NBP-90-28

<u>The Benthic Communities Within Narragansett Bay</u>

94 pp + Appendices A & B 103 pp

Appendix C available in office only

Frithsen (URI)

Narragansett Bay Estuary Program

Current Report

The Narragansett Bay Project

THE BENTHIC COMMUNITIES WITHIN NARRAGANSETT BAY

An Assessment Completed for the Narragansett Bay Project

Report #NBP-90-28

Jeffrey B. Frithsen
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Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882-1197

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The Narragansett Bay Project is sponsored by the U.S. Environmental Protection Agency and the R.I. Department of Environmental Management.

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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.

EXECUTIVE SUMMARY

This final report is a compilation and synthesis of benthic data sets pertaining to Narragansett Bay, Rhode Island. The specific goals of this report are: 1) to present a list of published and unpublished data sets describing the benthic communities within Narragansett Bay, 2) to assess the usefulness of each data set and identify data sets which should be archived in a computerized data base for the bay, 3) describe the spatial and temporal trends in benthic community composition, abundance, and biomass, and 4) comment upon the role of benthic communities in Narragansett Bay. The first two goals of this report are addressed in the report appendices, which are separately bound.

Approximately 30 data sets describing benthic communities within the bay were identified. Some date back to 1950; most were completed in the 1970's and 1980's. Comparisons between data sets were difficult due to many methodological differences. At least 12 different sampling methods and 8 different sieve sizes were used to collect and separate benthic organisms from sediments.

Benthic communities within Narragansett Bay are diverse. For all studies, 546 species or species groups were identified, although name changes over the past 40 years meant that some species were included in the list more than once. Species diversity was generally lowest in the Providence River and increased towards the mouth of the bay. Opportunistic species dominated the macrofaunal assemblages in the Providence River and upper bay. Macrofaunal abundances were lowest and populations more patchy in the Providence River compared to the remainder of the bay. Gradients in the bay to some extent reflect the distribution of contaminants found in the water column and sediments.

The benthic communities in many areas of the bay have never been adequately sampled. Seasonal trends are known for few regions since most studies sampled only once. Temporal dynamics are best known from the mid bay region where both macrofauna and meiofauna showed similar seasonal cycles with peak abundances usually in the late spring, and low abundances in the late summer. The temporal dynamics of benthic fauna, and information on the production, fate, and storage of phytoplankton detritus, suggest that mid bay benthic communities may be food limited in summer months. Experiment conducted in mesocosms support this view.

Metazoan benthic communities represent the largest living pool of carbon in the bay, overshadowing that of any other consumer group. Their respiration rates are roughly equivalent to 30% of the bay's annual primary production.

Although long-term trends are difficult to define due to methodological differences, evidence suggests that benthic communities in the mid bay region have changed during the past 30 years. What was previously described as a <u>Nephtys</u> - <u>Nucula</u> community, is now a <u>Mediomastus</u> - <u>Nucula</u> community. This change may indicate greater organic enrichment in the mid bay region since <u>Mediomastus</u> has been shown to increase abundance in response to organic enrichment.

Future studies of the benthic communities within Narragansett Bay should be conducted using standardized methods so as to avoid the problems faced comparing past data sets. Diver collected cores should be taken if at all possible and 300 um sieves should be used. Effort should be made to continue sampling in the mid bay region north of Conanicut Island to further build upon a benthic data set extending back to 1957. Efforts should also be made to start other long-term benthic sampling stations in the upper bay and in Rhode Island Sound.

In addition to the basic descriptive approaches of defining benthic species composition and abundance, energetic and mechanistic studies should also be undertaken. Biomass measurements need to be made over several annual cycles and direct measurements should be made of benthic secondary production. Finally, more information is needed concerning how benthic communities affect the fate of contaminants and the dynamics of plankton communities in the bay.

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INTRODUCTION

Narragansett Bay is one of the most well studied estuaries in the world. The reason for its popularity as a research subject stems from the bay's importance as a recreational and commercial resource and its proximity to academic institutions having active research programs (Brown University and the University of Rhode Island). In a now nearly 10 year old bibliography on the bay (Dunn et al. 1979), over 1700 journal articles, technical reports, dissertations and theses were detailed. Since then, an unknown number of additional publications have appeared.

Despite all this attention, no detailed analysis and synthesis of what is known about Narragansett Bay has been published. Past syntheses have focused upon specific approaches towards understanding the bay, such as numerical modeling (Nixon and Kremer 1977; Kremer and Nixon 1978). Other syntheses were written for a non-technical audience (Olsen et al. 1980; Hale 1980), or were limited with respect to geographic coverage or breadth of subject matter (Olsen and Lee 1979). Clearly what is needed is a synoptic, thorough summary of the Narragansett Bay ecosystem - where it is now and an historical perspective on how it has changed.

In late 1986, a loosely knit group of faculty, staff and students from the Graduate School of Oceanography, University of Rhode Island, began work to characterize the Narragansett Bay ecosystem. The group, referred to as the Narragansett Bay Associates, was funded by the EPA-sponsored Narragansett Bay Project to assess the current and historical status of the bay's water quality (including nutrients, dissolved oxygen, heavy metals, and certain organic pollutants) and living resources (phytoplankton, zooplankton and benthic fauna). This is the report of the benthic working group of the Narragansett Bay Associates.

The objectives of the benthic working group were to describe the existing benthic communities within Narragansett Bay and document changes that have occurred to those communities since the industrial revolution. The specific goals were as follows:

(1) Compile a list of published and unpublished data sets describing benthic communities.

(2) Evaluate the quality and usefulness of those data sets and enter selected data sets into a computer data base.

(3) Describe spatial and temporal trends in benthic community composition, abundance, and biomass.

(4) Comment upon the role of benthic communities within the Narragansett Bay ecosystem.

The first two goals are addressed mainly in the appendices; benthic community descriptions and analyses are given in the main body of the report. General descriptive information was found for many areas of the bay, but other areas remain to be explored. Temporal descriptions cannot be given for most regions since many data sets contain one sampling date only. Unfortunately, any descriptions of long-term changes to the benthic communities of the bay must rely on largely anecdotal information.

Project Scope:

Narragansett Bay is geologically a sedimentary environment (McMaster 1960). Consequently, the scope of this project focused upon soft-bottom (mud, silts, sand) benthic communities. Hard bottom communities, occurring mainly at the bay's fringes, were not analyzed. The northern-most extent of the project was located in the Seekonk River, opposite the Brown University Boat Club. The southern most extent was Rhode Island Sound. Except for those data collected by Marine Resources, Inc., for the Brayton Point Power Plant, Mt. Hope Bay was included in the project. Marine Resources, Inc., data were excluded because at the commencement of the project, plans were underway to have those data analyzed by separate contract. The Sakonnet River was included in the Project.

Unless otherwise stated, in this text the term "macrofauna" refers to organisms retained on sieves having mesh sizes 300 um or greater. Macrofauna include such groups as polychaetes (the majority of macrofauna in Narragansett Bay), bivalves, gastropods, and various crustaceans. The term "meiofauna" refers to organisms that pass through 300 um sieves. Common groups of meiofauna are nematodes (the most dominant group), harpacticoid copepods, and foraminifera.

NARRAGANSETT BAY

To set the stage for the discussion of the benthic communities within Narragansett Bay, the following general description of the bay is offered. Due to its brevity, the description is by no means a synoptic review of the bay as a complex ecosystem. No doubt, certain topics may not be developed which may be of paramount importance to others. Nonetheless, this brief description provides important background to the analysis of benthic communities which follows.

Physical Description:

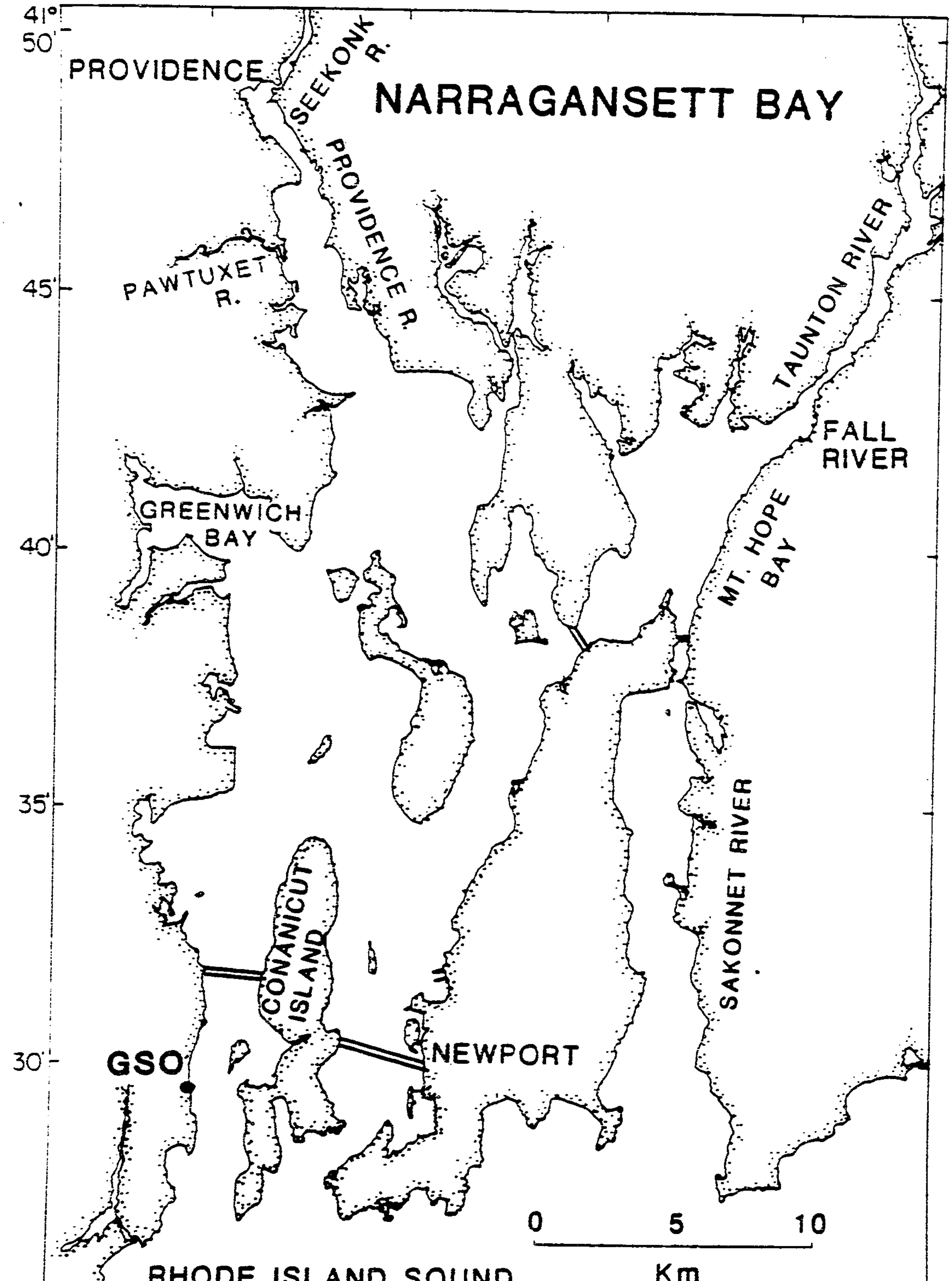
Narragansett Bay (Figure 1) is generally described as a temperate, shallow-water, well-mixed estuary. Temperatures moderate between -0.5 to 24 °C annually (Kremer and Nixon 1978). Physical dimensions reported for the bay vary greatly due to the use of different boundary definitions. Including Mt. Hope Bay and the Sakonnet River, the bay is 45 km long running approximately north to south, is about 18 km wide at its widest point, has an area of 342 km^2 (Chinman and Nixon 1985), a mean depth of 7.8 m (Chinman and Nixon 1985), and a drainage basin of 4,836 km^2 (Pilson 1985). Water residence time in the bay is driven by fresh water input. The long-term average fresh water input of 105 m^3/s brings about a mean water residence time of 26 d (Pilson 1985).

Although a well-developed horizontal salinity gradient has been shown for the north-south axis of the bay (Hicks 1959), fairly small (generally less than 2 ppt according to Pilson 1985) vertical gradients exist throughout most of the bay. It is these small vertical salinity gradients that have led investigators to describe Narragansett Bay as being well mixed (Kremer and Nixon 1978), or partially mixed (Weisberg and Sturges 1976). Vertical stratification can be more pronounced at particular times of the year at the most southern border of the bay (Rhode Island Sound - Shonting and Cook 1970) and at it northern reaches (Providence River - Doering et al. 1988).

Geologically, the bay is young. What was only a series of streams over 10,000 years ago became Narragansett Bay when the last great continental glaciers retreated and global sea level rose (McMaster 1984). Thus, the bay is comprised of a series of drowned river valleys. Surface sediments are mostly clayey silt and sand-silt-clays with sand being important in some areas (McMaster 1960). Finer sediments dominate the upper bay and poorly sorted sands are found at the mouth.

Mixing within the bay is accomplished primarily by the interaction of the wind and tides (Levine 1972; Weisberg and Sturges 1973; Gordon and Spaulding 1987). Wind patterns are seasonal, with predominantly northwest winds in the winter and southwest winds during the summer (Nixon and Kremer 1977). Tides are semidiurnal with an average range of 1.1 m, slightly more at the head. The tidal prism is 13% of the mean volume - over 250 times the mean total river flow during a tidal cycle (Kremer and Nixon 1978).

Figure 1



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

Biological Description:

Narragansett Bay is a phytoplankton-based ecosystem. Most consumers within the bay depend upon the production of microscopic plants (phytoplankton) within the water. Little energy is gleaned from production by fringing macroalgae (seaweeds), sea grasses (Zostera) and marshes.

The average primary production of the bay's phytoplankton is variously reported as 269 g C m^{-2} y^{-1} (Oviatt et al. 1981), 308 g C m^{-2} y^{-1} (Furnas et al. 1976) and 220 g C m^{-2} y^{-1} (Smayda 1973). Production tends to be higher at the head of the bay than at the mouth (Oviatt et al. 1981), most likely a result of nutrient enrichment from sewage discharges. Specific phytoplankton communities have been described by Smayda (1957, 1973), Pratt (1959, 1965) and Karentz and Smayda (1984). Typically, large phytoplankton blooms are seen in the winter and early spring, with shorter blooms occurring in the summer. However, intense blooms can occur at any time during the year (Hinga et al. 1988).

Zooplankton are thought to be the most important consumers of the phytoplankton. The zooplankton community is generally dominated by populations of Acartia hudsonica (formally Acartia clausi) in the winter and Acartia tonsa in the summer. Biomass is usually greatest in early summer (Kremer and Nixon 1978) and tends to be larger in the upper bay (Durbin and Durbin 1981). Annual zooplankton production has not been estimated but daily production rates range from 7.25 (A. hudsonica in the west passage) to 22.9 (A. tonsa in the upper bay) mg C m^{-3} d^{-1} (Durbin and Durbin 1981).

Benthic communities within the bay are heterotrophic and dependent upon material produced by phytoplankton in the overlying water column. Production at the sediment surface by autotrophs is thought to be minor and restricted to shallow regions and periods when light attenuation in the water column is minimal. However, no direct measurements of benthic autotrophy have been made for the sediments in Narragansett Bay. This is a subject that deserves consideration in future studies.

Phytoplankton material reaches the sediments through one of three major mechanisms: direct sedimentation, sedimentation after ingestion by consumers in the water column (fecal pellet transport), and through the feeding activities of benthic animals. The magnitude of each of these mechanisms is not known and the total amount of phytoplankton reaching the sediments has not been directly measured. Sediment traps, which are commonly used to measure sedimentation, are not helpful because recently resuspended material from the sediment surface overwhelms newly settled material (Oviatt and Nixon 1975) and newly settled material includes both phytoplankton detritus and terrigenous matter (both organic and inorganic). Estimates of net total sedimentation in the bay are variable and much disputed (Table 1).

The amount of phytoplankton detritus reaching the sediments within the bay has been estimated indirectly from measurements of benthic metabolism (Nixon et al. 1976; Nixon 1981). Little if any of phytoplankton-produced organic carbon and nutrients is

Table 1
Net Sedimentation In Narragansett Bay

Area	Rate (mm/yr)	Reference
Entire Bay	1.6 - 2.2	McMaster 1984
Entire Bay	0.3	Santschi et al.1984
Entire Bay	1.0	Farrington 1971
Upper Bay	10	Goldberg et al. 1977
Upper Bay	1.7	Santschi 1980
Ohio Ledge	5	Santschi et al. 1984

stored in the sediments from one annual cycle to the next, although short-term storage may be significant, particularly in the spring (Rudnick and Oviatt 1986). Without storage, the organic carbon and nutrients reaching the sediment must be released back to the overlying water column. This release is accomplished by the metabolic activities of benthic communities and, ignoring dissolved organic forms, is mainly in the forms CO_2, NH_3, NO_3 and PO_4. Benthic oxygen metabolism can account for approximately 40% of primary production in the bay, assuming negligible benthic autotrophy and using a respiratory quotient (RQ) of 1 to convert oxygen to carbon equivalents. This implies that around 40% of the phytoplankton in the bay reaches and is processed by sediment communities.

It is not known whether it is this supply of organic material from the water column, or disturbance and predation by predators, that limits and structures the benthic communities within Narragansett Bay. Both factors - food supply and predation - probably influence community structure, but which is more important, and when, is not known. Recent work (Whitehouse, Unpublished) will contribute to an understanding of the effects of predation, whereas experiments in mesocosms (Frithsen et al. 1989; Frithsen et al. 1985) will lead to a better understanding of the food limitation question. This ongoing work will be touched upon in subsequent sections of this report.

BENTHIC DATA SETS

History:

Qualitative descriptions of Narragansett Bay benthic communities are available from before the turn of the century (R.I. Commission of Inland Fisheries 1899). However, truly quantitative descriptions, such as those pioneered by Petersen (1911) working in Danish waters, were not completed in the bay until the early 1950's.

The first quantitative sampling of the Narragansett Bay benthos was done by Allen Stickney and Louis Stringer of the U.S. Fish and Wildlife Service, in 1951 and 1952 (Stickney and Stringer 1957) (Table 2). This work was limited to Greenwich Bay and was aimed at understanding the distribution of the hard clam (Mercenaria mercenaria, then Venus mercenaria) as related to the occurrence of other macrobenthic species. Stickney and Stringer were unable to identify specific benthic communities favoring Mercenaria, but were able to show the hard clam was less abundant in muds, a conclusion also shared by Pratt (1953) studying the distribution of Mercenaria throughout Narragansett Bay. Pratt's samples were taken in 1949 to 1950 and analyses were restricted to Mercenaria and Pitar morrhuana (then Callocardia morrhuana).

At about the same time Stickney and Stringer were sampling Greenwich Bay, Said (Said 1951), then a graduate student at the University of Rhode Island, was studying the distribution of benthic foraminifera. This was the first formal study of meiofaunal organisms in the bay. Said found that salinity was the major factor determining the distribution of forams and identified two distinct communities, one associated with saline water and one associated with brackish water. Interestingly, Said sampled no further north than Conimicut Point. What he called brackish water was probably at least 20 ppt.

Following these studies, the bay's benthos wasn't again sampled until 1957 (Phelps 1958). In this study, the abundance of dominant macrofauna at 22 stations was related to physical and chemical parameters such as water depth, sediment grain size, and percent organic matter. Phelps found that sediment grain size and the percent organic matter were the most important factors determining the distribution of benthic species within the bay. This study is frequently cited and remains one of the key descriptions of the benthic communities in Narragansett Bay.

Benthic communities were next studied by two students completing masters degrees in the Department of Geology at Brown University (McGetchin 1961; Crowley 1962). Both studies focused upon the occurrence in sediments of shelled benthic fauna (bivalves and gastropods). It is unclear to what abundance in these studies refer since it appears no preservative agents were used and no distinctions were made between material that was living or dead at the time of collection. However, these studies did continue in the same genre as Phelps (1958) looking at relationships between the abundance of dominant macrofauna and various sediment parameters.

