	0	0	0	0	0	0	0	0
Gastropod larvae	0	0	0	0	0	0	0	0	0	0	0	0
Polychaete larvae	48	50	27	30	22	32	32	319	82	382	86	486
Other Holoplankton												
Chaetognath	0	0	0	0	0	0	0	0	0	0	0	0
Medusae	0	0	0	0	0	0	0	0	13	85	0	40
Oikopleura	0	0	0	0	0	0	0	0	0	0	0	0
Ostracod	0	0	0	0	0	0	0	0	0	0	0	0
Rotifer	16	0	0	31	28	284	420	1134	1514	1616	542	3563
Tintinnids	0	0	0	0	0	0	0	0	0	0	0	0

4b

Appendix Table . Seasonal changes in zooplankton abundance (no/m3) off Wickford during 1973. Data from Hulsizer (1976). Formulae at the bottom of table indicate how total Acartia copepodites 1-3 were apportioned between A. hudsonica and A. tonsa.

Julian Date	3/26/73 85	4/2/73 92	4/9/73 99	4/16/73 106	4/24/73 114	4/30/73 120	5/7/73 127	5/14/73 134	5/21/73 141	5/28/73 148	6/4/73 155
Copepods											
Acartia hudsonica 1-3, Total	4075	17289	26974.5	17747.5	7404.5	10410	25722.5	14345.5	15676	9421	4478
Acartia hudsonica 4-6, Total	2510	9636	27966.5	18072.5	5419.5	4429	9802.5	13980.5	15162	9563	4126
Acartia hudsonica Total	6585	26925	54941	35820	12824	14839	35525	28326	30838	18984	8604
Acartia tonsa 1-3, Total	0	0	0	0	0	0	0	0	0	0	0
Acartia tonsa 4-6, Total	0	0	0	0	0	0	0	0	0	0	0
Acartia tonsa, Total	0	0	0	0	0	0	0	0	0	0	0
Total Acartia spp.	6585	26925	54941	35820	12824	14839	35525	28326	30838	18984	8604
Centropages hamatus	0	73	298	85	108	0	212	292	0	425	151
Harpacticoid	68	70	56	0	36	170	174	0	0	283	0
Hemicyclops (Saphirella)	0	0	0	0	0	149	0	0	0	0	0
Oithona sp.	386	820	468	156	121	1000	524	146	718	566	553
Parvocalanus crassirostrus	350	334	496	156	0	162	42	0	0	0	0
Pseudocalanus minutus	1351	4154	4644	2240	955	708	1436	2988	616	1557	1558
Pseudodiaptomis coronatus	0	0	0	0	0	0	0	219	923	283	704
Temora longicornis	0	0	142	0	0	241	0	364	0	425	503
Tortanus discaudatus	34	112	198	312	157	206	132	146	718	142	654
Cladocerans											
Evadne sp	0	0	0	0	57	889	3992	805	1247	1785	2384
Podon sp.	0	0	0	0	57	145	1878	434	394	55	179
Cladoceran	0	0	0	0	0	0	0	0	0	0	0
Total Cladocera	0	0	0	0	114	1034	5870	1239	1641	1840	2563
Temporary Plankton											
Barnacle nauplii	0	0	0	0	0	0	0	0	0	0	0
Bivalve larvae	18	73	0	0	0	71	0	4884	3591	1468	2865
Crab zoea	0	0	0	0	0	0	0	0	0	0	0
Gastropod larvae	0	66	0	0	0	128	88	292	0	425	201
Polychaete larvae	121	910	1984	737	676	1261	774	510	821	2973	1257
Other Holoplankton											
Chaetognath	0	0	28	0	0	0	0	0	0	0	100
Medusae	69	700	440	284	0	1318	42	0	0	0	0
Oikopleura	0	0	0	0	0	0	0	0	0	0	0
Ostracod	0	0	0	0	0	20	0	0	0	0	0
Rotifer	3210	8862	21556	12672	5952	1233	132	0	205	0	0
Tintinnids	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 4b. Seasonal changes in zooplankton abundance (no/m3) off Wickford during 1973. Data from Hulsizer (1976). Formulae at the bottom of table indicate how total Acartia copepodites 1-3 were apportioned between A. hudsonica and A. tonsa.

Julian Date	6/11/73 162	6/18/73 169	6/25/73 176	7/2/73 183	7/9/73 190	7/16/73 197	7/24/73 205	8/8/73 220	8/21/73 233	8/27/73 239	9/4/73 247
Copepods											
Acartia hudsonica 1-3, Total	25726	15431	15484	4805.785	939.5419	28.60879	210.3123	0	0	0	0
Acartia hudsonica 4-6, Total	12059	6978	5027	4562	544	122	108	0	0	0	0
Acartia hudsonica Total	37785	22409	20511	9367.785	1483.542	150.6088	318.3123	0	0	0	0
Acartia tonsa 1-3, Total	0	0	0	418.215	13521.46	10613.39	31737.69	417	22	2235	5413
Acartia tonsa 4-6, Total	0	0	0	397	7829	45260	16298	560	20	633	881
Acartia tonsa, Total	0	0	0	815.215	21350.46	55873.39	48035.69	977	42	2868	6294
Total Acartia spp.	37785	22409	20511	10183	22834	56024	48354	977	42	2868	6294
Centropages hamatus	268	722	1910	3306	978	3180	432	3	1	67	0
Harpacticoid	0	120	100	0	0	122	0	0	0	67	0
Hemicyclops (Saphirella)	0	0	0	0	0	0	108	26	26	0	0
Oithona sp.	938	1324	603	860	2283	8563	5073	42	4	500	550
Parvocalanus crassirostrus	0	0	0	0	0	122	0	0	0	67	275
Pseudocalanus minutus	1340	962	804	132	217	612	648	8	0	0	0
Pseudodiaptomis coronatus	3484	481	1206	1322	326	122	0	2	0	0	18
Temora longicornis	268	360	603	198	0	734	216	0	0	0	0
Tortanus discaudatus	1608	120	100	0	0	0	108	0	0	0	0
Cladocerans											
Evadne sp	5459	2392	5027	2116	3806	367	0	0	0	33	0
Podon sp.	169	977	8847	1455	74047	7339	1619	1	0	0	0
Cladoceran	0	0	0	0	0	0	0	0	0	0	0
Total Cladocera	5628	3369	13874	3571	77853	7706	1619	1	0	33	0
Temporary Plankton											
Barnacle nauplii	0	0	0	66	0	0	108	0	0.1	0	18
Bivalve larvae	670	6016	302	132	544	0	0	35	2	300	1321
Crab zoea	0	0	0	0	0	0	0	0	2	0	18
Gastropod larvae	268	120	0	0	109	367	216	44	4	334	0
Polychaete larvae	2278	3128	1408	3108	1631	2202	1187	37	14	2302	110
Other Holoplankton											
Chaetognath	0	0	0	0	0	0	0	0	0	0	0
Medusae	0	0	0	0	0	0	0	0	0	0	0
Oikopleura	0	0	0	0	0	0	0	0	0	0	0
Ostracod	0	0	0	0	0	0	0	0	0	0	0
Rotifer	804	0	0	0	0	0	0	0	0	0	0
Tintinnids	0	0	0	0	0	0	0	0	0	0	0

4b

Appendix Table . Seasonal changes in zooplankton abundance (no/m3) off Wickford during 1973. Data from Hulsizer (1976). Formulae at the bottom of table indicate how total Acartia copepodites 1-3 were apportioned between A. hudsonica and A. tonsa.