Table 2
History of Benthic Studies in Narragansett Bay

Study	Period of Study	General Location
Stickney and Stringer 1957	1951 - 1952	Greenwich Bay
Said 1951	1950	Bay wide
Phelps 1958	1957	Bay wide
McGetchin 1961	1960	South of Warwick Point
Crowley 1962	1961	East Bay
Chowder and Marching 1967	1967	Bay wide
Davis, Unpublished	1969 - 1973	West Passage
Pratt 1972	1970	Providence River
Marine Resources, Inc.	1972 - Present	Mt. Hope Bay
Hale 1974	1974	West Passage
Hoff and Moss 1976	1975	Providence River Apponaug Cove Greenwich Bay
Myers and Phelps 1978	1975 - 1976	Bay wide
Pratt and Bisagni 1976	1975	Providence River Upper Bay
Pratt 1977a	1976	Taunton River
Pratt 1977b	1976	Quonset-Davisville
Grassle et al. 1985	1976 - 1980	Conanicut Point
Oviatt et al. 1977	1977	Brushneck Cove
Rudnick 1984	1977 - 1980	Conanicut Point
Hyland 1981	1977 - 1978	Conanicut Point
Pratt and Seavey 1981	1980	Apponaug Cove
Frithsen, Unpublished B	1981	Seekonk River
Hughes, Unpublished	1983 - 1986	Conanicut Point
City of Newport 1985	1984	Lower East Passage
Frithsen, Unpublished A	1986	Greenwich Bay

In 1967, a group of students at the Graduate School of Oceanography set about to study the bay (Chowder and Marching Society 1967). Numerous chemical and biological variables including macrofaunal abundance were measured at five stations along a single transect from Gaspee Point in the Providence River to Whale Rock at the mouth of the west passage. These results are parochially referred to as the "Jiffy Cruise" results. Benthic samples from the Jiffy Cruise were collected and analyzed by Mr. Sheldon Pratt, then a student at the Graduate School of Oceanography, University of Rhode Island, and later one of the recognized authorities on benthic communities within the bay. Like Phelps

(1958), Pratt concluded that the distribution of benthic communities was related to sediment grain size.

A record number of studies focused upon benthic communities during the 1970's followed by a decline in interest in the 1980's (Table 2). In the 1980's, fewer benthic studies were initiated. Many of the benthic studies in the 1970's and 1980's were 'reactionary', in that they were done in reaction to a proposed, or actual, activity that could potentially impact the bay. These activities, and the studies they sparked, were: the proposed citing of a power plant at Rome Point (Davis, Unpublished), dredging of the Providence River (Pratt 1972; Pratt and Bisagni 1976), monitoring for effects of discharges from the Brayton Point power station in Mt. Hope Bay (Marine Resources, Inc.), dredging of the Taunton River (Pratt 1977a), proposed dredging of Brushneck Cove (Oviatt et al. 1977), development at Quonset and Davisville (Pratt 1977b, 1985), development of Apponaug Cove (Pratt and Seavey 1981), proposed discharges into the Seekonk River by the Hunt Chemical Company (Frithsen, Unpublished B), and application for a 301h waiver for the City of Newport (City of Newport 1985). The studies conducted by Marine Resources, Inc. in Mt. Hope Bay were the first to use efficient coring methods (diver collected cores) and small sieve sizes (500 um sieves) to assess macrofaunal abundance.

In addition to these reactionary, or directed studies, the 1970's was also a time when some of the better, and consequently more often cited, benthic studies were started. As part of a study of benthic metabolism and nutrient regeneration (see Nixon et al. 1976), Hale (1974) measured benthic abundance and biomass at three stations in the west passage. In this study, three distinct community types were defined which are still used in general descriptions of the Narragansett Bay benthos. Those community types were: an Ampelisca dominated community found at the mouth of Greenwich Bay, a Nephtys - Nucula community found north of Conanicut Point, and a Mercenaria dominated community in the lower bay. Hale's study (Hale 1974) was the first benthic study in the bay to measure macrofaunal biomass. Unfortunately, very few biomass numbers have been collected since.

In 1975, Myers and Phelps (1978) started a year-long study of benthic communities at six stations in the bay from Gaspee Point to north of Conanicut Point. Since this study, there have been no bay-wide studies of benthic fauna. Subsequent studies (Grassle and Grassle 1984; Grassle et al. 1985; Hyland 1981; Rudnick 1984; Hughes, Unpublished) have concentrated upon the benthic communities in mid Narragansett Bay between Hope and Conanicut Islands. These studies span the period 1977 to 1986, with some gaps in the early 1980's. Were it not for the work of Hughes, an unfunded graduate student, work at the mid bay site would have been discontinued in the early 1980's.

There exists few ongoing studies of the benthic communities within Narragansett Bay. These studies are being completed by graduate students at the Graduate School of Oceanography, University of Rhode Island, with much of the work being unfunded. Paul Fofonoff is studying the occurrence of benthic larvae in the plankton of the bay. Much of this work is unpublished, but a limited data set was presented in Smayda (1987). Sandra Thornton Whitehouse is studying the ecology of the epibenthic shrimp Crangon septemspinosa. This study has been supported in part with small grants from NOAA and the Rhode Island Sea Grant Program, but results remain unpublished. Nancy Craig is completing a thesis on the growth of the small nut shell Nucula annulata. This study also has been partially supported by NOAA. Unlike that for phytoplankton (Karentz and Smayda 1984) and demersal fish (Jeffries and Johnson 1974; Jeffries and Terceiro 1985; Jeffries et al. 1986), there is no long-term monitoring of benthic communities in Narragansett Bay.

Table 3
Sources of Funding for Benthic Studies

U.S. Environmental Protection Agency	5
Army Corps of Engineers	3
NOAA and Sea Grant	2
U.S. Fish and Wildlife Service	1
Department of Marine Resources - URI	1
City of Newport, Rhode Island	1
Hunt Chemical Company	1
Gordon R. Archibald, Consultant	1
Applied Science Associates	1
Robinson Green Beretta Corporation	1
New England Light and Power	1
Unfunded Studies	4
Funding Sources Unknown	4

Data Set Comparisons:

The benthic data sets for Narragansett Bay were collected over nearly a 40 y period by many investigators, each having specific goals and objectives. To some extent, the objectives of the benthic studies reflect their sources of funding (Table 3). Many of the benthic studies concerned with dredging effects, for example, were directly funded by the Army Corps of Engineers (Pratt 1977a, Pratt and Bisagni 1976). Environmental impact studies (Marine Resource, Inc.; Frithsen, Unpublished B; City of Newport 1985) were funded directly by those proposing new activities that could affect the Bay. In all, benthic studies have been funded by 11 agencies or companies (Table 3). Of 26 data sets considered, four were essentially unfunded and sources of funding could not be discovered for another four. The EPA has funded the greatest number of benthic studies in Narragansett Bay.

Unsurprisingly, many different methods were used in these benthic studies. For example, 12 different sampling methods have been used (Table 4) and fauna enumerated using eight different sieve sizes (Figure 2). At the time, the methods used were probably adequate to meet the objectives of the studies within which they were used and were

Table 4
Sampling Methods Used In Benthic Studies

Type	Number of Studies
Diver or Hand Collected Cores	9
Smith-McIntyre Grab	5
Van Veen Grab	3
Eckman Dredge	3
Clamshell Bucket Dredge	2
Ponar Grab	2
Modified Petersen Grab	2
Remote Flow-through Corer	1
'Gas Can' Corer	1
Box Corer	1
Grab (not specified)	1
Forester Anchor Dredge	1
Orange Peel Grab	1

Note: Some studies used more than one collection method.

accepted by the scientific community. However, the use of non-standard methods makes comparisons between data sets difficult. This problem is explored in more detail below.

The problems encountered when comparing data collected using different sampling methods and sieve sizes, and even the problems sometimes faced when comparing similarly collected data generated by different investigators, are well known to benthic ecologists. The detail given below is not presented to show what has become generally known. Rather, the details are given to help define, using specific data sets from Narragansett Bay, the degree of variation introduced by using different sampling methods, or sieve sizes. Only when this variability is defined can various data sets be compared to attempt to identify spatial or temporal trends in the bay.

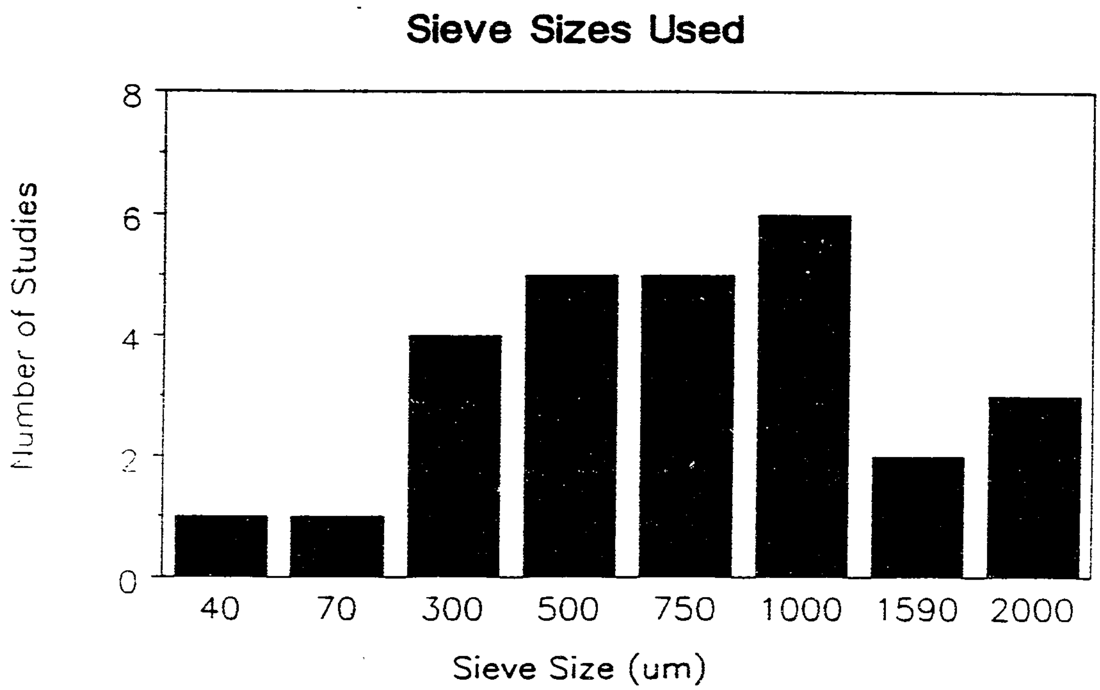
Sources of Variation Between Data Sets:

Sieve Size:

The size of the sieves used to extract organisms from the sediment in which they live profoundly affects the abundance recorded for a sample (De Bovee et al. 1964). Direct evidence for this comes from those studies that have used nests of sieves to fractionate organisms by size. Indirect evidence can be seen in comparisons of different data sets produced using different sieve sizes.

Few investigators have used groups of sieves to size fractionate benthic organisms. In those that have (Grassle et al. 1985; Hughes, Unpublished; Frithsen, Unpublished A; Rudnick 1984), the data show that finer sieves retain more organisms. For example, if all of the data of Hughes (Unpublished) are considered, and variation between stations and

Figure 2



seasons are ignored, about 35% of all macrofauna found were captured by using a 500 um sieve with an additional 65% captured on a 300 um sieve (Figure 3). The difference is more dramatic for certain species. For example, 71% of all Polydora ligni were found on the 300 um sieve. Clearly, use of a 500 um sieve instead of a 300 um sieve may miss as much as, and maybe more than, 50% of all macrofauna. The error would be greater with courser sieves and somewhat dependent upon the particular species being considered.

Meiofaunal data sets provide further examples of the utility of using finer sieves. Figure 4 shows the size distribution of meiofauna in a core from the Providence River. The 300 um sieve retained only 1% of the meiofauna in that core, with most passing through the finer 200 and 100 um sieves. Sixty one percent of all meiofauna were caught on the 40 um sieve. Use of a 20 um sieve has been shown to increase total meiofaunal abundance further by about 6% (Frithsen 1984).

Figure 3: Macrofaunal size distribution (Hughes, Unpublished). Percent of total abundance found on 300 and 500 um sieves. Group a: Total macrofaunal abundance. Group B: Abundance of Polydora ligni.

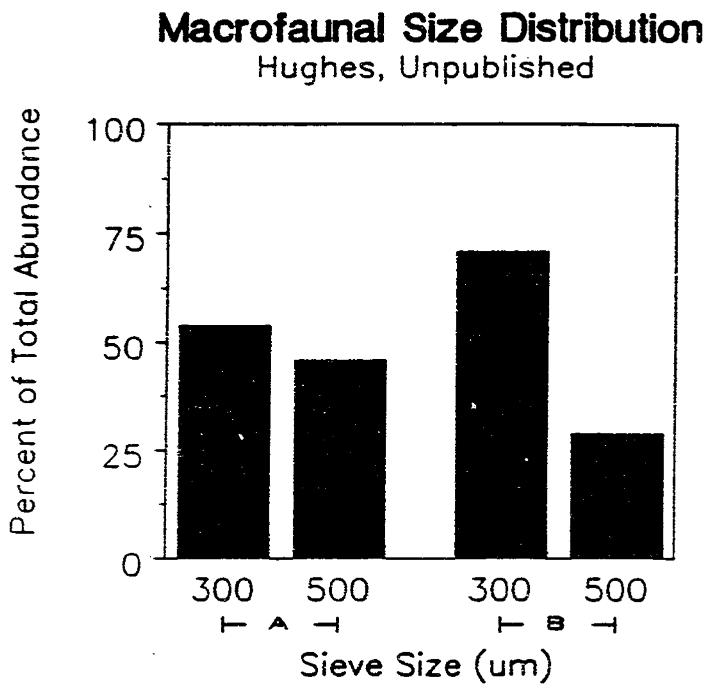
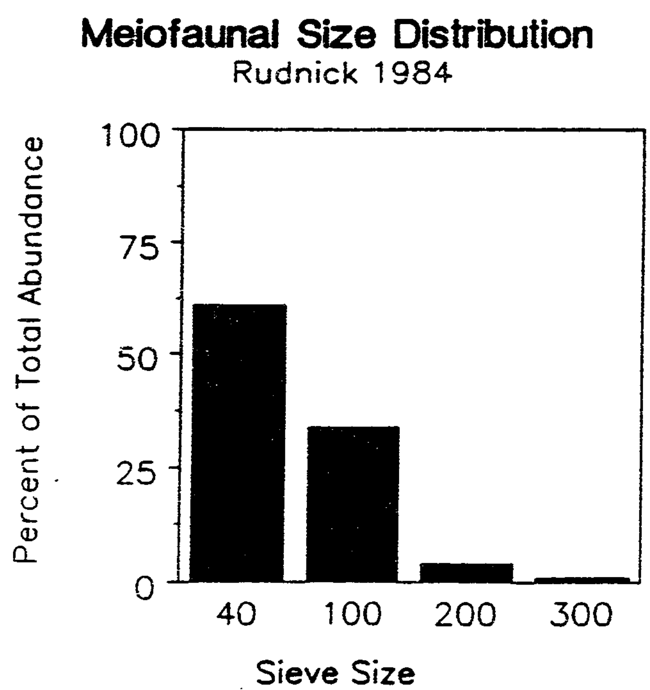


Figure 4: Meiofaunal size distribution (Rudnick 1984). Percent of total abundance found on 40, 100, 200, and 300 um sieves.



Indirect evidence for the effects of sieve size comes from comparing various studies that have used different sieve sizes. These comparisons are not completely valid since other factors (sample collection and sorting methods, investigator biases, etc.) also may differ, but the comparisons do further illustrate the problems of comparing the benthic data sets available for Narragansett Bay.

In order to separate the effect of different sampling methods from the effect of sieve size, we need to look for areas of the bay that have been sampled by investigators using the same methods, but employing different sieve sizes. One such areas lies between the mouth of Greenwich Bay and just north of Conanicut Island (Figure 5). This area has been sampled using a Smith-McIntyre grab during three studies over a ten year period (Chowder and Marching 1967; Hale 1974; Pratt 1977b). Abundances were different (Figure 6) between these studies, but not dramatically so. Abundances were 2 to 4 times greater in the study using a 750 um sieve, compared to those using a 1000 um sieve.

A more dramatic difference is apparent from comparison of two studies that employed diver collected cores in the area between Hope and Conanicut Islands. Myers and Phelps (1978) sampled during the period 1975 to 1976 and used a 500 um sieve. The average macrofaunal abundance at their Station 1 was 4,240 individuals/m^2. Just two years later (1977 to 1978), Hyland (1981) sampled a site a few hundred yards to the west using a 300 um sieve. The average abundance at Hyland's station was 34,814 - more than eight times the abundance at Myers and Phelps' station.

In both these examples, the studies sampled in slightly different sections of the same general area of the bay. Spatial variability does contribute significantly to the total variation that exists between studies. However, later sections will demonstrate that spatial variability is minor compared with those differences introduced by using different sieve sizes.

Sampling Methods:

It is generally recognized that diver collected cores most efficiently sample fauna living at or near the sediment surface (McIntyre 1971; Frithsen et al. 1983). Many of these organisms, particularly those of meiofaunal size, are found in the uppermost, surface flocculent layer. It is this layer that is most easily resuspended during coring resulting in loss of fauna and underestimation of abundances. Even diver collected and other flow through coring devices (Frithsen et al. 1983) can disturb surface floc if approach to the sediment and penetration isn't made as slowly as possible. Not only biologists, but sediment chemists and geochemists are aware of the potential problems introduced by sampling, since concentrations of metals and organics are most often highest at the sediment surface (Baxter et al. 1983).

No comparisons have been made of the dredges, grabs and corers used in the various investigations of the Narragansett Bay benthos. Some speculation may be made, however, concerning the efficiency at which these sampling methods capture benthic

Figure 5
Station locations for sieve size comparison

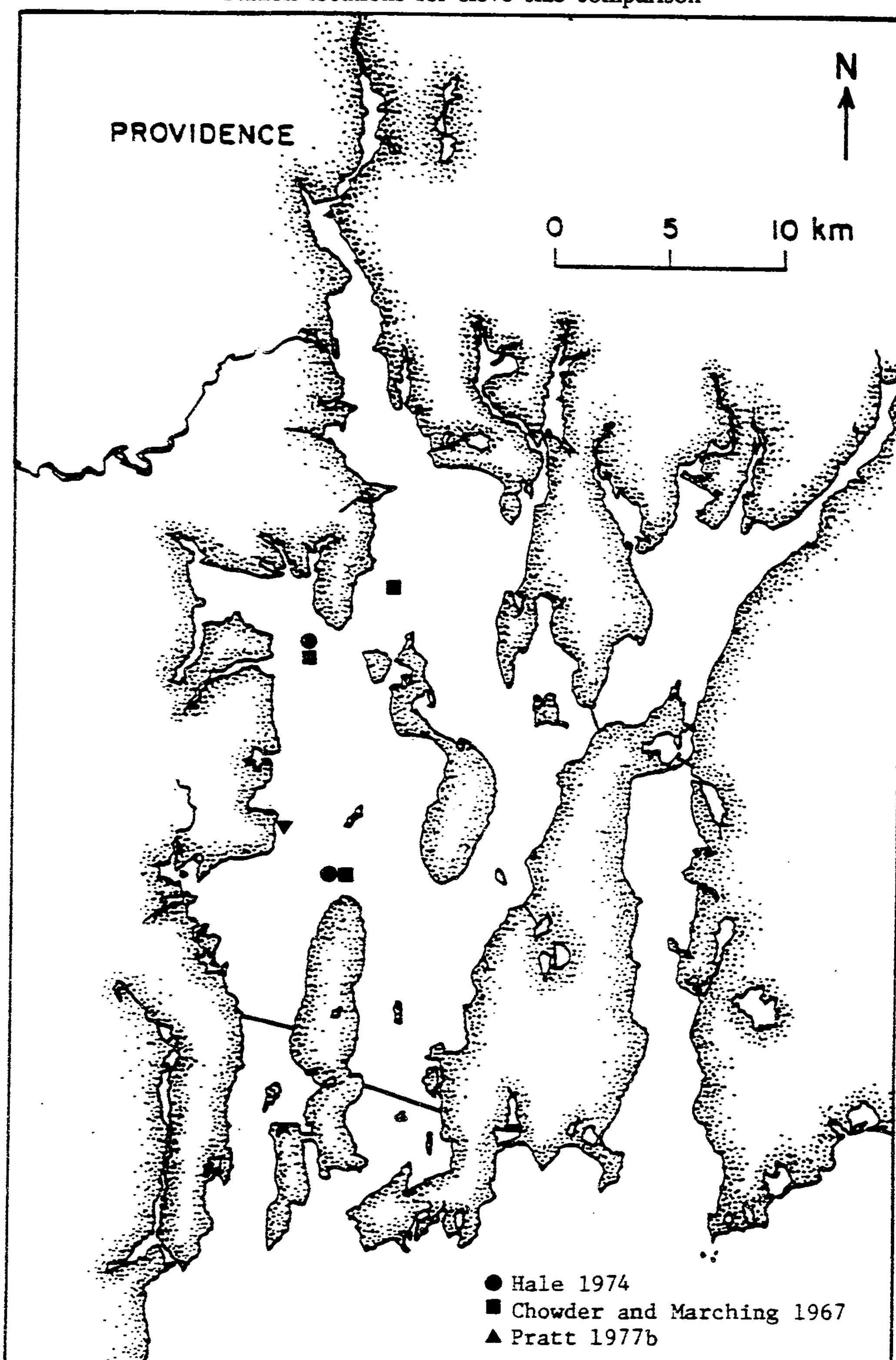


Figure 6: Mean abundances for studies using a Smith-McIntyre grab, but employing different sieve sizes. Study 1: Chowder and Marching Society (1967), mean abundance at Stations, B, C, and D using a 1000 um sieve. Study 2: Pratt (1977b) mean abundance at all 30 stations using a 1000 um sieve. Study 3: Hale (1974), mean abundance at Stations A and B using a 750 um sieve. See Figure 5 for station locations.