Julian Date	9/9/73 252	9/17/73 260	9/24/73 267	10/1/73 274	10/9/73 282	10/15/73 288	10/23/73 296	10/29/73 302	11/5/73 309	11/12/73 316	11/26/73 330
Copepods											
Acartia hudsonica 1-3, Total	0	0	0	0	0	47.81923	1694.29	34.08	419.6614	21.64894	1105.676
Acartia hudsonica 4-6, Total	0	0	0	0	0	30	315	15	753	88	1544
Acartia hudsonica Total	0	0	0	0	0	77.81923	2009.29	49.08	1172.661	109.6489	2649.676
Acartia tonsa 1-3, Total	7798	6500	1171	2370	2878	3285.181	3759.71	1101.92	1476.339	348.3511	463.3241
Acartia tonsa 4-6, Total	1720	1782	1015	588	1136	2061	699	485	2649	1416	647
Acartia tonsa, Total	9518	8282	2186	2958	4014	5346.181	4458.71	1586.92	4125.339	1764.351	1110.324
Total Acartia spp.	9518	8282	2186	2958	4014	5424	6468	1636	5298	1874	3760
Centropages hamatus	115	0	0	0	0	182	175	121	182	153	75
Harpacticoid	0	0	0	36	0	30	0	45	0	0	0
Hemicyclops (Saphirella)	0	1363	742	873	682	2000	1678	303	2961	442	573
Oithona sp.	6766	1940	429	267	758	1030	804	439	208	88	124
Parvocalanus crassirostrus	18922	2412	1015	356	758	1578	1783	697	130	96	75
Pseudocalanus minutus	0	0	0	0	0	0	0	0	52	32	0
Pseudodiaptomis coronatus	115	0	0	0	0	0	0	15	0	0	0
Temora longicornis	0	0	0	0	0	0	0	0	0	0	0
Tortanus discaudatus	0	0	0	0	0	0	0	0	0	0	0
Cladocerans											
Evadne sp	0	52	0	36	212	0	0	61	26	16	349
Podon sp.	0	0	0	18	0	121	0	273	286	153	124
Cladoceran	0	0	0	0	0	0	0	0	0	0	0
Total Cladocera	0	52	0	54	212	121	0	334	312	169	473
Temporary Plankton											
Barnacle nauplii	0	157	39	0	0	91	0	106	0	0	25
Bivalve larvae	4587	891	351	249	1212	1515	664	167	52	8	0
Crab zoea	0	0	39	0	0	0	0	0	0	0	0
Gastropod larvae	229	0	117	107	76	61	35	15	26	0	0
Polychaete larvae	1835	944	390	53	682	485	385	227	1532	88	423
Other Holoplankton											
Chaetognath	0	0	0	0	0	0	0	0	0	0	0
Medusae	0	0	0	0	0	0	0	0	0	0	0
Oikopleura	1720	0	0	0	0	0	35	0	0	0	0
Ostracod	0	0	0	0	0	0	0	0	0	0	0
Rotifer	0	0	0	0	0	0	0	0	0	0	0
Tintinnids	4358	0	0	0	0	0	0	0	0	0	0

Appendix Table 4b. Seasonal changes in zooplankton abundance (no/m3) off Wickford during 1973. Data from Hulsizer (1976). Formulae at the bottom of table indicate how total Acartia copepodites 1-3 were apportioned between A. hudsonica and A. tonsa.