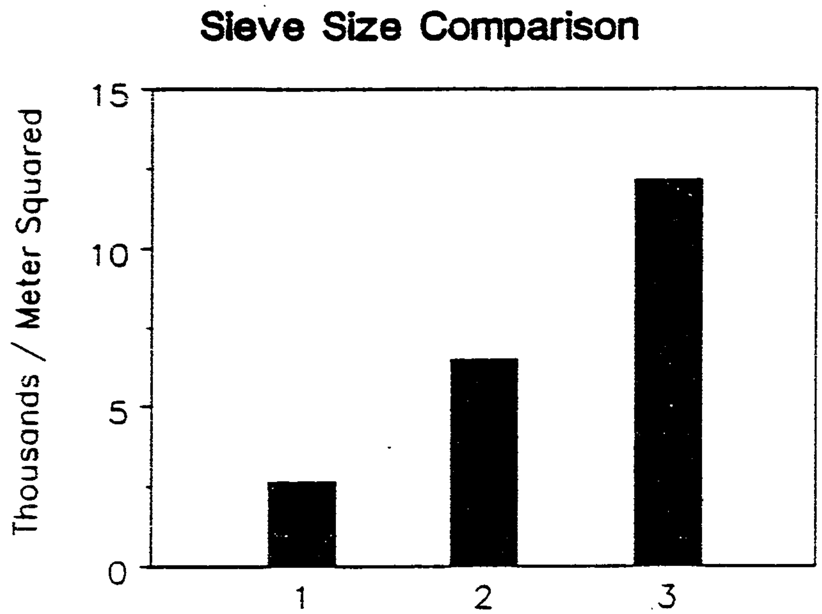
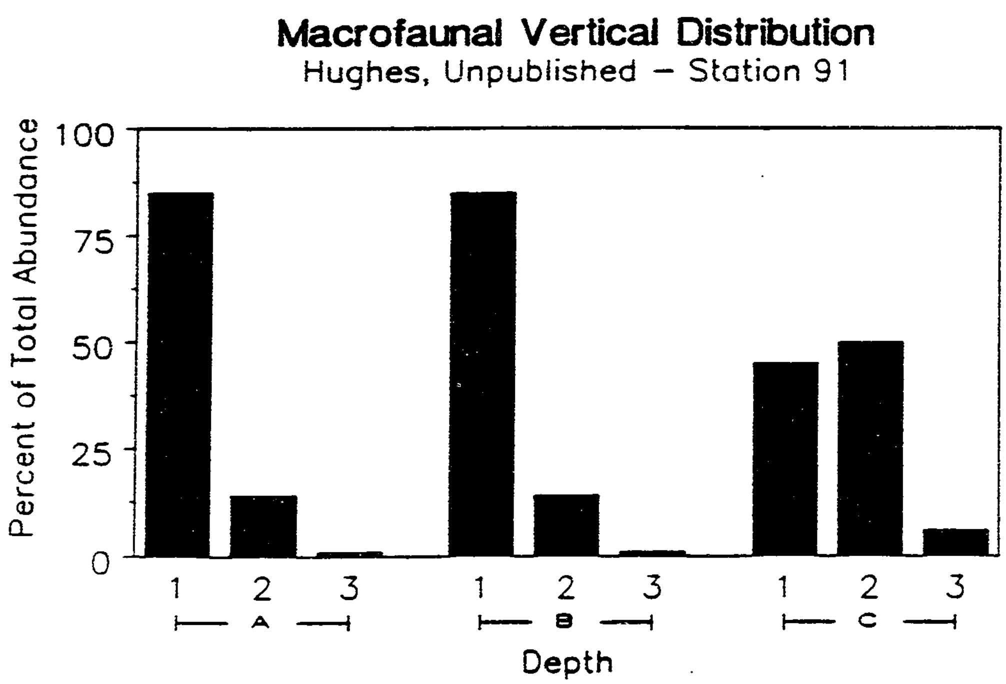


Figure 7: Macrofaunal vertical distribution (Hughes, Unpublished). Percent of total abundance found in (1) 0-2 cm horizon, (2) 2-6 cm horizon, and (3) 6-10 cm horizon. Group A: Total macrofauna, Group B: Mediomastus ambiseta, Group C: Nucula annulata.



organisms. If the sieve size was fairly course (> 1 mm), then it is unlikely that a significant number of organisms would be disturbed by the bow waves produced by non flow through sampling devices. However, the bow waves from grabs can potentially disturb smaller fauna caught on finer sieves. Species living deeper in the sediment, be they large or small, would not be disturbed by bow waves. In general, dredges, grabs and non flow through devices employed in studies that have utilized sieves smaller than about 1 mm probably have underestimated total macrofaunal abundances due to disturbance of surface dwelling fauna.

Depth of Sampling in Sediments:

The depth of sampling in sediments is not a major source of variation between studies. All abundances were normalized by area (m^2) not volume (m^3). Most benthic organisms in all but the sandiest of sediments are concentrated in the uppermost sediment horizons where organic matter and oxygen are abundant. For example, Figure 7 shows the vertical distribution in sediments at a mid bay site for total macrofauna, and two dominant species, Mediomastus ambiseta and Nucula annulata. Eighty five percent of all macrofauna were found in the top 2 cm of sediment. While this was true for many species like Mediomastus ambiseta, some, like Nucula annulata had broader vertical distributions.

All of the sampling methods used (Table 4) would have collected at least the top 6 cm of sediment containing the majority of benthic organisms present. Inclusion of deeper sediments would not have significantly increased total abundance, but could affect the number of species found and, if measured, total biomass.

DESCRIPTIONS OF BENTHIC COMMUNITIES

Spatial Variability:

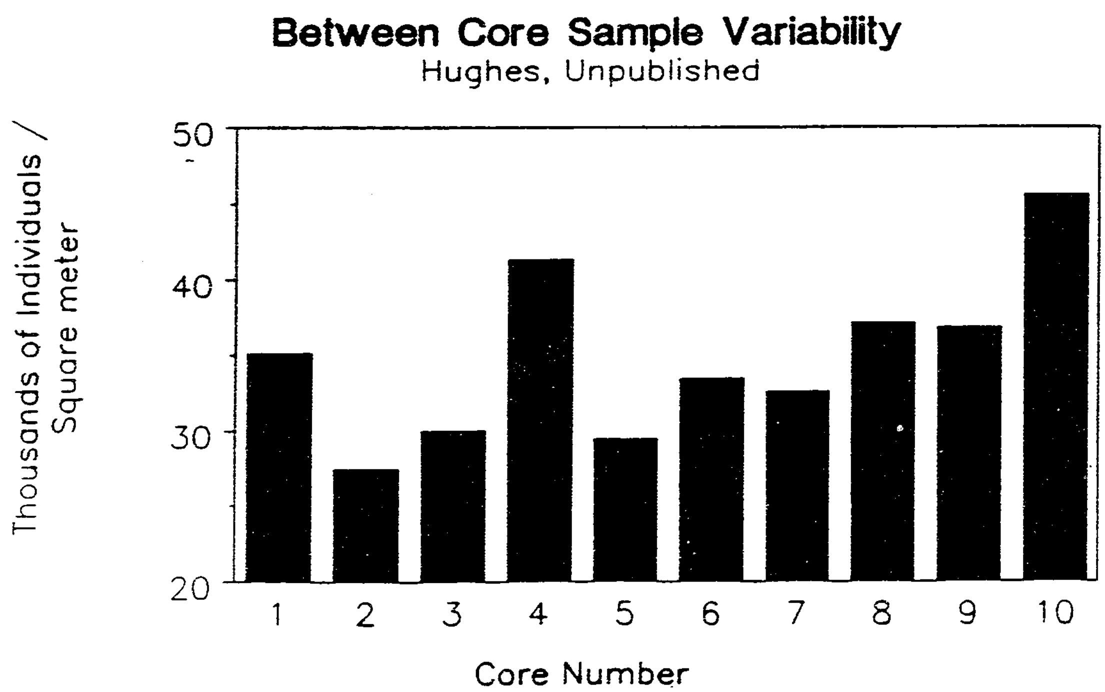
Spatial variability may be considered at different scales. None of the studies considered have dealt with spatial variability on the scale of millimeters to centimeters. Instead, spatial variability has been considered at larger scales - tens of centimeters to meters for those studies that have taken replicate samples at stations (between core variability) and meters to kilometers for these and other studies (variability between stations).

Benthic communities are inherently patchy due to variations in larval recruitment, interactions between resident fauna and incoming larvae, disturbance and predation by epifauna and demersal fish, and the anthropogenic influence of trawling and dredging. Many of the benthic studies considered have sampled without taking replicates at each station. This does not make possible assessment of variability at different spatial scales and makes difficult the determination of temporal dynamics.

Variability Between Cores:

The variation that might be expected between cores taken at any one station is illustrated in Figure 8. In this example, the variation between cores (expressed as the coefficient of variation of the mean) is about 16% for total macrofaunal abundance. The average between-core variability differs between stations and between investigations. For

Figure 8: Between core sample variability (Hughes, Unpublished). August 25, 1985, Station 91, 0-2 cm horizon. Average abundance = 34,900 individuals/m^2, C.V. = 16%.



example, in the Myers and Phelps (1978) study, between-core variability averaged 31%, being lowest at mid and upper bay stations (about 26%) and highest at stations in the Providence River (about 51%). This suggests that macrofauna are spatially more variable in the Providence River.

Hughes (Unpublished), working in the mid-bay region, took more replicates per station (10 vs. 3 for Myers and Phelps 1978), but his data show an average between-core variation of about 44% for the three stations he sampled. The greater number of cores should introduce less, not more variation. The difference may be due to Myers and Phelps using a 500 um sieve and Hughes using a 300 um sieve. However, Grassle et al. (1985) have presented evidence that between-core variability for cores sieved through a 300 um sieve is lower than for cores sieved through a 500 um sieve.

In addition to varying between regions of the bay and between investigators, between-core variability also differs between species. Dominant species are less variable, whereas rarer species are often tremendously variable with coefficients of variation in the hundreds of percent. For example, Station 6 of Myers and Phelps (1978), located just north of Gaspee Point, averaged 47% variation between cores for total macrofaunal abundance. Variation for Mulinia lateralis, which made up 32% of all individuals found, was 96%, whereas variation for Nucula annulata, which averaged less than 1% of total abundance, was 173%. Additional examples can be found in other data sets as well. Generally, spatial and temporal trends are much harder to define for rare species than for dominant species.

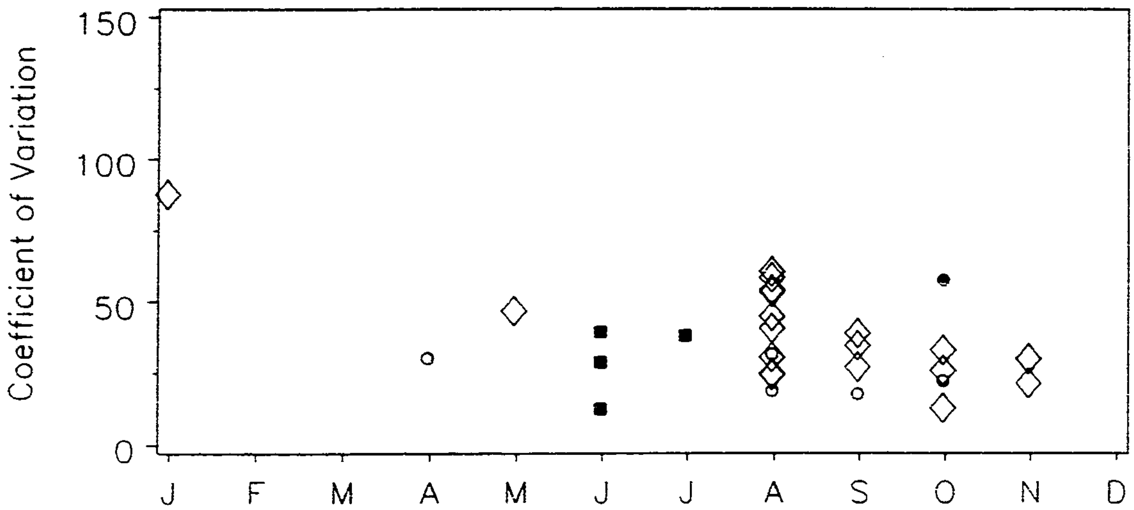
In summary, between-core variability for total abundance ranges from about 25 to 50%, with cores taken from the Providence River being more variable than cores taken from lower reaches of the bay. There does not appear to be a seasonal cycle to between core variability (Figure 9).

Variability Between Stations in Similar Regions:

The variation in macrofaunal abundance between stations depends upon the distance between stations and differs between regions of the bay. Closely spaced stations generally are more similar to each other than are stations in different regions. For example, Hughes (Unpublished) sampled three stations in the mid bay region south of Hope Island during the period 1983-1986. These stations were located a little more than a maximum of 3 km apart (Figure 10). Average abundances at the three stations were fairly similar and differed by about 21% (Figure 11). Even the seasonal cycle of macrofaunal abundance was similar at these three stations (Figure 12) with a peak at the beginning of the summer, low abundances in mid-summer, and an extremely high burst in abundance during the fall.

Replicability between stations in the mid bay region is not always so good. During 1978 and 1979, Grassle and Grassle (Unpublished) sampled at two stations located no more 0.5 km apart (Figure 10). Not all cores from the second station (Station 92) were sorted, but data are available for two dates in 1978. Figure 13 shows total macrofaunal abundance

Figure 9: Seasonality of between-core sample variability (Hughes, Unpublished). Symbols refer to depth horizons in sediments.



for the two stations on August 15 and November 17, 1978. Replication was good in August (C.V. 21% variation), but not so good in November (C.V. 70% variation).

Good replicability between stations in other regions of the bay can be found also. Myers and Phelps (1978) sampled two stations (Stations 3 and 4) in the upper bay that were about 3.25 km apart (Figure 14). The average abundances at these stations were fairly similar (C.V. 22% variation) (Figure 15). Farther north, however, two stations that were even closer together (2.25 km) did not replicate well (Figure 15). Station 6 north of Gaspee Point supported a macrobenthic community that was about five times less abundant than Station 5, just south of Gaspee Point. Station 5 was sampled only once (June 1976), but all three replicates were more than three times the mean abundance at Station 6 during the same month. It is unlikely that differences in sediment grain size (shown to be important by Phelps 1958) can explain the macrobenthic abundances reported. Stations 5 and 6 had exactly the same mean grain size when sampled during the summer of 1976 (Myers and Phelps 1978). Instead, the differences may be due to exposure to contaminants in the Providence River.

Just as between-core variability was found to be higher in the Providence River, variations between stations was also higher in this region of the bay compared with regions south of Conimicut Point. Figure 16 shows the between core variability for three stations sampled by Pratt (1972) in August 1970 (Figure 14). These stations all lie in the upper reaches of the Providence River and are separated by no more than 1.56 km, yet the coefficient of variation of the mean macrobenthic abundance at these stations was 68%.

Figure 10
Mid bay Sample Locations

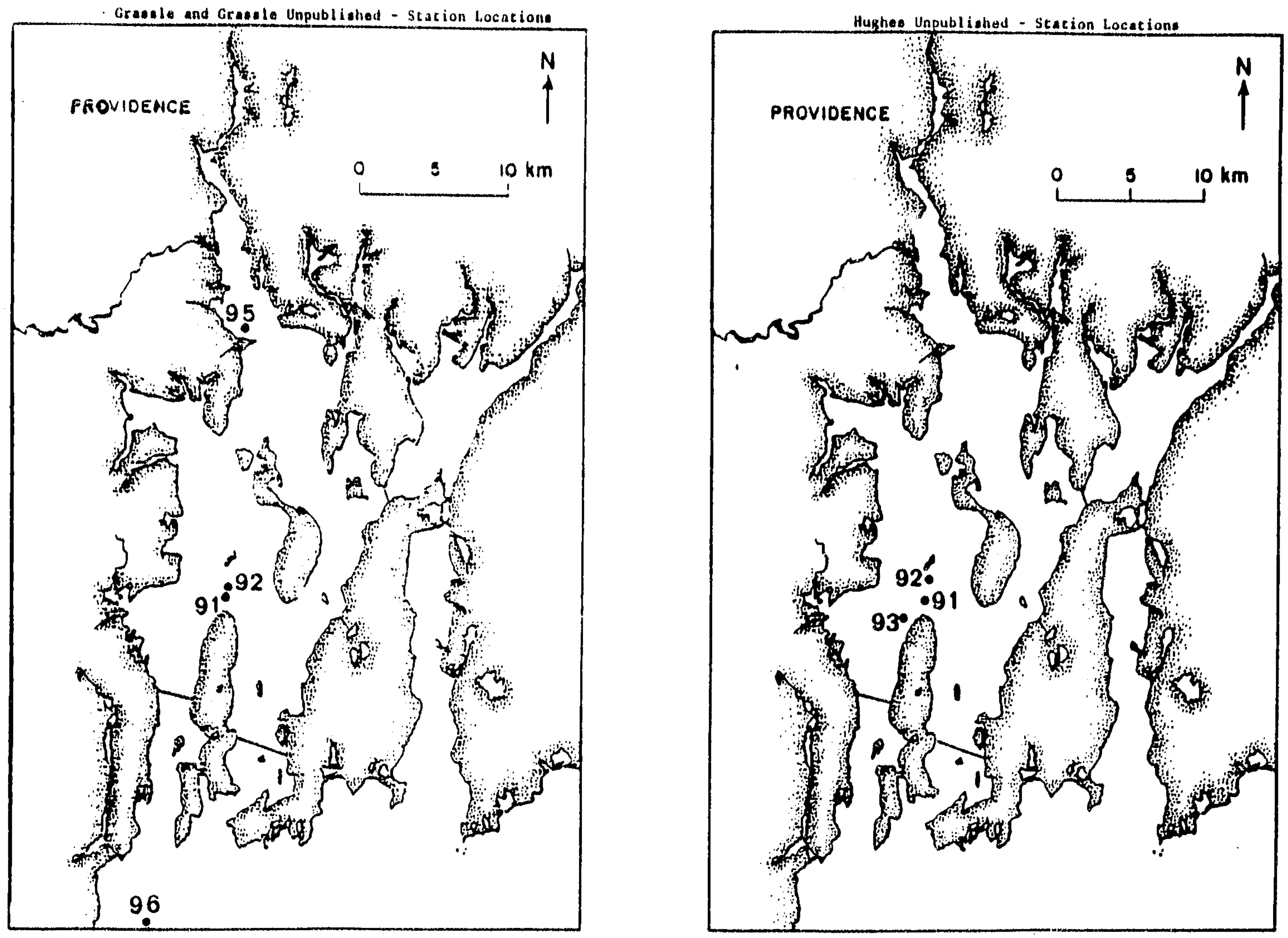


Figure 11: Average macrofaunal abundance at Hughes (Unpublished) mid bay stations. Overall mean = 120,000 individuals/m^2, C.V. = 21% (Station 91, n=15; Station 92, n=7; Station 93, n=8). See Figure 10 for station locations.

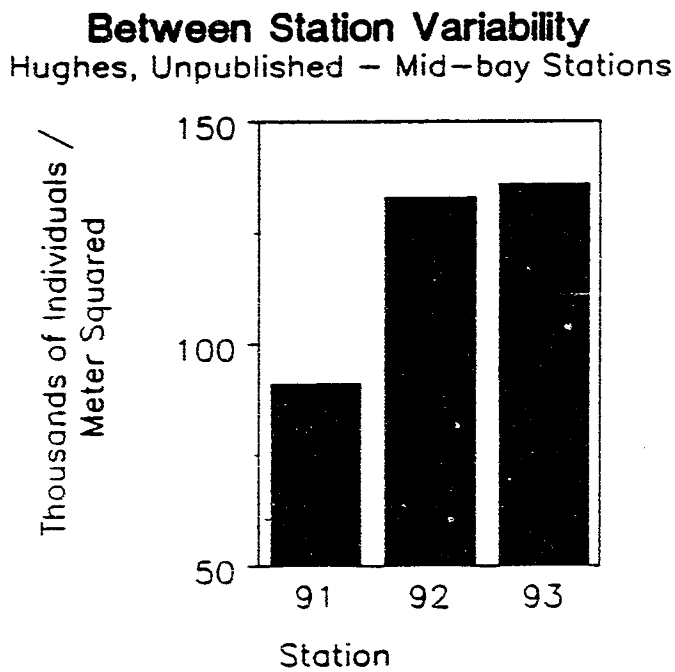


Figure 12: Seasonal replicability for Hughes (Unpublished) mid bay stations. ● = Station 91, ○=Station 92, ■= Station 93.

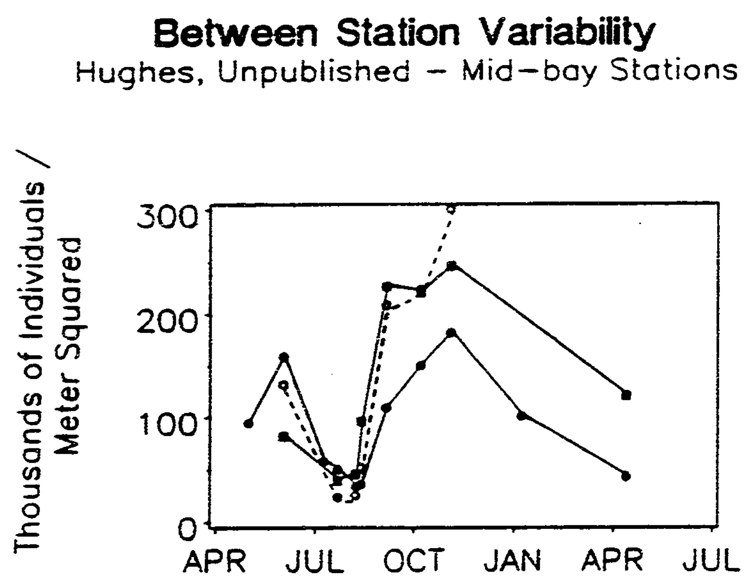
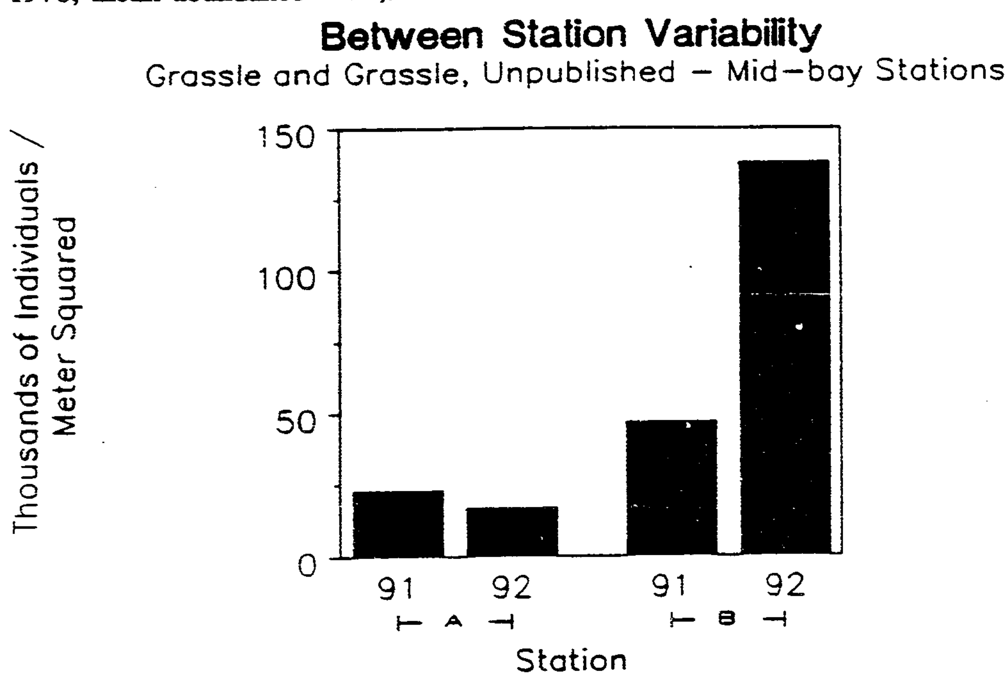


Figure 13: Average macrofaunal abundance at Grassle and Grassle (Unpublished) mid bay stations. Group A: August 15, 1978, mean abundance = 20,000 individuals/m^2, C.V. = 21%. Group B: November 17, 1978, mean abundance = 92,500 individuals/m^2, C.V. = 70%.



The region of the Providence River adjacent to Field's Point is even more variable (Figure 15). Pratt sampled four stations in this region in January 1970. These stations are farther apart (maximum distance 7.6 km), but the variation between station is almost 100%. The possibility exists that the Smith-McIntyre grab Pratt used in January introduced more variation than the Ekman dredge used in August, but if the difference between groups of stations is real, then the spatial variability of macrofaunal abundance is higher in the Field's Point region of the Providence River than it is in its upper reaches.

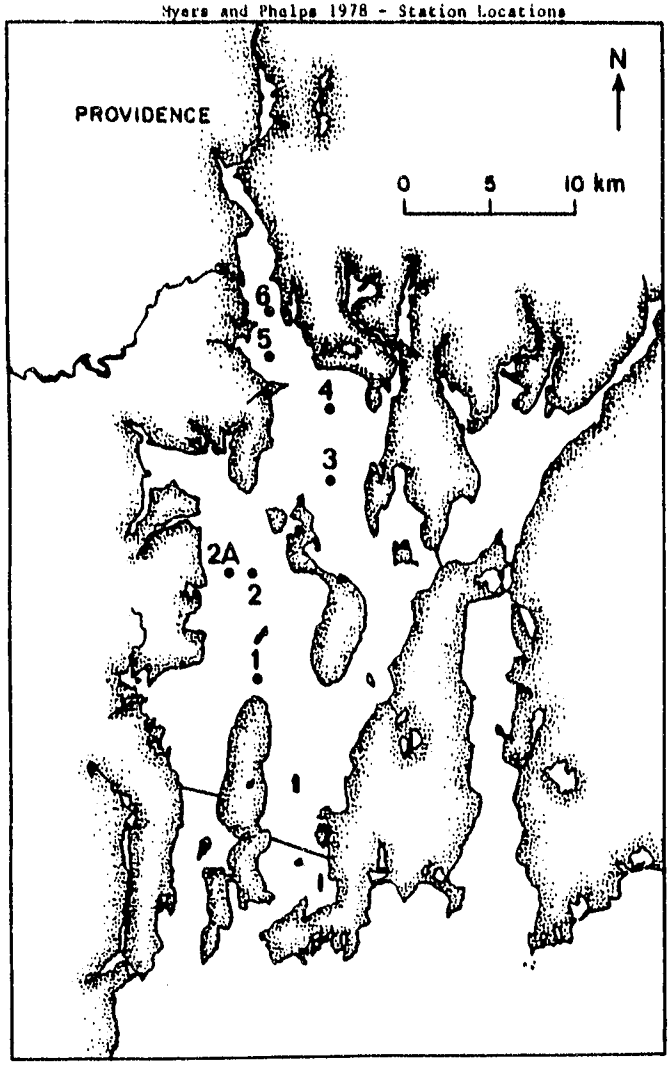
Variations Between Regions of the Bay:

There exists a number of distinct gradients along the north-south axis of Narragansett Bay. At the head of the bay, salinity is lower (Hicks 1959), primary productivity is higher (Oviatt et al. 1981), there is more suspended matter in the water column (Morton 1967; Pilson and Hunt 1988), and hydrocarbon and metal concentrations in the water column, sediments, and biota are higher (Hurtt and Quinn 1979; Cullen 1984; Pilson and Hunt 1988). It is logical to look for differences in the composition and abundance of benthic communities along those same gradients.

Within the Providence River, both the number of species per station and total macrofaunal abundance increase down bay (Figure 17). Pratt (1972) found about 4 or 5 species (or groups of species) were present at the head of the bay, near the mouth of the Seekonk River. South of Sabin Point, both species number and abundance increased

Figure 14
Station Locations for Myers and Phelps (1978) and Pratt (1972)

Myers and Phelps 1978 - Station Locations



- Pratt 1972 - Station Locations

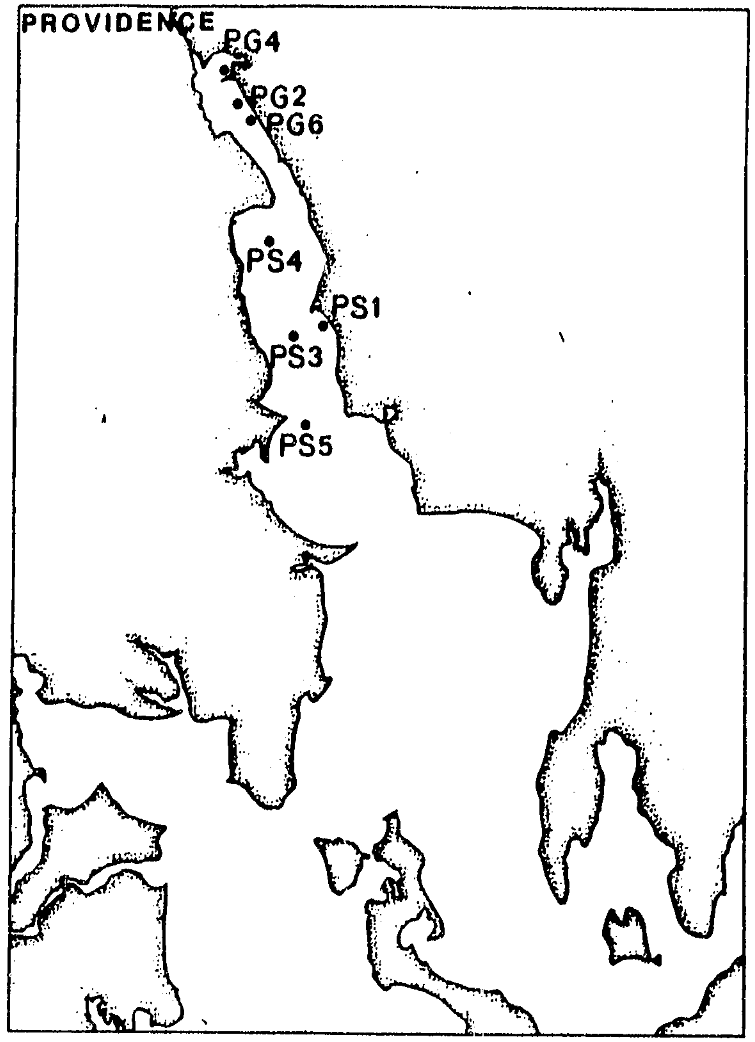


Figure 15: Comparison of between-station variability at Myers and Phelps (1978) upper bay stations (Stations 3 and 4, mean abundance = 4,850 individuals/m^2, C.V. = 22%), and their Providence River stations (Stations 5 and 6, mean abundance = 5,650 individuals/m^2, C.V. = 96%. See Figure 14 for Station locations.

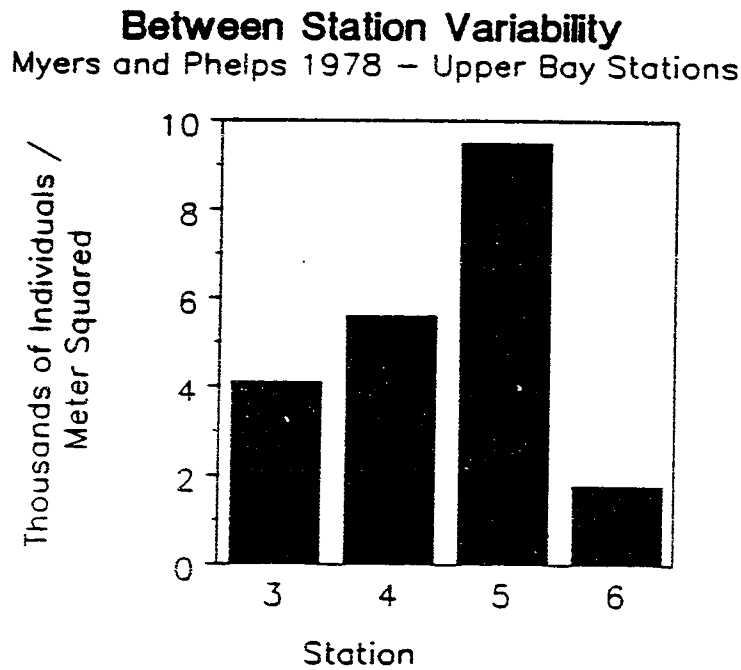


Figure 16: Comparison of between-station variability at Pratt (1972) upper Providence River Stations (PG2, PG4, and PG6) and his lower Providence River Stations (PS1, PS3, PS4, and PS5). See Figure 14 for station locations.

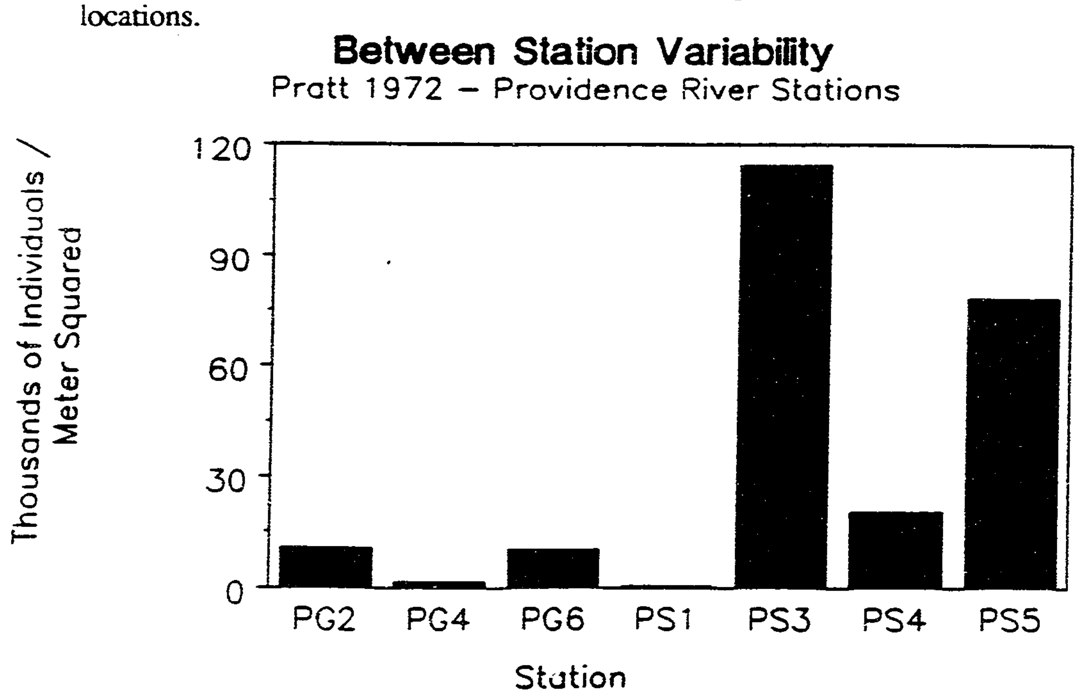
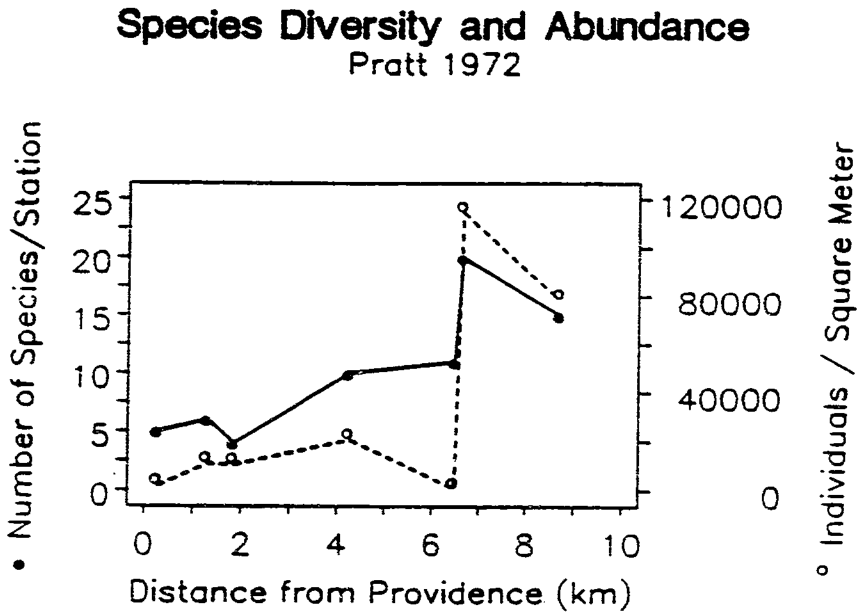


Figure 17



sharply. This increase is not shown by all of Pratt's stations south of Sabin Point, Station PS1 being the exception. However, the general trend is still apparent. In all of Pratt's stations, except Station PS1, the opportunistic spionid polychaete Streblospio benedicti dominated. Streblospio abundances averaged 84% of total macrobenthic abundance at stations near the head of the bay, but only 32% at stations south of Sabin Point.

The trend for both the number of species and macrobenthic abundance to increase down bay in the Providence River can be seen in other data sets as well. Pratt and Bisagni (1976) sampled along a transect from Sabin Point to the Ohio Ledge area of the upper bay. Although the gradients of species diversity and abundance are variable, the trends for more species and larger abundances down bay remain (Figure 18). Except for Station 7 (about 14 km from Providence in Figure 18), all sediments "were soft with a high apparent water content" (Pratt and Bisagni 1976). Differences in sediment grain size was probably not, therefore, responsible for the trends, nor the variability observed. At Pratt and Bisagni's stations, the small, opportunistic coot clam Mulinia lateralis was numerically dominant at all stations except Station 7. Sediments at Station 7 were coarser (only 27% 'fines' vs. an average of 61% for other stations) and dominated by the amphipod Ampelisca abdita.