	12/3/73	12/10/73	12/17/73				
Julian Date	337	344	351	Area, 1973	Mean, 1973	Area,, 1973D T=232 Day 64-296	Mean, 1973D T=232 Day 64-296
Copepods							
Acartia hudsonica 1-3, Total	1094	1540	2936	1861511.0	5333.84	1627014.1	7012.99
Acartia hudsonica 4-6, Total	1094	3459	3566	1403241.8	4020.75	1177485.3	5075.37
Acartia hudsonica Total	2188	4999	6502	3264752.8	9354.59	2804499.3	12088.36
Acartia tonsa 1-3, Total	680	227	130	826730.7	2368.86	782628.2	3373.40
Acartia tonsa 4-6, Total	796	480	304	722660.0	2070.66	663881.5	2861.56
Acartia tonsa, Total	1476	707	434	1549390.7	4439.51	1446509.7	6234.96
Total Acartia spp.	3664	5706	6936	4814143.5	13794.11	4251009.0	18323.31
Centropages hamatus	116	50	0	100406.0	287.70	93898.5	404.73
Harpacticoid	33	0	0	10021.5	28.71	9402.0	40.53
Hemicyclops (Saphirella)	149	556	805	97333.5	278.89	50271.5	216.69
Oithona sp.	100	278	109	326540.5	935.65	296138.5	1276.46
Parvocalanus crassirostrus	133	50	22	205163.5	587.86	190964.5	823.12
Pseudocalanus minutus	50	0	22	330326.5	946.49	237305.0	1022.87
Pseudodiaptomis coronatus	0	0	0	64666.0	185.29	64482.0	277.94
Temora longicornis	0	0	0	29778.5	85.33	29687.5	127.96
Tortanus discaudatus	0	0	0	33768.0	96.76	33768.0	145.55
Cladocerans							
Evadne sp	962	1490	43	236121.5	676.57	214396.0	924.12
Podon sp.	298	177	43	705204.0	2020.64	695043.5	2995.88
Cladoceran	0	0	0	728.0	2.09	441.0	1.90
Total Cladocera	1260	1667	86	942053.5	2699.29	909880.5	3921.90
Temporary Plankton							
Barnacle nauplii	66	0	0	60951.0	174.64	9803.5	42.26
Bivalve larvae	16	0	0	221957.0	635.98	218242.5	940.70
Crab zoea	0	0	0	409.0	1.17	409.0	1.76
Gastropod larvae	0	25	0	24812.0	71.09	24252.5	104.54
Polychaete larvae	199	25	87	275816.5	790.31	251231.5	1082.89
Other Holoplankton							
Chaetognath	0	50	0	1246.0	3.57	896.0	3.86
Medusae	0	0	0	20420.0	58.51	20374.5	87.82
Oikopleura	0	0	0	11425.0	32.74	11320.0	48.79
Ostracod	0	25	0	305.0	0.87	130.0	0.56
Rotifer	0	0	0	452059.5	1295.30	433447.5	1868.31
Tintinnids	0	0	0	28327.0	81.17	28327.0	122.10

Appendix Table 5a. Mean annual abundance of zooplankton at Stations A and B. (Frolander, 1955).

Appendix Table 5a. Mean annual abundance of zooplankton (no/m3) in lower West Passage (St B) and SW of Pt Judith (St A). From Frolander (1955). Means were calculated by calculating the integrated area (abund. times days between each sampling interval and then summing over the total study period), and then dividing this by the number of days during the study period. Also shown are the means calculated over the same period as that in the study by Durbin and Durbin (1981).

	Station A T=356 days Mean, 1951	Station B T=358 days Mean 1951	Station A T= 239 days Day 65-304 Mean, 1951D	Station B T= 245 days Day 59-304 Mean 1951D
Copepods (adults only)				
Acartia hudsonica	316.81	1106.17	469.38	1355.97
Acartia tonsa	258.70	872.32	326.27	749.43
Acartia longiremis	3.40	0.14	5.06	0.20
Calanus finmarchicus	16.00	0.22	23.84	0.32
Candacia armata	0.00	0.0	0.00	0.0
Centropages hamatus	226.49	136.07	337.17	195.98
Centropages typicus	13.42	0.58	16.60	0.78
Eurytemora sp.	30.89	40.58	46.01	59.30
Labidocera aestiva	0.53	0.14	0.79	0.20
Metridia lucens	0.83	0.0	1.21	0.0
Oithona sp.	76.28	59.14	86.68	55.13
Oncea sp.	6.67	0.0	9.94	0.0
Pseudocalanus minutus	263.16	180.04	363.95	242.20
Pseudodiaptomus coronatus	0.00	131.86	0.00	154.38
Paracalanus crassirostris	106.34	103.99	94.87	87.56
Paracalanus parvus	0.48	1.18	0.00	0.78
Rhincalanus nasutus	0.02	0.0	0.00	0.0
Temora longicornis	160.10	33.81	237.65	48.56
Tortanus discaudatus	10.86	8.27	16.17	12.09
Harpacticoid spp.	0.0	34.42	0.0	19.70
Cladocera				
Evadne nordmanni	276.93	143.92	410.01	209.87
Evadne spinifera	24.69	0.0	36.77	0.0
Penilia avirostris	547.17	275.09	815.03	401.97
Podon sp.	96.82	170.34	143.67	248.08
Temporary Plankton				
Decapod larvae	13.01	747.69	19.38	1091.31
Balanus larvae	4.07	64.04	3.83	14.20
Gastropod larvae	48.18	291.47	68.67	422.14
Polychaete larvae	0.74	11.46	0.78	11.14
Other Holoplankton				
Oikopleura sp.	60.14	14.11	83.60	19.76
Fritillaria borealis	4.38	0.0	6.53	0.0
Doliolium nationalis	0.10	0.0	0.15	0.0
Chaetognaths	15.23	5.77	17.83	1.42
Obelia sp	19.04	6.04	27.28	8.33
Rathkea octopunctata	2.22	0.36	3.26	0.52
Hydromedusae sp	3.61	0.0	5.37	0.0