South of Conimicut Point, the trends toward increasing species diversity and abundance along a down bay transect were generally not so apparent. The 1967 survey completed by Pratt (Chowder and Marching Society 1967) shows increasing species diversity towards the mouth of the bay, but macrofaunal abundance showed no such trend

Figure 18

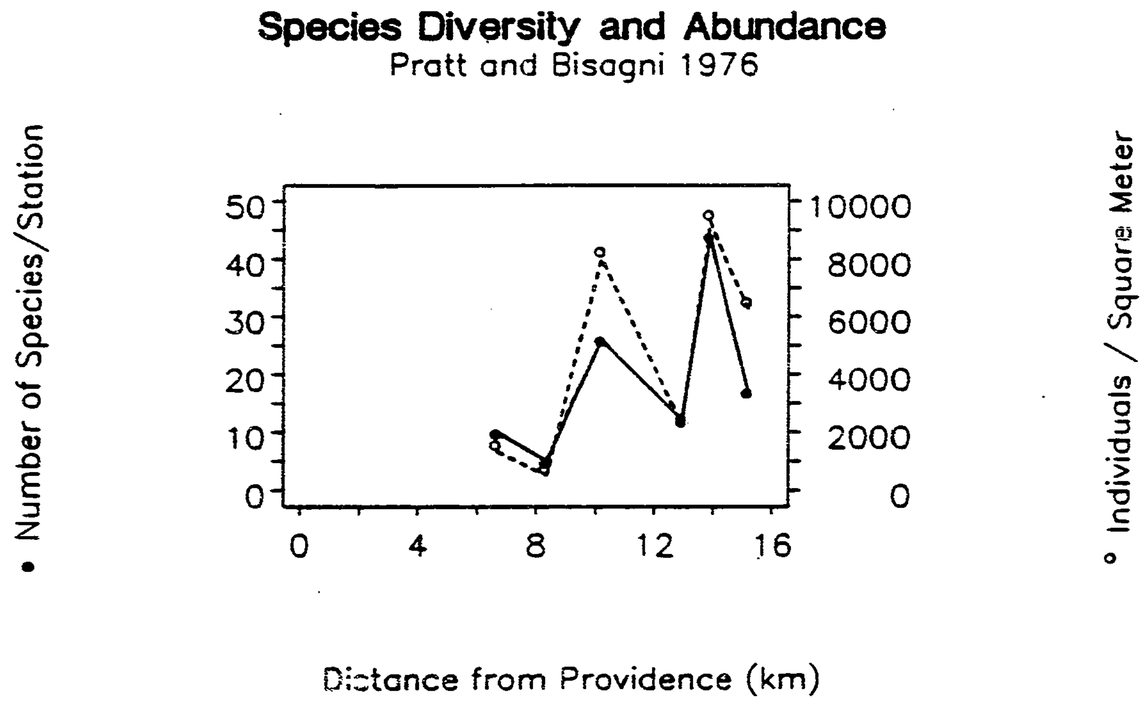
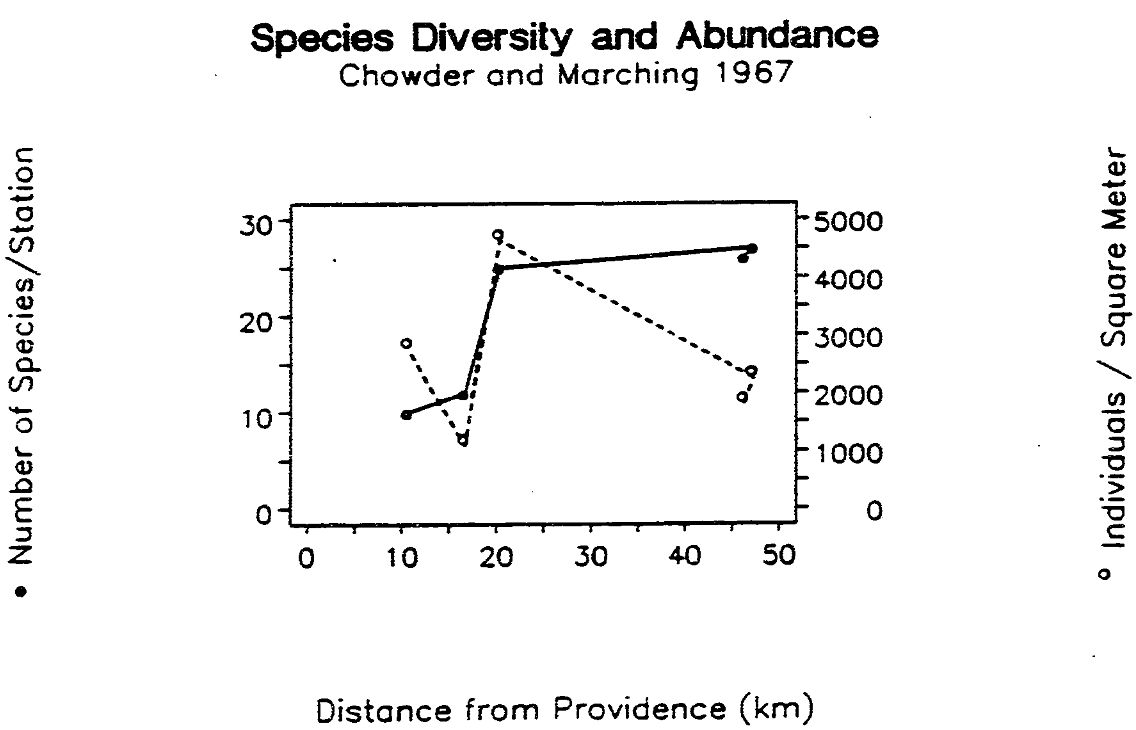


Figure 19

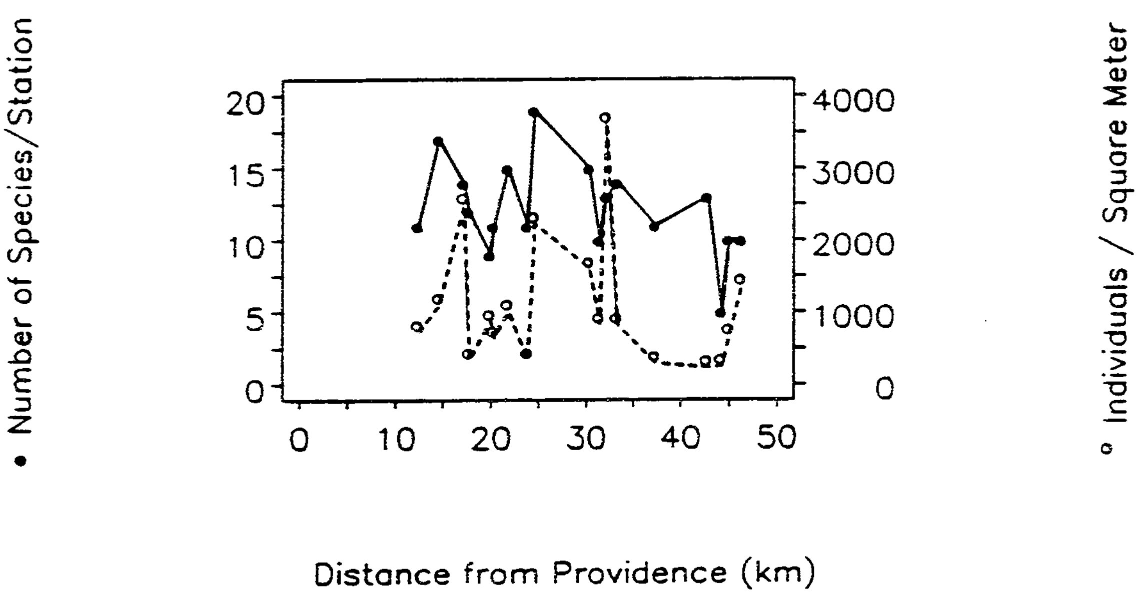


(Figure 19). Phelps' earlier study (Phelps 1958) showed no trend for either species diversity or abundance (Figure 20) as did his later study with Myers (Myers and Phelps 1978) (Figure 21). All three studies suggested that sediment type (grain size or organic content) were important factors determining macrobenthic structure. Chowder and Marching Society (1967) went so far as to say the communities "did not form an up-bay gradient in response to salinity, depth or pollution".

Figure 20

Species Diversity and Abundance

Phelps 1958



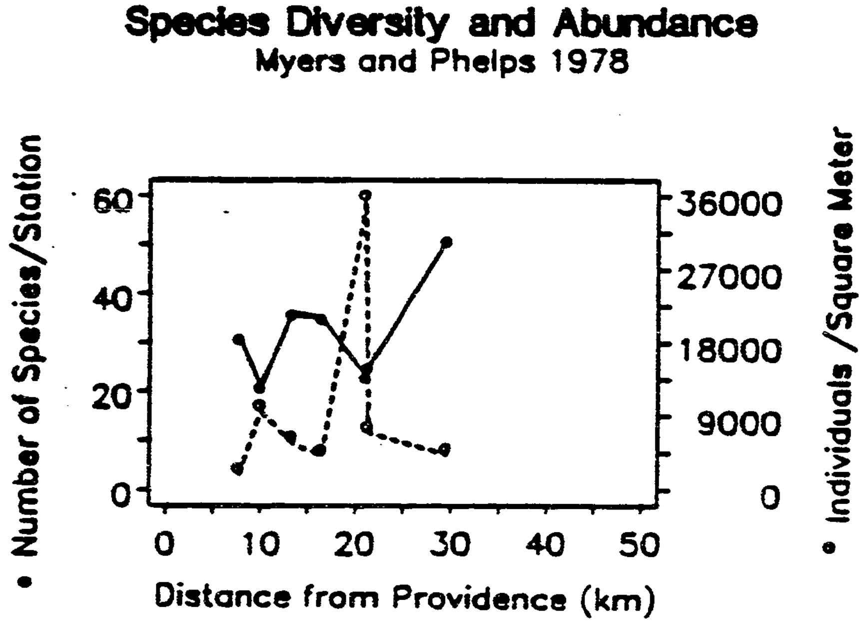
The gradients observed within the upper reaches of the bay may be due to any number of factors among them being organic loadings from sewage effluents, hypoxia and anoxia caused by organic loadings (Oviatt 1981), and even certain phytoplankton blooms (Nixon 1988). Given the spatial and temporal scales covered in the benthic studies available, it is difficult to definitively attribute macrobenthic structure to any of these factors, and most likely, they all act in concert to determine the structure of communities in the upper reaches of the bay.

Temporal Variability:

Seasonal Trends:

The vast majority of benthic studies in the bay present no data concerning seasonal changes. Samples were collected once and no justification given for the season selected. Not surprisingly, most of these studies were conducted during the summer months:

Figure 21



Benthic seasonal changes for macrofauna in the mid bay region has been well described by Grassle et al. (1985) using a five year data set (1976-1980) (Figure 22). Seasonal changes for the meiofauna in this region have also been described (Rudnick et al. 1985) (Figure 23). The general patterns described for both the macrofauna and meiofauna are similar with high abundances observed in May and June and lowest values observed in late summer and fall. Rudnick et al. (1985) present evidence that seasonal trends in biomass were similar to those for abundance, and showed that spring meiofaunal abundance increases were observed to a sediment depth of 10 cm.

The reasons given for these seasonal patterns are related to seasonal changes in the production, fate, and storage of phytoplankton carbon. In the winter and spring, phytoplankton generally are dominated by large diatom blooms (Pratt 1965; Durbin et al. 1975). Zooplankton activity, in terms of feeding rates, biomass, and production, is low during the winter (Durbin and Durbin 1981) as is the activity of other heterotrophs, such as bacteria (Hobbie and Cole 1984). Therefore, only a small fraction of these large diatom blooms are grazed. At the termination of these blooms, diatoms may rapidly sink out of the water column (Smetacek 1980, 1985) and be deposited on the sediment surface. Sedimentation events following the crash of large blooms can cause the entire sediment surface to become colored yellow-brown (Frithsen, personal observation) and the total organic content of the sediment may become slightly elevated (Rudnick 1984; Frithsen et al. 1985). At low temperatures, very little of this freshly deposited organic matter is remineralized (Nixon et al. 1976). Thus, a significant fraction of the winter-spring diatom bloom in Narragansett Bay is not immediately utilized by consumers and is stored in the sediments (Rudnick 1984; 1988).

Rudnick et al. (1985) have suggested that the rapid spring rise in macrofaunal abundance and meiofaunal abundance and biomass is triggered by a rapid rise in temperature "from about 2 °C to about 13 °C during April and May". Benthic metabolism also increases due to this temperature rise and the inference is that with the rise in temperature, benthic organisms are utilizing organic matter deposited from the winter-spring diatom blooms. Experiments using radiotracers in mesocosms have produced evidence consistent with this view (Rudnick 1988).

In the summer, patterns of phytoplankton production and the fate of that production suggest that benthic communities are food limited. Summer pelagic production is dominated by nannoplankton (Durbin et al. 1975) and successive blooms by small diatoms occur. High temperatures and low sinking rates favor decomposition of these small nannoplanktors in the water column (Itarriaga 1979; Newell et al. 1981; Hobbie and Cole 1984) and stable carbon isotope data support the view that little nannoplanktonic carbon enters the benthic food web (Gearing et al. 1984). These factors suggest that very little phytoplankton carbon reaches the sediments during the summer via direct sedimentation. A significant amount, however, may reach the sediments in the form of zooplankton fecal pellets since zooplankton biomass and feeding rates are at an annual maximum (Durbin and Durbin 1981).

What all this means is that in the summer, the bay's benthic communities are limited to carbon from three sources; that stored in the sediment from the previous winter's diatom blooms; carbon deposited to the sediments in the form of zooplankton fecal pellets; and whatever carbon the benthos can actively remove from the water column. [This latter route has never been measured in the bay, but its potential importance has been addressed using mesocosms (Doering et al. 1986; Frithsen and Doering 1986).] As the stored carbon is depleted, benthic communities become more strongly food limited. Surface feeding fauna (harpacticoid copepods and spionids) are most affected (Rudnick et al. 1985). Sub-surface feeders appear to be less affected and are somewhat buffered from these seasonal changes. Grassle et al. (1985) have pointed out that "some populations such as Nuçula annulata were surprisingly unaffected by the fluctuations in surface food supply, perhaps because this species does not depend on the surface layer of sediment for food (Young 1971)". Indeed, Nuçula annulata abundance responded little to a range of organic enrichment treatments in mesocosms (Frithsen et al. 1989). However, some sub-surface groups in the bay (nematodes, for example, Rudnick et al. 1985) do show the same seasonal trends as their surface feeding counterparts.

The evidence for food supply governing the seasonal cycles observed in the bay is largely circumstantial, somewhat compelling, but certainly not solid. There are other factors that to some extent play an important role in determining the seasonal cycle of benthic fauna. Of food supply, disturbance, predation, and competition, "although there is

Figure 22: Seasonal variability of macrofauna in mid Narragansett Bay. Reproduced from Grassle et al. 1985. Left hand axis: number of species/35 cm^2 core. Right hand axis: number of individuals/10 cm^2. Means and two standard error confidence limits plotted.

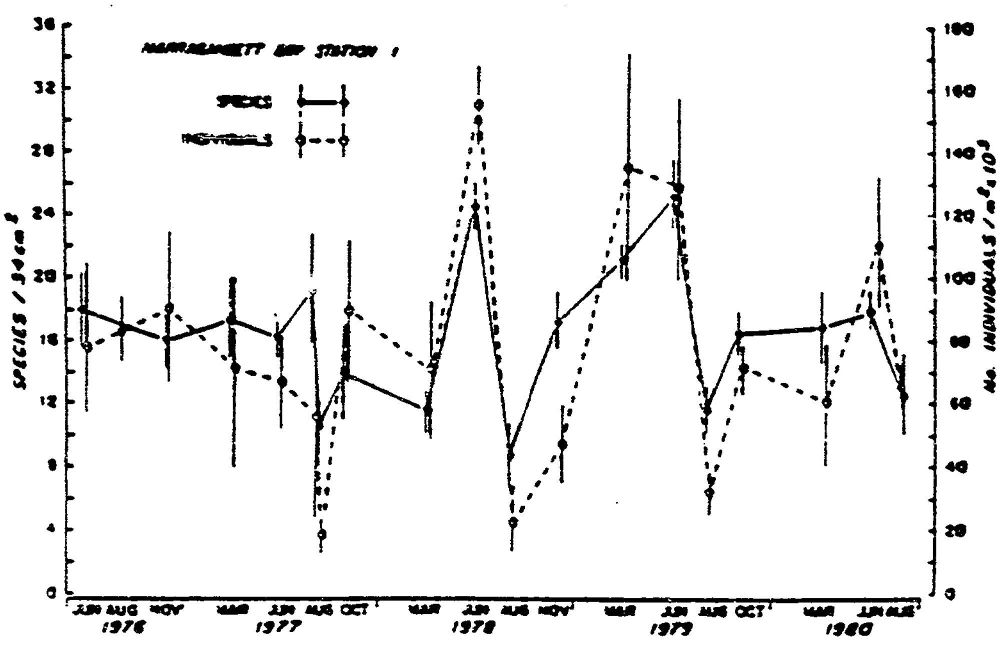
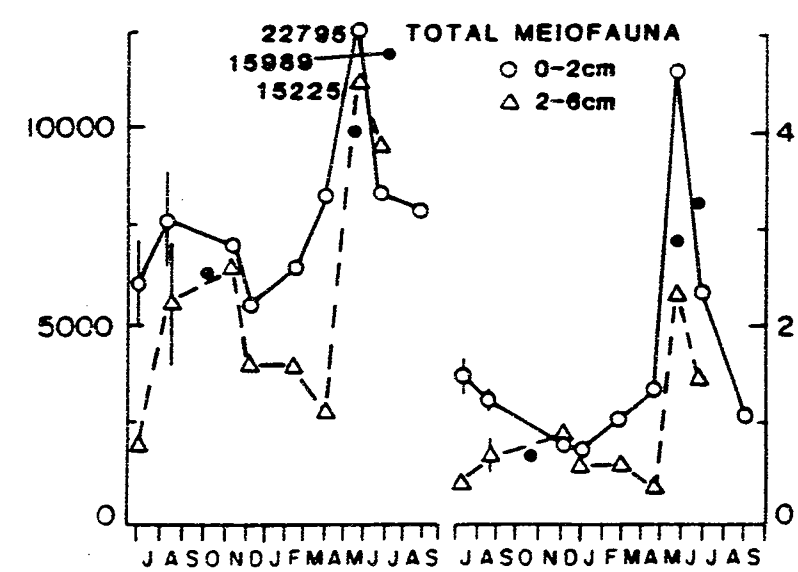
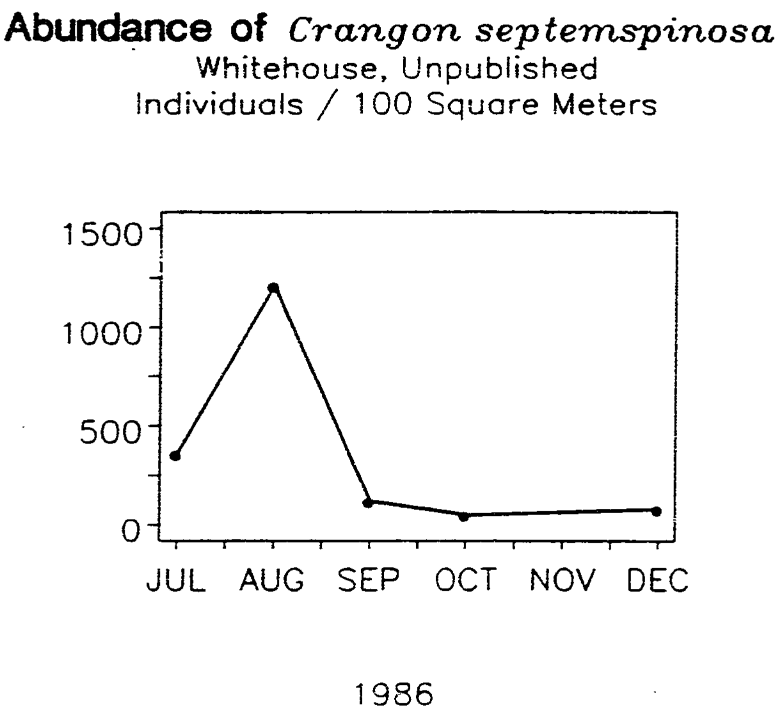


Figure 23: Seasonal variability of meiofauna in mid Narragansett Bay. Reproduced from Rudnick et al. 1985. Left hand axis: number of individuals/10cm^2. Right hand axis: grams ash free dry weight/m^2.



ample evidence that all three of these processes are operating, we are unable to say that the magnitude of any one of these three processes determine variations in species abundances in ... the natural community in Narragansett Bay" (Grassle et al. 1985). Experiments in mesocosms have shown that some predators (the epibenthic shrimp Crangon septemspinosa, for example, Frithsen et al. 1989) can dramatically change the abundance and composition of benthic communities. This same predator has been shown to reach large abundances in the mid bay region at about the same time low macrofaunal and meiofaunal abundances have been observed (Whitehouse, Unpublished, and Figure 24). Evidence for the presence of predators, at least in the summer, is the finding by Grassle et al. (1979) that about 10% of all Mediomastus, a head-down deposit feeder, have portions of their tail filaments missing.

Figure 24



It is a given that more research must be done to determine how food supply, predation, and other factors interact to determine the benthic seasonal patterns within Narragansett Bay. The ongoing work of Whitehouse (Unpublished) will add to our understanding of the distribution, abundance, and feeding behavior of one epibenthic predator within the bay (Crangon), but there are a host of other benthic invertebrates of which we know very little except for the geographically limited study of Terceiro (1985). If the bay benthos is truly food limited in the summer, it should be reflected in various biochemical parameters. Yet no seasonal studies of seasonal biochemistry have been completed. This is an avenue for future research.

Thus far, benthic community seasonal trends have been presented using the data of Grassle et al. (1985) and Rudnick et al. (1985). Evidence for similar patterns may be found for the mid bay region in other data sets, and may be found for other regions of the bay as well. However, the patterns are not universal and exceptions abound.

Data collected by Hughes (Unpublished) were previously presented (Figure 12) to show how well seasonal patterns were replicated between three stations located in the mid bay region. The late spring peak in abundance and low abundances in the summer were apparent at all stations. The high fall abundances at two of Hughes three stations, present a different pattern than that of the five year data set of Grassle et al. (1985) (Figure 22). No reason can be given for these high fall abundances and it would be interesting to know if similarly high abundances were present during subsequent years.

The data collected by Myers and Phelps (1978) do not quite extend through a full annual cycle. However, the seasonal patterns shown for their Station 1 (Figure 24) in the mid bay region support the seasonal patterns shown by Grassle et al. (1985) and Rudnick et al. (1985) (Figure 25). Due to infrequent sampling, seasonal cycles of macrofaunal abundances were not available for Myers and Phelps (1978) Stations 2, 2A, and 5. Their Station 6 in the Providence River did show a similar pattern to that of Grassle et al. (1985) and Rudnick et al. (1985), but Myers and Phelps (1978) upper bay Stations 3 and 4 did not (Figure 24).

The only other data set that can be used to show seasonal patterns in the bay is that collected by the City of Newport in support of their 301h waiver application to the U.S. Environmental Protection Agency (City of Newport 1985). Samples included in this study were taken in the vicinity of the Newport sewage treatment plant effluent discharge off of Coasters Harbor in the East Passage. Although some stations show the same seasonal patterns as Grassle et al. (1985) and Rudnick et al. (1985), most did not (Figures 26).

Long Term Trends:

No single data set describing benthic communities within Narragansett Bay spans a period greater than four years with the exception of the data collected in Mt. Hope Bay by Marine Resources, Inc. An almost 30 year record can be pieced together for the benthic community in the mid bay region by combining the following data sets: Phelps (1958) for data from 1957; Davis (Unpublished) for data from 1969-1972; Hale (1974) for data collected in 1974; Myers and Phelps (1978) for data from 1975-1976; Hyland (1981) for data from 1977-1978; Grassle and Grassle (1984) and Grassle et al. 1985) for data from 1976-1980; and Hughes (Unpublished) providing data collected from 1983 to 1986. These studies were produced using different sampling methods (Table 4) and sieve sizes (Figure 2), and interpretation most be done with some care. Stations used by these investigators are shown in Figure 27.

Figure 25
Myers and Phelps 1978

Macrofaunal Seasonal Variability - Individuals/square meter

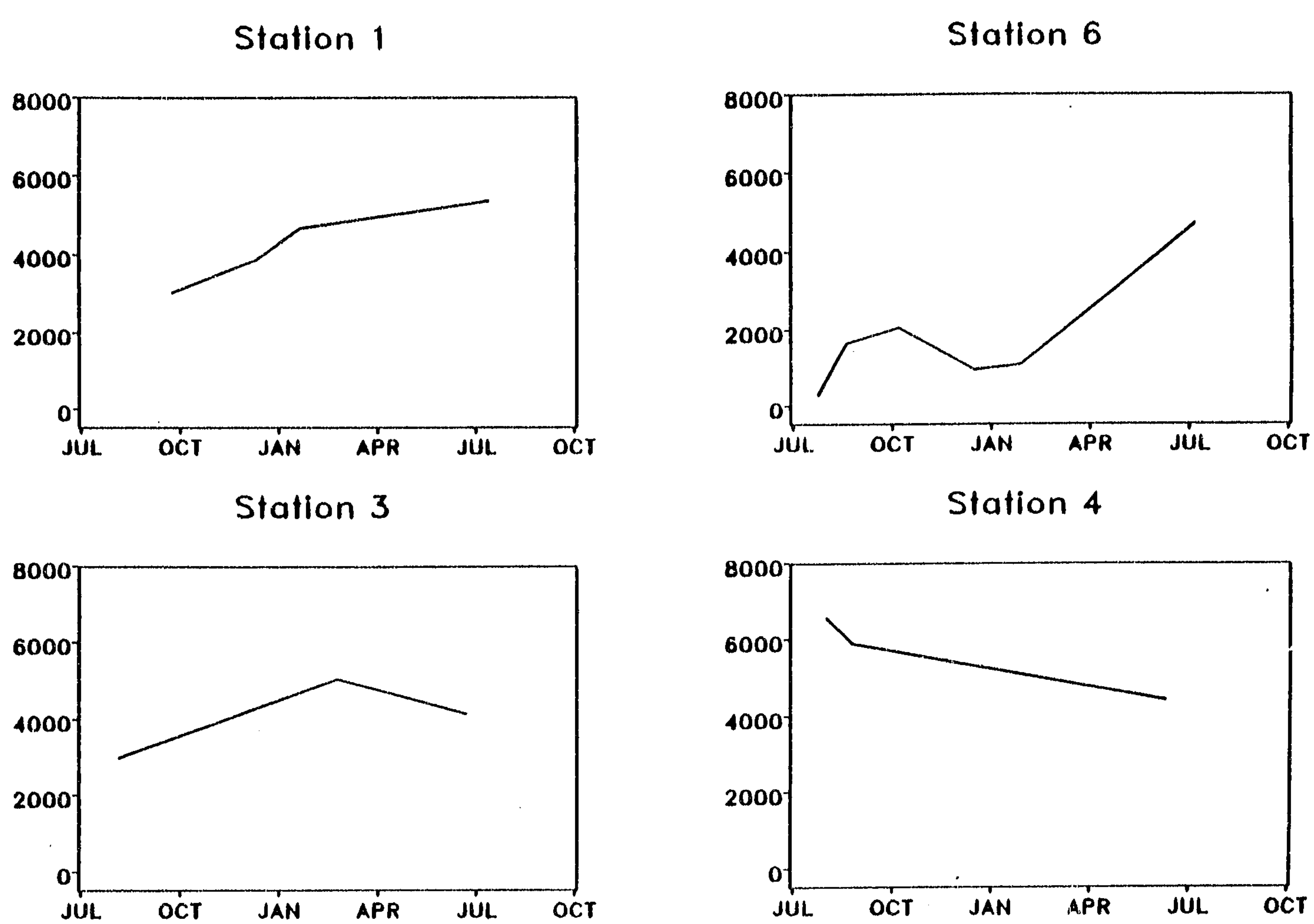


Figure 26
City of Newport 1985

Macrofaunal Seasonal Abundance - Thousands/square meter

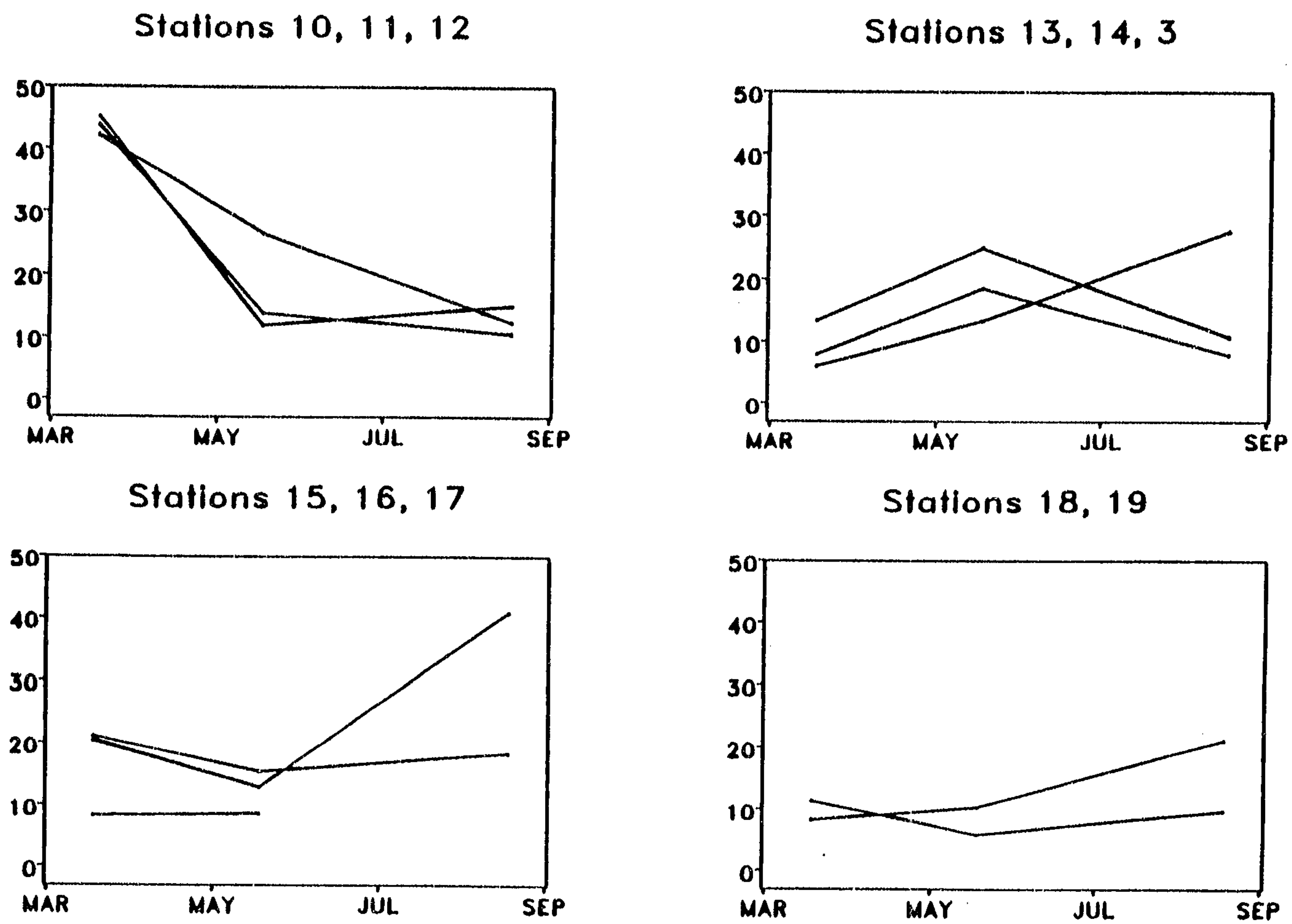
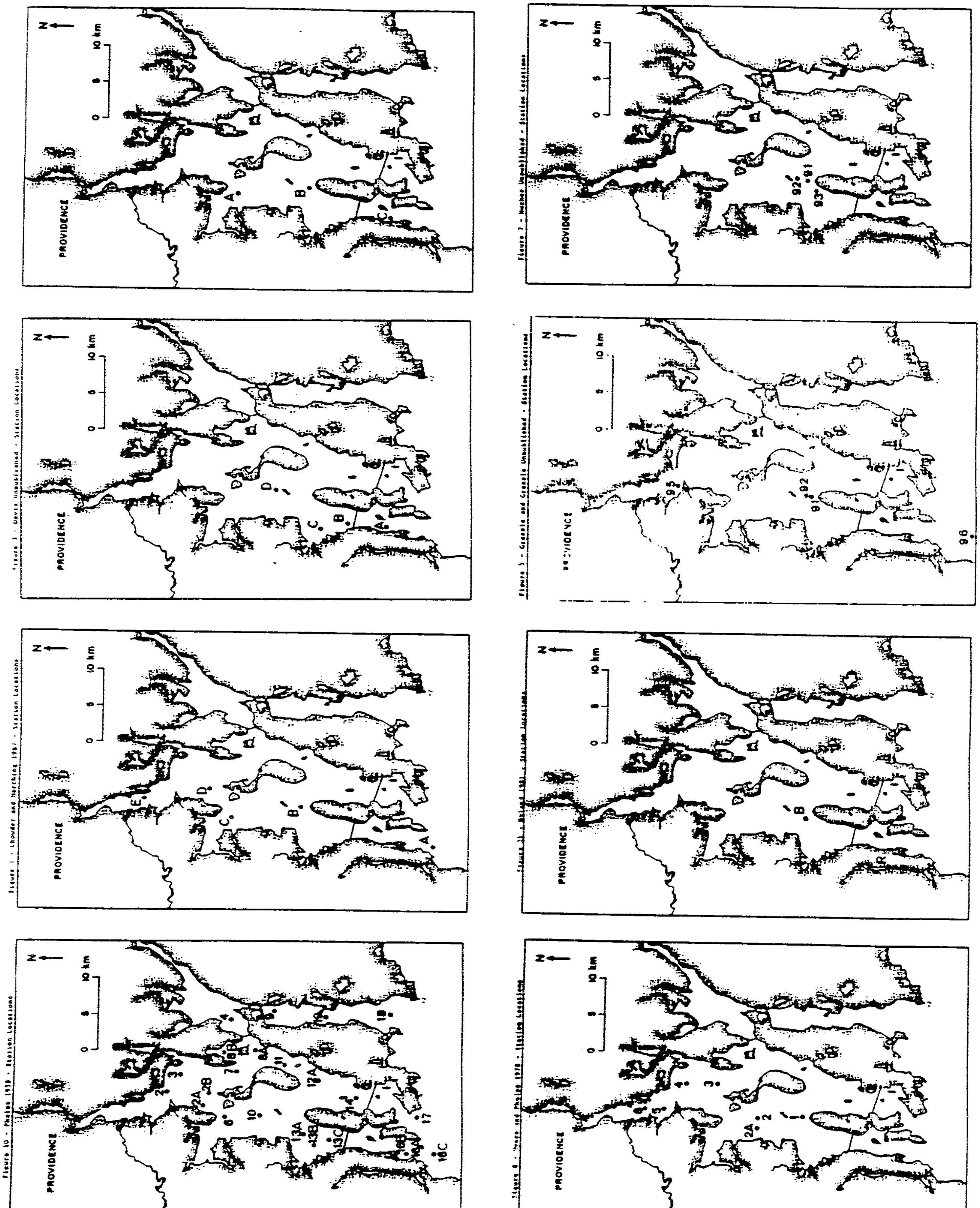


Figure 27
Locations of Mid Bay Stations



The combined data suggest that macrofaunal abundance has been increasing in the mid bay region since the mid 1970's (Figure 28). Macrofaunal abundance reported at Station 13A by Phelps (1958) was 1,595 individuals/m^2 in 1957. Over a decade later, Davis (Unpublished) reported abundances at his Stations C and D averaged 629 individuals/m^2. Based upon cores collected in 1975 to 1976, Myers and Phelps (1978) reported abundances at their Station 1 of 4,240 individuals/m^2. By the mid-1980's, Hughes (Unpublished) data were indicating an average annual abundance of about 100,000 individuals/m^2.

The increase, from nearly 1,600 individuals/m^2 in 1957 to 100,000 individuals/m^2 in the 1980's, was not steady. Rather, abundance appeared to have jumped in the mid 1970's. Such a jump is suggestive of a change in methodologies.

Early data sets (Phelps 1958; Chowder and Marching 1967; Davis, Unpublished; Hale 1974) were collected with grab or dredge type samplers. Starting in the mid-1970's, coring by divers was the preferred sampling method. This change is at about the same time abundances dramatically jumped and suggests that earlier sampling methods may have lost a considerable number of surface fauna due to bow wave effects, which have been discussed previously.

Another methodological change was the choice of sieve size to extract organisms from sediment samples (see Figure 2). Early studies used 500 um mesh and larger sieves, whereas all studies reporting average abundances greater than 10,000 individuals/m^2 (Hyland 1981; Grassle et al. 1985; Hughes, Unpublished) used 300 um sieves.

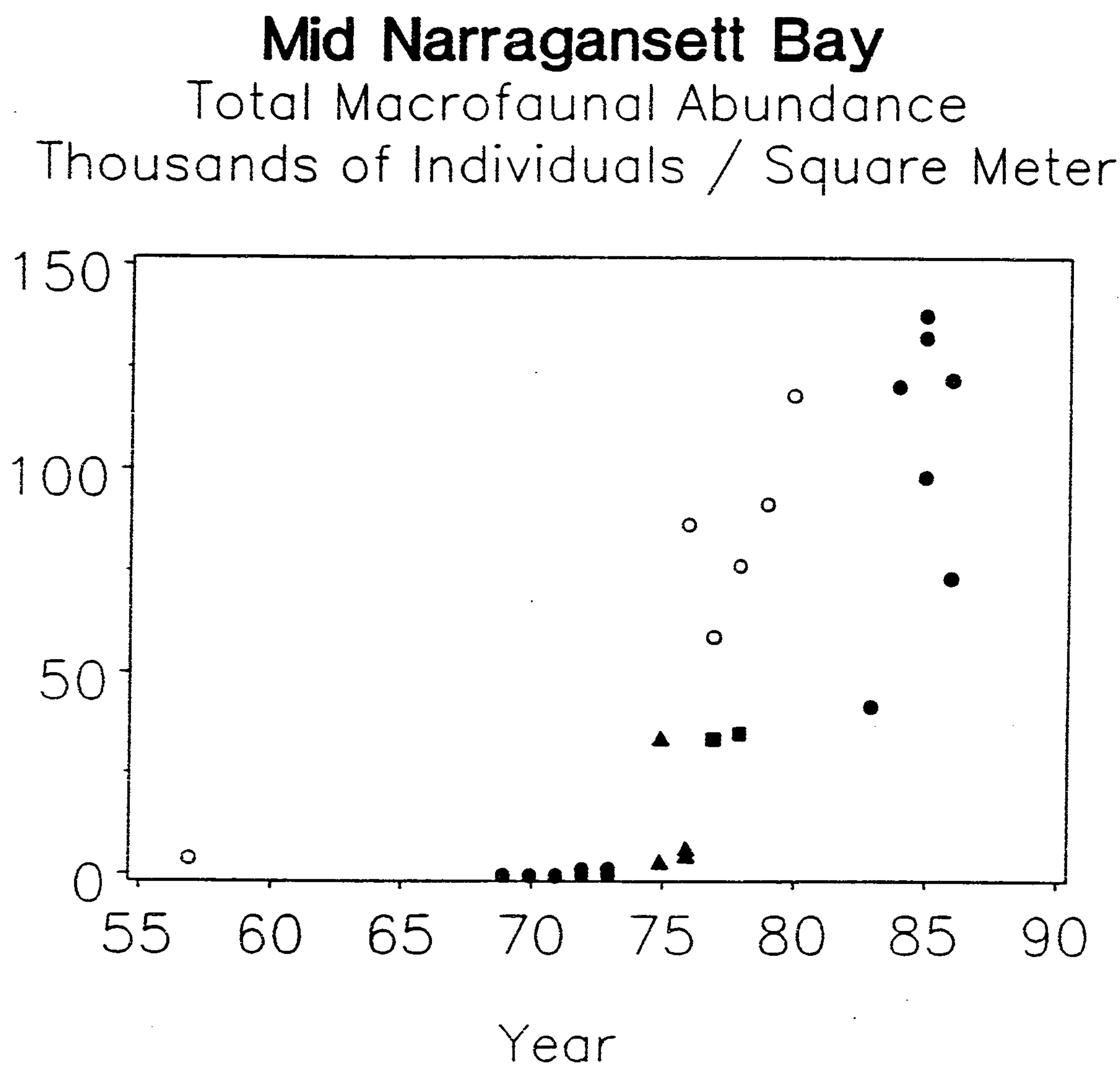
These methodological differences are probably responsible for at least some, but not all of the apparent increase of macrofaunal abundance from 1957 to 1986. One way to assess if this change was real, is to look at the dominant species identified by each study. Table 5 shows the three most numerically dominant species for each study. The Ampelisca spinipes reported in Phelps (1958) is the name of a European species and was at the time of the study used for individuals that would later be identified as Ampelisca abdita and Ampelisca vadorum. All of the species mentioned in Table 10 have been identified in recent studies of the mid bay macrofauna. Amphipods are no longer dominant as was indicated by Phelps (1958) and Hale (1974), but amphipods are notoriously patchy both in space and time and Phelps' one sample (no replicates were taken) could have sampled a particularly abundant patch.

In earlier descriptions of the mid bay benthos (Olsen et al. 1980) and in local folklore, the community was described as a Nephtys - Nucula community based upon the numerically dominant species. This community was thought to be similar to the Nephtys - Nucula community described by Sanders in Long Island Sound (Sanders 1956) and Buzzards Bay (Sanders 1958, 1960). Support for the Nephtys - Nucula moniker came from Chowder and Marching Society (1967) and Hale (1974), and not from the earlier study of Phelps (1958) (see Table 10).