Appendix Table 5b. Mean annual abundance of zooplankton at Stations 1 and 3 (Martin, 1965).

Appendix Table 5b. Mean annual abundance of zooplankton (no/m^3) over the period 1959-1962. From Martin (1965). The columns where the station number is followed by a D is the mean calculated for a similar period to that used in the study by Durbin and Durbin (1981).

	St 1 Mean	St 3 Mean	St 1 D Mean T=245 days	St 3 D Mean T=245 days
Copepods (adult only)				
Acartia clausi	950.68	761.10	707.76	1047.76
Acartia tonsa	2670.14	327.12	2612.24	413.47
Centropages hamatus	77.75	194.27	57.43	249.43
Centropages typicus	0.00	36.58	0.00	11.27
Eurytemora herdmanni	20.03	31.81	29.84	47.39
Harpacticus gracilis	0.00	0.00	0.00	0.00
Microsetella norvegica	85.62	921.64	72.24	443.67
Oithona spp.	4314.52	4947.40	4545.31	5652.24
Oithona spinirostris	2.12	25.12	3.16	22.61
Paracalanus parvus	0.00	80.44	0.00	94.08
Pseudocalanus minutus	168.90	952.33	125.31	1098.78
Pseudodiaptomus coronatus	44.30	49.81	34.04	64.33
Temora longicornis	20.00	126.88	16.24	167.71
Tortanus discaudatus	22.58	142.58	22.41	194.65
Cladocerans				
Evadne nordmanni	234.41	145.29	340.53	216.45
Penillia avirostris	0.82	14.55	1.22	21.06
Podon polyphemoides	911.78	153.97	1248.16	223.27
Temporary plankton				
Balanus larvae	118.22	82.81	37.55	31.53
Bivalve larvae	41.37	292.33	0.00	138.78
Decapod larvae	36.30	61.81	54.08	92.08
Gastropod larvae	369.04	292.60	537.55	423.67
Polychaete larvae	356.44	140.21	204.49	90.71
Other Holoplankton				
Chaetognaths	6.56	15.90	6.86	16.31
Dolioletta gegenbouri	0.00	0.00	0.00	0.00
Obelia sp.	17.89	15.88	26.65	23.65
Oikopleura spp.	0.00	81.37	0.00	112.04
Rathkea octopunctata	16.64	0.85	24.80	1.27
Rotifers	1878.08	351.78	2188.57	455.51

Appendix Table 5c. Mean annual abundance of zooplankton at Station 2 during 1972 and 1973 (Hulsizer, 1976).

Appendix Table 5c. Mean abundance of zooplankton (no/m3) during 1972 and 1973 in lower West Passage. From Hulsizer (1976). Means were calculated from the integrated area and the number of days in the study period. Also shown are the means calculated over the same period as that in the study by Durbin and Durbin (1981).