Table 5
Dominant Species in the Mid Narragansett Bay Region

1957 Phelps 1958 Station 13a	1967 Chowder and Marching 1967 Station B
Ampelisca spinipes (26%) Retusa canaliculata (21%) Mulinia lateralis (16%)	Nucula proxima (42%) Nephtys incisa (13%) Yoldia limatula (7%)
1969 - 1973 Davis, Unpublished - Station C	1969 - 1973 Davis, Unpublished - Station D
Nephtys incisa (29%) Nucula annulata (23%) Pitar morrhuana (9%)	Nucula annulata (31%) Nephtys incisa (26%) Pitar morrhuana (14%)
1974 Hale 1974 - Station B	1975 - 1976 Myers and Phelps 1968 - Station 1
Mulinia lateralis (62%) Nucula annulata (21%) Leptocheirus pinquis (4%)	Nucula annulata (38%) Turbonilla interrupta (23%) Macoma tenta (5%)
1977 - 1978 Hyland 1981	1976 - 1980 Grassle and Grassle, Unpublished
Nucula annulata (69%) Mediomastus ambiseta (15%) Turbonilla spp. (2%)	Mediomastus ambiseta (43%) Nucula annulata (25%) Mulinia lateralis (7%)
1983 - 1986 Hughes, Unpublished	
Mediomastus ambiseta (72%) Nucula annulata (15%) Polydora ligni (2%)	

Figure 28
Long-term Trends - Total Macrofaunal Abundance



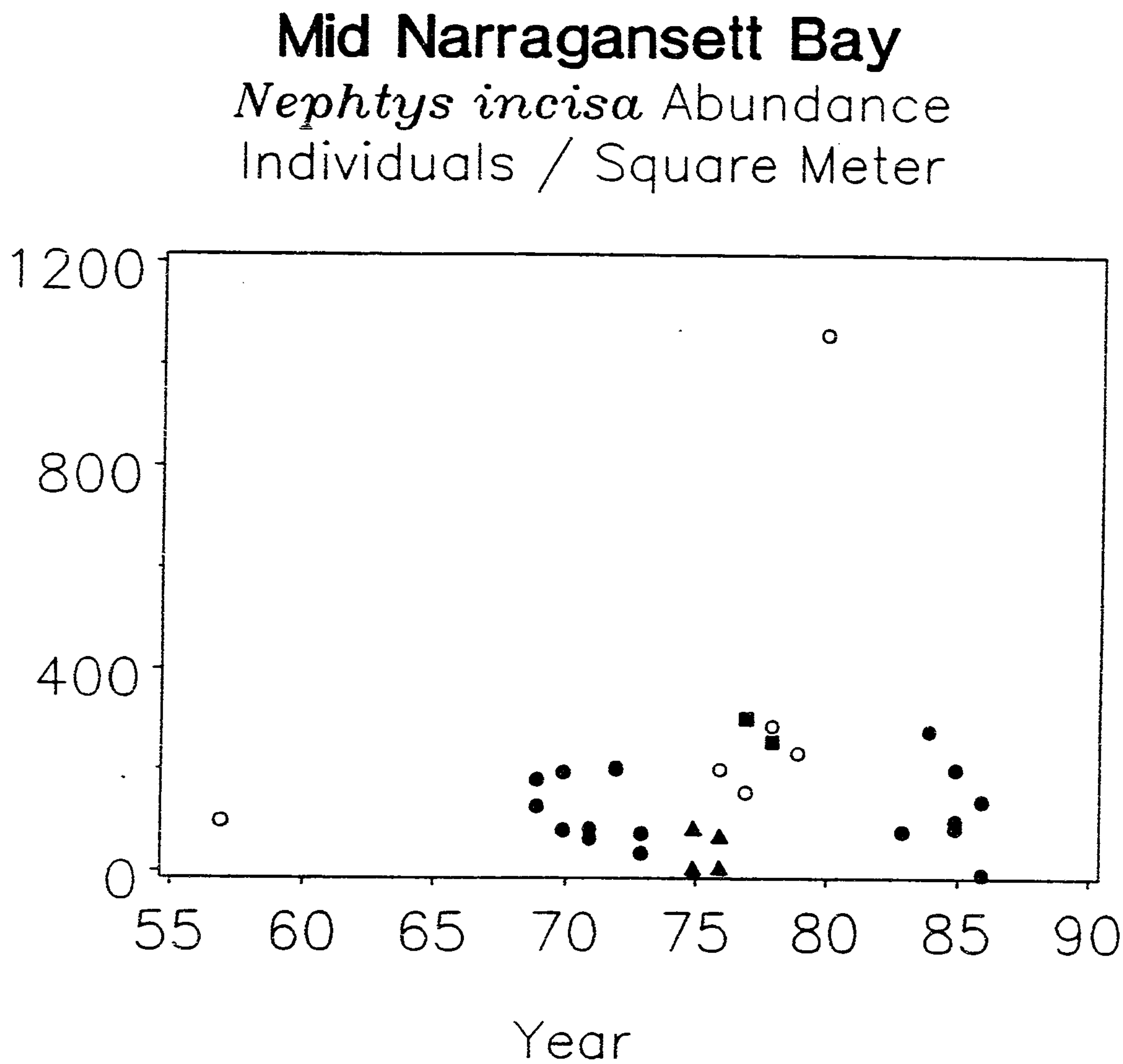
Starting in the late 1970's, the mid-bay benthos started to be described as a Mediomastus - Nucula community, again reflecting the dominant species. The new dominant (Mediomastus ambiseta, a small Capatellid, sub-surface deposit feeder), was one that had been entirely omitted in data sets collected prior to 1975. This was not solely due to these earlier studies using course sieve sizes or grab and dredge samplers. For example, Phelps (1958) and Myers and Phelps (1978) used 500 um sieves instead of the 300 um sieves used by Hyland (1981); Grassle et al. 1985; and Hughes (Unpublished). Five hundred micron sieves should have been adequate to capture some individuals of Mediomastus ambiseta, since about 43% of all Mediomastus collected by Hughes was caught on a 500 um sieve, the remainder falling through to a 300 um sieve. The total lack of Mediomastus in earlier studies is, therefore, unlikely to be due to changes in sieve size. Likewise, changes in sample methods cannot account for the apparent increase in abundance from 1957 to 1986. Even if the grabs and dredges used by Phelps (1958), Chowder and Marching (1967) Davis (Unpublished), and Hale (1974) blew away the entire top 2 cm of sediment (an extremely unlikely scenario), 14% of the Mediomastus found would remain, assuming a vertical distribution as in Hughes (Unpublished).

The possibility exists that Mediomastus was incorrectly identified in earlier descriptions of the mid bay benthos. [The genus was first described in 1944 (Hartman 1944). Hartman (1947) first described the species in 1947 (Hartman 1947), but placed it in the genus Capitita. The species was placed in its current genus by Hartmann-Schroder (1962).] If this species was misidentified, it would most likely be confused with another of its family (Capitellidae), or, more rarely, an aberrant oligochaete. It is unlikely that Phelps (1958) misidentified Mediomastus. No Capitellids or oligochaetes were found in any of his samples. Similarly, no oligochaetes and only one unidentified Capitellid were found in the Chowder and Marching Society (1967) study, and no Capitellids or oligochaetes were identified by Davis (Unpublished) or Hale (1974). Mediomastus was found in only 2 of the 20 cores taken by Myers and Phelps (1978) in the mid bay region (their stations 1, 2, and 2A). In studies thereafter (Hyland 1981; Grassle et al. 1985; Hughes Unpublished), Mediomastus regularly appears as a dominant species.

Although the evidence is not entirely satisfying, the appearance of Mediomastus as a dominant species in mid Narragansett Bay beginning in the 1970's, cannot be entirely attributed to changes in sampling methods, sieve sizes, or the taxonomic experience of individual investigators. Mediomastus appears to have entered the mid bay benthos in the early seventies (although could have been present at low abundances for many years previous) and quickly was established as a dominant species. By 1976-1977, Mediomastus was firmly established and there is little evidence that the abundance of this opportunistic species has increased since.

The rapid establishment of Mediomastus as a member of the mid bay benthic community in the 1970's may be indicative of greater organic enrichment in this part of the bay. Studies conducted in experimental ecosystems (mesocosms) have clearly shown Mediomastus populations can quickly increase abundance and biomass in response to

Figure 29
Long-term Trends - Nephtys incisa Abundance



organic enrichment (Frithsen et al. 1989). Whether the mid-bay region is experiencing greater organic enrichment, be it from a gradual eutrophication (nutrient enrichment) or allochthonous carbon sources, must await further evidence from other components of the system. Hinga et al. (1988) found no evidence for a long term increase in phytoplankton biomass or production in Narragansett Bay. Such an increase should be apparent if the bay was becoming more eutrophic since fairly good relationships between nitrogen loading and phytoplankton biomass and production have been demonstrated by a number of investigators (Oviatt et al. 1986; Nixon et al. 1986).

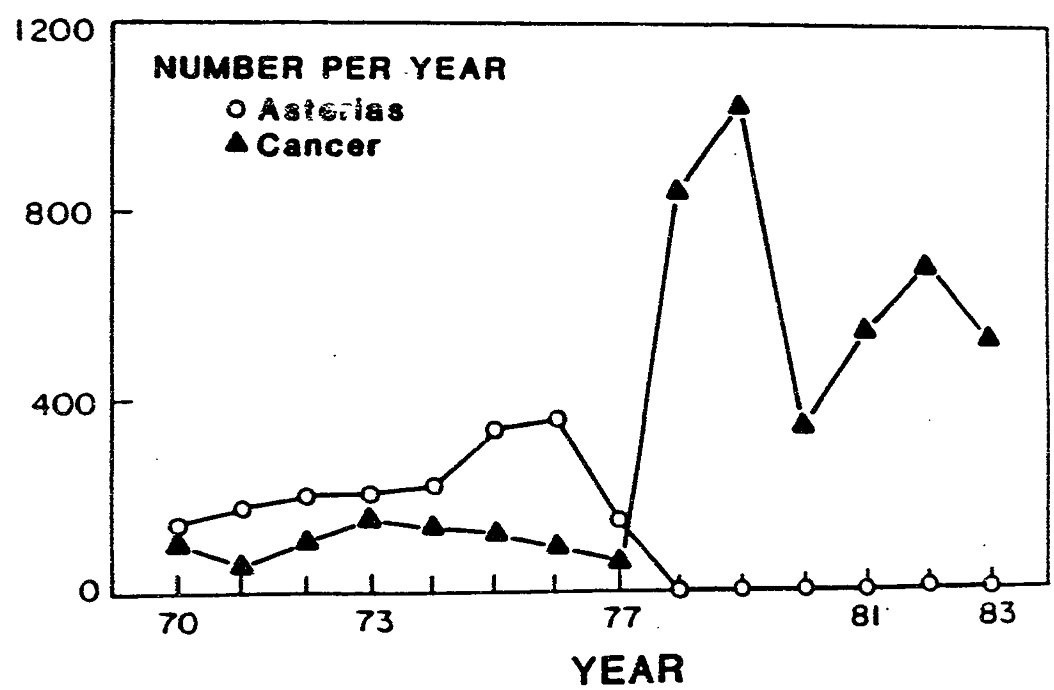
The change from a Nephtys - Nucula dominated community to a Mediomastus - Nucula dominated community implies either an increased presence of Mediomastus, or a decreased abundance of Nephtys, or both. The evidence for an increase in the abundance of Mediomastus has been reviewed above. Grassle et al. (1985) have suggested that "the middle bay community has undergone some changes over the decade prior to [...1976]" e.g., Nephtys incisa was more abundant in the 1950's (Phelps 1958). Such a decline was observed over a very similar period in Long Island Sound (compare Sanders 1956, and Reid 1979) although Nephtys remained the dominant polychaete during the period 1972-1978 (Reid 1979).

Evidence for such a decline in the abundance of Nephtys is difficult to tease out of the information available for Narragansett Bay because of the same methodological problems considered for the increased abundance of Mediomastus. Nephtys is considerably larger than Mediomastus and, therefore, likely to be less sensitive to bow wave effects during sampling and the effects of smaller sieve sizes. Even accounting for differences in methodology, the evidence for a decline in the abundance of Nephtys in Narragansett Bay is unconvincing (Figure 29). It appears the change from a Nephtys -Nucula community to a Mediomastus - Nucula community is primarily due to an increase in the population of Mediomastus.

The discussions above make apparent the difficulties of analyzing long-term trends for the infaunal communities of Narragansett Bay. The data sets that exist were not collected for that purpose. Better data exist with which to make an analysis of long-term trends for the larger epifaunal benthic species in the bay. These data were collected as part of a survey of demersal fish in the west passage conducted since 1966 (Jeffries and Johnson 1974; Jeffries and Terceiro 1985). Terceiro (1985), as part of a doctoral dissertation completed at the Graduate School of Oceanography, University of Rhode Island, has used the abundances of epibenthic macroinvertebrates caught in these fish trawls during the period 1970 to 1983, to detail long term changes.

The trawls were conducted weekly at a station near Fox Island in the west passage, and at a station near Whale Rock at the mouth of the bay. Dominant species at both stations were the rock crab (Cancer irroratus), starfish (Asterias forbesi), spider crabs (Libinia emarginata), horseshoe crabs (Limulus polyphemus), lobsters (Homarus americanus) and whelks (Busycon canaliculatum). Terceiro (1985) has identified what he calls a successional pattern for these large epibenthic fauna. "Prior to 1978, Asterias was the most abundant bay species, dominating the assemblage in every season except spring. Cancer, Libinia, and Limulus experienced short term peak abundances during spring and summer ... Beginning in 1978, Asterias catch in the bay declined to less than 10% of previous totals. Cancer experienced a concurrent 10-fold increase, and became the most abundant bay species in 1978 and later years" (Terceiro 1985) (Figure 30). Asterias also disappeared from the sound catch in 1978. Overall, the epibenthic fauna at the Fox Island Station shifted from a Asterias - Libinia - Limulus dominated assemblage to a Cancer - Homarus dominated assemblage. The replacement of Asterias by Cancer may be related to their similar diet requirements and the firm establishment of Cancer when Asterias declined in 1978. A change towards warmer summer temperatures is another possible cause suggested by Terceiro (1985), but no temperature data are presented to support this view. The possibility that other factors may be responsible for the starfish decline cannot be excluded. Similar rapid declines have been documented in Long Island Sound and Narragansett Bay and are thought to be a part of a 14 year cycle (Burkenroad 1946, 1957).

Figure 30
Long-term Trends - Asterias and Cancer (Terceiro 1985)



Benthic Biomass:

The biomass of benthic communities within Narragansett Bay has been measured only rarely. The first published numbers for macrofaunal biomass were those of Hale (1974) who measured biomass along a three station transect from the mouth of Greenwich

Bay to the lower west passage adjacent to the University of Rhode Island's Narragansett Bay campus. Biomass ranged from 8.7 g to 37.46 g formalin dry weight/m^2 (Table 6)

Table 6
Biomass Dominant Species
Hale (1974)
g formalin dry weight/m^2

Station	A Greenwich Bay	B Conanicut Island	C Lower W.Passage
Total Biomass	8.67	9.88	37.46
Ampelisca abdita	3.08 (32%)		
Nassarius trivittatus	2.32 (27%)		
Neopanope texana sayi	1.60 (18%)		
Ensis directus	0.52 (6%)		
Pitar morrhuana		2.12 (21%)	
Nucula annulata		1.74 (18%)	
Lumbrinereis fragilis		0.94 (10%)	
Nephtys incisa		0.9 (9%)	
Mercenaria mercenaria			19.38 (52%)
Pitar morrhuana			9.32 (25%)
Ensis directus			2.70 (7%)
Tellina agilis			1.00 (3%)

Amphipods and polychaetes were removed from tubes and molluscs removed from shells prior to weighing.

with the lowest biomass at the mouth of Greenwich Bay and the highest in the lower west passage. Dominant species at one station were generally subdominant at others (Table 6). For example, the amphipod Ampelisca abdita and the gastropod Nassarius trivittatus dominated at the Greenwich Bay station, the bivalves Pitar morrhuana and Nucula annulata dominated at the mid bay station, and the bivalves Mercenaria mercenaria and Pitar morrhuana dominated macrofaunal biomass at the lower bay station. Dry weight biomass was 11% of wet weight at the station dominated by amphipods, and 6% at stations dominated by bivalves. Ash free dry weight was 70 to 79% of dry weight.

Macrofaunal biomass has been measured in the vicinity of Hale's (1974) Station B by Grassle et al. (1979) and Rudnick et al. (1985). The methods used by these later studies differed significant from those of Hale (1974); diver collected cores were taken instead of Smith-McIntyre grabs and 300 um sieves were used in place of the 750 um sieve used by Hale. Grassle et al. (1979) reported a mean biomass of 10.41 ± 1.79 g decalcified ash free dry weight/m^2 for five 35.3 cm^2 cores. The numerically dominant polychaete, Mediomastus ambiseta, made-up about 10% of this total, with a mean biomass of 0.99 ± 0.28 g/m^2. Although the sample size is small, these numbers would suggest that the between-core variability for biomass is less than that for abundance.

Rudnick et al. (1985) working at the same station as Grassle et al. (1979), reported macrofaunal biomass to be 3.42 g C/m^2, of which 60% was accounted for by the bivalves Nucula annulata, Mulinia lateralis, and Yoldia limatula.

Cores used by Grassle et al. (1979) and Rudnick et al. (1985) can exclude many large and deeper living macrofauna, thus providing only minimal estimates of macrofaunal biomass. Better measurements of biomass can be made by sieving large volumes of sediments. This has been done only once or twice in Narragansett Bay, but these data could not be located for this report. Analogous data are available from experiments conducted in large mesocosms. In one such experiment, sediment was collected from Station I of Grassle et al. (1979) and Rudnick et al. (1979), and held in flow-through mesocosms for 30 months (control mesocosms in Frithsen et al. 1989). Approximately 1 ton (2.52 m^2 X 37 cm deep) sediment was then sieved through 3.2 mm sieves. Macrofaunal biomass was 33.58 g ash free dry weight/m^2, of which, about 59% was bivalve biomass.

Although the mesocosms used in this experiment are thought to be good analogues to Narragansett Bay, similar biomass measurements of large sediment volumes should be made in Narragansett Bay to confirm the presence of these large macrofaunal standing stocks. Further, biomass measurements should be made in other regions of the bay to confirm the north-south biomass gradient found by Hale (1974).

In addition to macrofaunal biomass, Rudnick et al. (1985) measured meiofaunal biomass and reported it to be 1.14 g C/m^2. Nematodes, the most abundant meiofaunal group, contributed 44% to the total meiofaunal biomass.

Benthic Communities of Specific Areas:

Brush Neck Cove:

Brush Neck Cove is a small, tidally flushed inlet of Greenwich Bay currently classified as a Class A conservation area by the CRMC (Olsen and Seavey 1983). The macrofauna within this cove were studied in 1977 as part of an environmental impact assessment of proposed dredging (Oviatt et al. 1977). Five stations along the axis of the cove were sampled once, with two or three replicate cores taken at each station. Total macrofaunal abundance (0.5 um sieve) ranged from 33 to 27,300 individuals/m^2, with highest abundance supported at the mouth of the cove (Station 5). Highest species diversity was also found at the mouth, but highest biomass (87 g dry weight/m^2) was found at the head of the cove in sandy muds where a Capitellid polychaete (Notomastus luridus) dominated. Lowest abundances, species diversity and biomass were found in central, deeper areas (Stations 3 and 4).

The study identified 32 species (or species groups) dominated by small, surface deposit feeding polychaetes (Capitella spp., Scoloplos robustus, Notomastus luridus) and the suspension feeding steamer clam (Mya arenaria). Opportunistic spionids (Streblospio benedicti and Polydora ligni) also were dominant in some samples. The species assemblages identified are those generally found in organic rich, euryhaline environments.

Brush Neck and the adjacent Buttonwoods Cove supports a robust sport fishery for both fin and shellfish. Diversity of both piscine and avian fauna is greater in these undeveloped coves compared with the more developed neighboring Warwick Cove (Oviatt et al. 1977).

Greenwich Bay:

The benthos of Greenwich Bay was extensively studied in 1951 and 1952 by the shellfish survey branch of the U.S. Fish and Wildlife Service which, at that time, supported an office in Narragansett. The purpose of this infaunal survey was to attempt correlations between macrobenthic community types and the occurrence of the commercially important clam, Mercenaria mercenaria (then called Venus mercenaria). To this end, 213 stations were sampled in 1951 and 226 stations sampled in 1952. Macrobenthic communities in other parts of Narragansett Bay have not been studied in such detail.