	Mean, 1972	Mean,1973	Mean,1972D T=231 days Day 67-298	Mean, 1973D T=232 Day 64-296
Copepods,copepodites only.				
Acartia hudsonica 1-3,Total	3596.72	5333.84	4523.07	7012.99
Acartia hudsonica,4-6 Total	3976.70	4020.75	3912.60	5075.37
Acartia hudsonica , Total	7573.42	9354.59	8435.67	12088.36
Acartia tonsa 1-3 Total	200.61	2368.86	223.30	3373.40
Acartia tonsa 4-6	134.10	2070.66	90.45	2861.56
Acartia tonsa, Total	334.72	4439.51	334.72	6234.96
Total Acartia spp.	7908.14	13794.11	8749.41	18323.31
Centropages hamatus	99.72	287.70	139.46	404.73
Harpacticoid	10.14	28.71	12.07	40.53
Hemicyclops sp (Sophirella)	50.22	278.89	23.15	216.69
Oithona sp.	355.36	935.65	486.51	1276.46
Parvocalanus crassirostris	51.39	587.86	74.00	823.12
Pseudocalanus minutus	624.52	946.49	795.85	1022.87
Pseudodiaptomus coronatus	126.63	185.29	196.26	277.94
Temora longicornis	81.91	85.33	126.01	127.96
Tortanus discaudatus	32.78	96.76	50.47	145.55
Total Copepods	9340.82	17226.78	10653.20	22659.17
Cladocera				
Evadne sp	167.57	676.57	259.70	924.12
Podon spp.	262.34	2020.64	406.57	2995.88
Cladoceron	5.36	2.09	3.14	1.90
Total Cladocera	435.27	2699.29	669.40	3921.90
Temporary Plankton				
Barnacle larvae	100.56	174.64	67.15	42.26
Bivalve larvae	143.94	635.98	219.81	940.70
Decapod larvae	3.74	1.17	5.80	1.76
Gastropod larvae	13.67	71.09	20.53	104.54
Polychaete larvae	620.49	790.31	929.73	1082.89
Other				
Chaetognath	0.34	3.57	0.46	3.86
Medusae	11.18	58.51	17.32	87.82
Oikopleura	0.17	32.74	0.26	48.79
Ostracod	0.00	0.87	0.00	0.56
Rotifer	720.14	1295.30	1011.94	1868.31
Tintinnids	0.00	81.17	0.00	122.10

Z-A. hud 1-3,4-6 est = (Z. A. hud. All)/2

A. hud 1-3 est=(A. hud 4-6)/((A. hud 4-6) + (A. ton 4-6))* (A. spp. 1-3)

A. tonsa 1-3 est = (A. ton. 4-6)/((A. hud 4-6) + (A. ton 4-6))* (A. spp. 1-3)

Appendix Table 6. Seasonal changes in zooplankton biomass in Narragansett Bay (Kremer and Nixon, 1978).

Appendix Table 6. Zooplankton dry weights (gm/m3) in Narragansett Bay during 1972-1973. Data from Kremer and Nixon (1978). Means were calculated by adding 1972 data after 1973 data and then integrating between 2/28/73 and 11/13/72 to provide a time period similar to that used in the study by Durbin and Durbin (1981).

DATE	JULIAN DATE	STATION NO. 3	4	5	6	7	8	9	10	11	12	13	14	15
7/26/72	208	0.028	0.221	0.143	0.131	0.144	0.208	0.244	0.115	0.09	0.113	0.149	0.118	0.037
8/8/72	221	0.109	0.066	0.052	0.076	0.113	0.166	0.043	0.088	0.138	0.076	0.065	0.064	0.041
8/22/72	235	0.152	0.288	0.084	0.048	0.094	0.094	0.14	0.078	0.064	0.063	0.098	0.027	0.049
9/6/72	250	0.026	0.039	0.046	0.013	0.024	0.041	0.03	0.027	0.066	0.037	0.058	0.037	0.022
9/27/72	271	0.069	0.105	0.08	0.055	0.031	0.028	0.076	0.053	0.211	0.087	0.051	0.039	0.058
10/11/72	285	0.055	0.122	0.029	0.067	0.073	0.063	0.084	0.128	0.178	0.115	0.091	0.025	0.048
10/26/72	300	0.02	0.023	0.028	0.018	0.01	0.021	0.141	0.062	0.074	0.064	0.032	0.029	0.029
11/13/72	318	0.047	0.061	0.059	0.039	0.045	0.051	0.023	0.086	0.045	0.044	0.046	0.031	0.039
12/7/72	342	0.049	0.063	0.075	0.031	0.052	0.039	0.071	0.041	0.039	0.062	0.019	0.021	0.018
12/20/72	355	0.035	0.038	0.066	0.05	0.058	0.084	0	0	0	0	0.106	0.064	0.046
1/5/73	5	0.041	0.075	0.062	0.052	0.051	0.058	0.06	0.024	0.034	0.03	0.015	0.043	0.025
1/18/73	18	0.064	0.073	0.156	0.07	0.096	0.071	0.036	0.026	0.03	0.035	0.036	0.047	0.056
2/1/73	32	0.073	0.055	0.061	0.076	0.164	0.058	0.055	0.034	0.025	0.046	0.064	0.051	0.058
2/8/73	39	0.055	0.128	0.071	0.078	0.077	0.061	0.14	0.095	0.027	0.092	0.052	0.051	0.05
2/14/73	45	0.034	0.069	0.088	0.069	0.134	0.088	0.284	0.097	0.041	0.072	0.077	0.101	0.09
2/23/73	54	0.049	0.045	0.094	0.331	0.255	0.284	0.258	0.083	0.034	0.051	0.102	0.236	0.105
2/28/73	59	0.097	0.035	0.082	0.064	0.162	0.096	0.051	0.04	0.035	0.029	0.065	0.109	0.088
3/7/73	66	0.101	0.219	0.178	0.15	0.129	0.112	0.057	0.064	0.068	0.042	0.065	0.092	0.103
3/14/73	73	0.022	0.061	0.045	0.043	0.14	0.032	0.046	0.026	0	0	0.059	0.068	0.065
3/21/73	80	0.023	0.067	0.091	0.078	0.117	0.092	0.046	0.014	0.017	0.014	0.025	0.069	0.067
3/28/73	87	0.033	0.092	0.068	0.033	0.063	0.033	0.033	0.083	0.021	0.04	0.052	0.044	0.064
4/11/73	101	0.037	0.149	0.152	0.091	0.134	0.214	0.213	0.061	0.034	0.025	0.106	0.147	0.067
4/18/73	108	0.087	0.184	0.156	0.141	0.178	0.1725	0.229	0.122	0.059	0.061	0.099	0.143	0.096
4/25/73	115	0.144	0.313	0.171	0.171	0.194	0.131	0.245	0.183	0.084	0.097	0.092	0.14	0.125
5/9/73	129	0.141	0.588	0.382	1.064	0.447	0.43	0.062	0.068	0.088	0.046	0.098	0.332	0.258
5/23/73	143	0.283	0.151	0.159	0.267	0.207	0.117	0.101	0.093	0.075	0.091	0.113	0.093	0.112
6/6/73	157	0.235	0.343	0.221	0.177	0.154	0.11	0.119	0.178	0.094	0.117	0.147	0.102	0.206
6/20/73	171	0.303	0.358	0.31	0.198	0.341	0.184	0.102	0.22	0.152	0.155	0.179	0.226	0.227
7/5/73	186	0.141	0.133	0.169	0.159	0.2	0.146	0.121	0.075	0.132	0.096	0.068	0.055	0.088
7/17/73	198	0.442	0.293	0.492	1.202	0.62	0.98	0.677	0.401	0.111	0.116	0.262	0.234	0.153
8/1/73	213	0.218	0.073	0.117	0.042	0.055	0.156	0.095	0	0.06	0.087	0.129	0.084	0.102
AREA		39.83	54.89	47.82	62.03	52.58	51.55	43.21	32.52	27.82	24.55	30.69	32.63	30.28
MEAN		0.107	0.148	0.129	0.167	0.142	0.139	0.116	0.088	0.075	0.066	0.083	0.088	0.082