The principal findings of the infaunal survey were published by the principal investigators (Alden Stickney and Louis Stringer) in 1957. Since then, benthic communities in Greenwich Bay have been sampled occasionally, but only the unpublished data of Frithsen (Unpublished A) could be included in this report.

Although Stickney and Stringer's survey used a course sieve (2 mm), 72 species (or groups) were identified in 1951 and 102 identified in 1952. Samples in both years were dominated by amphipods of the genus Ampelisca. Stickney and Stringer reported most Ampelisca to be Ampelisca spinipes, a european species. In actuality, what they called A. spinipes were really a combination of A. vadorum and A. Abdita (Mills 1963).

Individuals identified as A. spinipes by Stickney and Stringer averaged 77 individuals/m^2 in 1951 and 3,835 individuals/m^2 in 1952. In both surveys, spatial variability was high with the coefficient of variation of the mean being greater than 100%. Ampelisca like many amphipods, tend to be patchy both spatially and temporally and high variability is typically observed in many benthic surveys.

It is not unusual for macrobenthic abundances to vary greatly from year to year. Indeed, abundances within Narragansett Bay show large seasonal variations (Grassle et al.

Table 7

Greenwich Bay
Stickney and Stringer Infaunal Surveys
Dominant Species
Abundance as Individuals per Meter Squared

1951 Survey
213 Stations

	Mean	S.D.	Range
Ampelisca spinipes (Amphipod)	77	334	0 - 3543
Gemma gemma (Bivalve)	73	552	0 - 6522
Nassa sp. (Gastropod)	67	147	0 - 978
Pectinaria gouldii (Polychaete)	67	147	0 - 1587
Podarke obscura (Polychaete)	38	88	0 - 522
Total	502	777	21 - 6804

1952 Survey
226 Stations

	Mean	S.D.	Range
Ampelisca spinipes (Amphipod)	3835	4533	0 - 21739
Crepidula spp. (Gastropod)	130	597	0 - 3696
Corophium spp. (Amphipod)	93	317	0 - 3478
Spiochaetopterus oculatus (Polychaete)	84	165	0 - 1261
Podarke obscura (Polychaete)	70	174	0 - 1196
Total	4788	4745	0 - 23674

1985) and similar variations have been shown in other estuaries as well (Nichols and Thompson 1985; Holland et al. 1987). It is somewhat unusual, however, that dominant species changed so much from 1951 to 1952 (Table 7). Other studies of the Narragansett Bay benthos have demonstrated very little change in composition from year to year (Grassle et al. 1985). Of the five most dominant species identified in 1951, only two made the same list in 1952. This type of shift in species dominance, coupled with the nearly ten fold increase in total abundance between 1951 and 1952 (Table 7), suggests that either something in Greenwich Bay was dramatically different between those years, or that the methods used by the investigators introduced much variability into the analysis of macrofaunal abundance. Since there was much variability both spatially (between stations) and temporally (between years), the variability most likely is due to the coarse sampling methods used. In their published paper, Stickney and Stringer (1957) concluded that the variability observed was due to the irregular and discontinuous distribution "of nearly all species collected".

Despite the variability, some broad distributional patterns were identified from the Stickney and Stringer surveys. Muddy sediments were generally dominated by Ampelisca. Associated with Ampelisca, but with much lower abundances, were the amphipod Corophium cylindricum, the polychaete Tharyx acutis, the gastropod Acteocina (Tornatina) canaliculata, and the bivalve Macoma tenta. Stickney and Stringer (1957) described this Ampelisca dominated community as "the most extensive community in Greenwich Bay".

In sandy or shelly sediments, the slipper shell Crepidula fornicata dominated. Associated with Crepidula were the jingle shell Anomia simplex, and the clam worm Nereis succinea. Stickney and Stringer (1957) noted that Nereis were more abundant and larger when associated with Crepidula dominated communities, than when associated with other community types.

Several species were believed to be characteristic of the bay due to their abundance and broad distribution. These species were: Mercenaria (Venus) mercenaria, Ampelisca spp. (spinipes), Corophium cylindricum, Podarke obscura, Pectinaria gouldii, Nereis succinea, Spiochaetopterus oculatus, and Heteromastus filiformis. The broad distribution of these species was not always consistent between the two surveys. For example, Corophium cylindricum was found in only 3 of the 213 stations sampled in 1951, but was found in 103 of the 223 stations sampled in 1952. This degree of temporal variability may or may not be real, but is most likely due in part to the methods used.

The Stickney and Stringer surveys were unable to identify any correlations between the distribution of Mercenaria mercenaria and other benthic species. Mercenaria was less abundant in muds, as has been shown by others for Narragansett Bay as a whole (Pratt 1953). The distribution of the hard clam was similar to that of the clam worm, Nereis succinea, but no relationship was inferred by Stickney and Stringer (1957). The authors did note, however, that other east coast records had indicated that the distribution of Mercenaria was similar to that of the ice cream cone worm Pectinaria gouldii. The relationship remains unproven.

Over thirty years after Stickney and Stringer completed their infaunal survey of Greenwich Bay, a far more limited study (2 cores taken at 1 station) was completed by Frithsen (Unpublished A). In the latter study, diver collected cores were used instead of a clamshell bucket, and 300 um sieves were used instead of a 2 mm mesh net. Mean macrofaunal abundance for the two cores was over 1.5×10^6 individuals/m^2 compared with a mean abundance of 2.7×10^3 individuals/m^2 for all stations in the Stickney and Stringer surveys. As in the 1951-52 surveys, the 1986 study by Frithsen indicated the amphipod Ampelisca (A. abdita) was the numerically dominant macrofaunal species (mean abundance 982.8×10^3 individuals/m^2). The second most abundant species in the 1986 study was the small capitellid polychaete Mediomastus ambiseta. Conceivably, Stickney and Stringer mistakenly identified Mediomastus as Heteromastus in their study. Species also dominant in the 1986 study were Corophium spp., Polydora ligni and an unidentified Syllid. Differences between the 1951-1952 study and the 1986 study may be attributed to methodological differences.

Kickimuit River:

The Kickimuit River is a small estuary emptying into the southeast corner of Mt. Hope Bay. Thirteen stations along the river were sampled once in 1983 (Pratt, Unpublished) using a gas can corer and Ekman dredge. Exact station locations were not available for this project. Abundances (1 mm sieve) ranged from 444 to 49,134 individuals/m^2. Fifty species were identified in all, with 17 species dominant (>1% of total abundance). The most dominant species were the polychaetes Heteromastus filiformis and Streblospio benedicti, the gastropods Odostomia trifida and Illyanassa hyalina, the bivalve Gemma gemma, and the amphipod Ampelisca abdita. The species assemblage in the Kickimuit River is suggestive of a clean, euryhaline environment, having some degree of organic enrichment.

Narragansett Bay Estuarine Santuary:

The Narragansett Bay Estuarine Sanctuary was established in September 1980 and is comprised of 2,626 acres of land and water located between 41° 41' 36" N and 41° 35' 42" N latitude and 71° 22' 28" W and 71° 19' 45" W longitude. Patience Island, northern Prudence Island and Hope Island are included in the Sanctuary area. To date, there has been no complete infaunal survey of the sanctuary sediments. However, in 1983 a shellfish survey was completed (Satchwill et al. 1983) and areas of the sanctuary have been sampled by various graduate students at the Graduate School of Oceanography, University of Rhode Island, to study the bivalve Nucula annulata (Craig, Unpublished) and the epibenthic shrimp Crangon septemspinosa (Whitehouse, Unpublished).

Shellfish in the seawater borders of the estuary include three species with commercial or recreational value. The quahog (Mercenaria mercenaria dominates, accounting for 79% of all shellfish found (Satchwill et al. 1983). The soft shelled clam (Mya arenaria) makes up 18% of the shellfish, and the razor clam (Ensis directus) 3%. The majority of the quahogs (50%) were large, 'chowder' size individuals, but a fair proportion (31%) of the population was made up of individuals smaller than the minimum legal size for shellfishing (at the time of the survey 38.0 mm length) indicative of successful recruitment to this population. Approximately 32% of the soft shell clam population was also smaller than the minimum legal size (at the time of the survey, 38.0 mm length). "Much of the quahog resource was located in areas where the substrate was not suitable for commercial harvesting devices such as bullrakes and tongs" (Satchwill et al. 1983).

Rhode Island Sound:

Rhode Island Sound lies at the mouth of Narragansett Bay. Although not strictly within the scope of this project, a brief review of the benthic communities within the sound is useful because these communities are to some degree, albeit unknown, a source of benthic larvae for the lower reaches of the bay. Sediments in the sound are predominately sands, silty-sands, and sandy silts, and are generally coarser than sediments within Narragansett Bay (McMaster 1960).

Benthic communities within the sound have been studied on an irregular basis since 1972. Only two studies (Pratt 1972; Reid et al. 1981) have included benthic stations at the mouth of Narragansett Bay. Other studies have been extensions of benthic studies focusing on Long Island Sound and were concentrated in Block Island Sound (Reid 1979; Reid et al. 1979; Steimle 1982).

Benthic communities within the sound are fairly distinct from those in Narragansett

Table 8
Dominant Species in Rhode Island Sound
Reid et al. 1981
Individuals/m^2

December 1975 5 Cores		July 1980 5 Cores	
Nucula proxima	17,614	Nucula proxima	15,038
Ampelisca agassizi	2,594	Periploma papyratium	4,104
Paraonis gracilis	1,158	Paraonis gracilis	1,130
Periploma papyratium	774	Euchone incolor	1,018
Ninoe nigripes	544	Ninoe nigripes	980
Nucula delphinodonta	434	Clymenella torquata	792
Retusa obtusa	266	Nucula delphinodonta	594
Edwardsia elegans	258	Lumbrineris tenuis	404
Rhynchocoela	226	Retusa obtusa	37
Nephtys incisa	224	Edwardsia elegans	352

Bay. Species present are often congeners of species found in the bay and are probably adapted to life in an environment having smaller temperature variations (Shonting and Cook 1970), lower productivity, and diminished suspended loads than are found in most of Narragansett Bay. Pratt (1972) reports that Ampelisca agassizi was the numerical dominant in samples taken from Rhode Island Sound using a Smith-McIntyre grab and a 750 um mesh sieve, a finding confirmed by a later study (Pratt 1988a). Reid et al. (1981), using a similar Smith-McIntyre grab and a 500 um sieve, reported Nucula proxima was the numerical dominant, but his station was located at a mud patch atypical of the remainder of the sound. Ampelisca agassizi was among the ten most abundant species in only one of the two sample dates reported by Reid et al. (1981) (Table 8). This Ampelisca -Nucula community assemblage is similar to that described by Steimle (1982) for Block Island

Sound. More specific community types associated with specific sediment types and dredge spoil in Rhode Island Sound are described by Pratt (1972).

Table 8
Sheffield Cove Shellfish Survey
Bockstael 1972
Individuals/m^2

Mercenaria mercenaria (quahaug)	12.3
Mya arenaria (soft-shelled clam)	20.7
Ensis directus (razor clam)	5.6
Aequipecten irradians (bay scallop)	1 - 2
Crassostrea virginica (oysters)	Scarce

Sheffield Cove:

Sheffield Cove is a small, shallow (< 1 m), tidally flushed cove entering Dutch Island Harbor on the west side of Conanicut Island. Sediments are generally course (sand, shells and stones) but some mud patches can be found in more isolated areas of the Cove. No infaunal survey has been completed in the cove except for the shellfish survey of Bockstael in 1972 (Bockstael 1972). Only the species Mercenaria mercenaria, Mya arenaria, Aequipecten irradians, Crassostrea virginica, and Ensis directus were surveyed (Table 9), although Crepidula fornicata were also reported to be present. As in past surveys of the bay (Pratt 1953; Russell 1972), Mercenaria mercenaria were more abundant in coarse sediments compared with muddy patches. At the time of the survey, most quahogs and all soft shelled clams were below the minimum legal size for shellfishing.

Taunton River:

Four stations have been sampled in the Taunton River to assess the macrofauna (Pratt 1977a). Abundance ranged from 3,943 to 38,358 individuals/m^2 with highest abundances north of the confluence with the Assonet River. Lower abundances down river may reflect past dredging and industrial discharges.

The study identified 36 macrofaunal species (or groups) dominated by the polychaetes Streblospio benedicti, Polydora ligni and Mediomastus ambiseta, and oligochaetes (not identified to the species level). The species assemblage is typical of organic rich environments and reflected the low and variable salinity found in this portion of the river. Pratt (1977a) reports that the area shows the potential to support recreational shellfishing for the soft-shelled clam Mya arenaria. Since this area of the Taunton River formally received discharges of mercury, some amount of monitoring of sediments and shellfish may be prudent.

BENTHIC LARVAE

Most benthic meiofaunal species restrict their development entirely within the sedimentary milieu, whereas most benthic macrofauna generally release larvae into the water column (Warwick 1980). There, benthic larvae are transported by the currents and, those forms that must feed in the water column, compete with zooplankton for available resources. Exceptions are those groups that brood young, such as Isopods, Cumaceans, and Amphipods.

There have been few studies of the occurrence of benthic larvae within Narragansett Bay. In most cases, benthic larvae are enumerated as meroplankton in studies of the zooplankton, and taxonomic detail is restricted to large categories such as 'bivalve larvae', 'polychaete larvae', and 'decapod larvae'. The few studies that have treated benthic larvae in more detail have concentrated upon the occurrence of Mercenaria larvae (Landers 1954), or decapod larvae (Hillman 1964; Trifan 1987). Mr. Paul Fofonoff, currently a doctoral candidate at the Graduate School of Oceanography, University of Rhode Island, has attempted to identify pelagic larvae of benthic species in the bay, but this work is ongoing.

Meroplankton studies have shown that benthic larvae are more abundant in the upper bay than in the lower bay (Smayda 1987; Durbin and Durbin 1988). Figure 31 presents the mean (trapezoidal integration) number of benthic larvae at seven stations in the bay sampled weekly by Smayda (1987). The trend towards more benthic larvae in the upper bay may reflect the occurrence of a greater number of opportunistic species in this

Figure 31

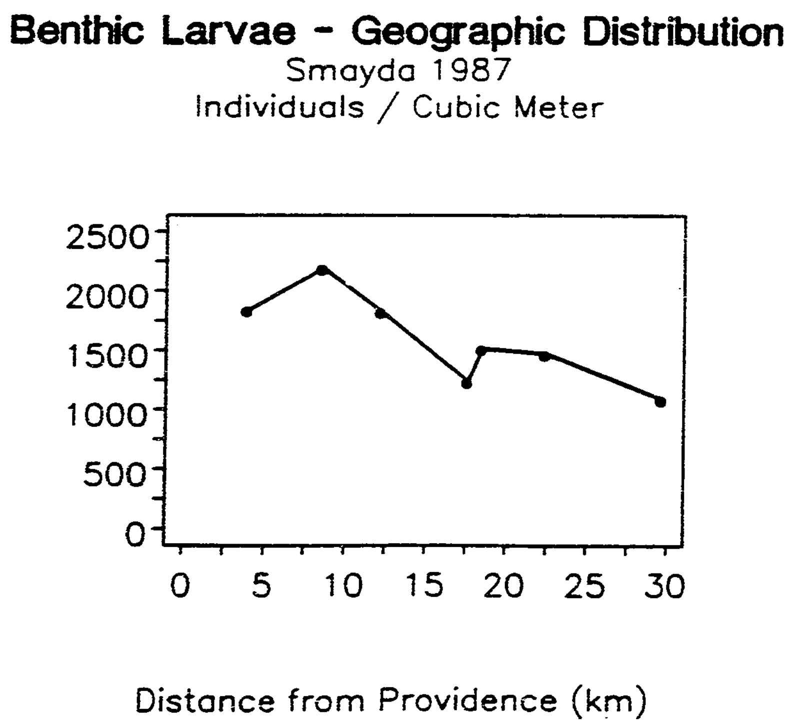
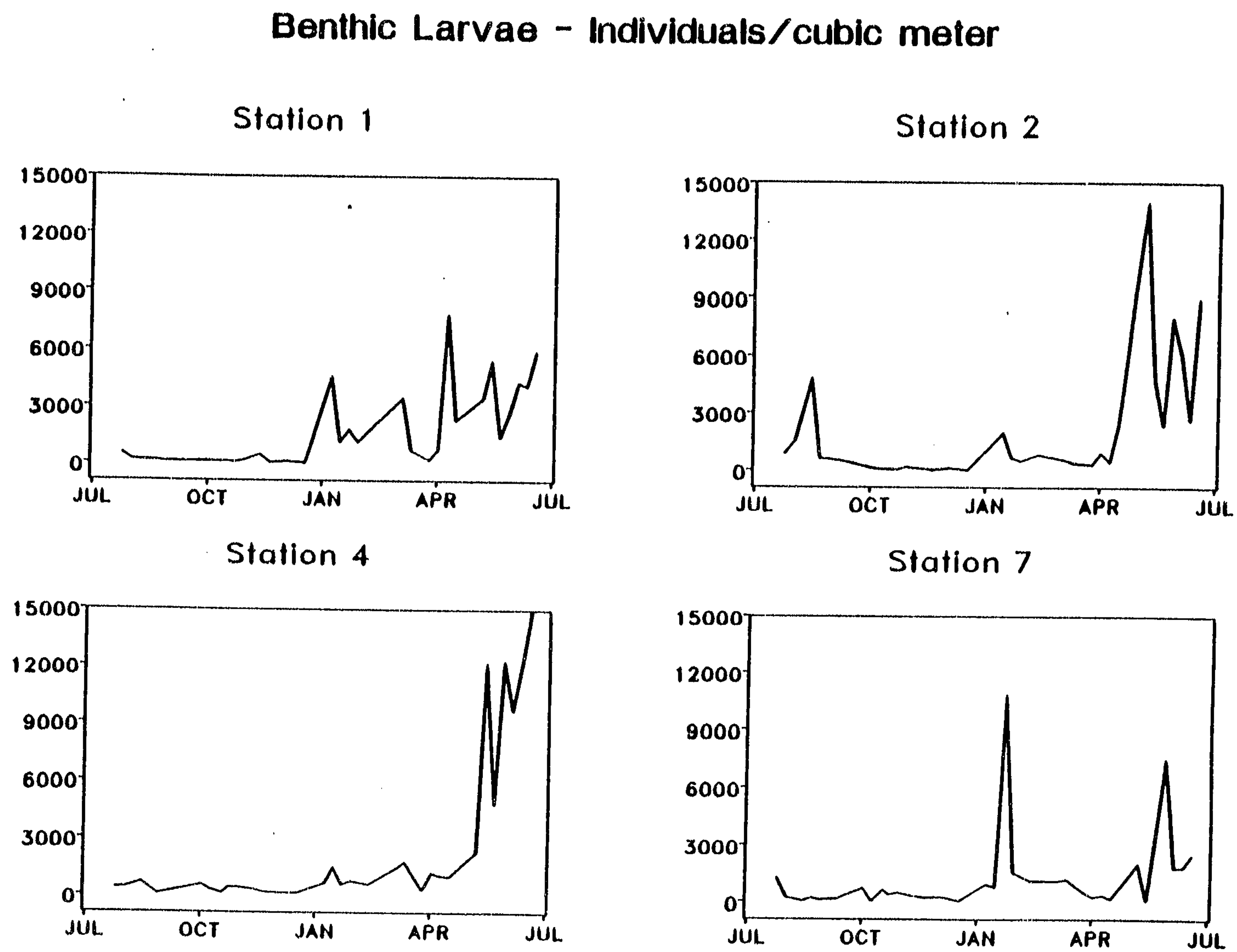


Figure 32
Smayda 1987



portion of the bay. Opportunistic species (like Mulinia lateralis, Polydora ligni, and Streblospio benedicti) by definition (Grassle and Grassle 1974; Pearson and Rosenberg 1978) have high reproductive potentials and can produce enormous numbers of larvae. (Calabrese has shown that each female Mulinia can release an average of 3-4 million eggs per spawning.) Similar distributional trends have been observed by Durbin and Durbin (1981, as reported in Durbin and Durbin 1988). For the period March 1, 1976 to October 22, 1976, the average number of polychaete larvae at their upper bay station (Station 5) was 16,435 individuals/m^3, whereas at their lower bay station (Station 1), polychaete larvae numbered 4,288 individuals/m^3. Bivalve larvae followed a similar trend with 24,633 individuals/m^3 at the upper bay station, and 11,007 at the lower bay station.

The abundances of benthic larvae are generally low in the winter and reach maximums in the later spring and summer months. This seasonal cycle is somewhat similar to the seasonal cycles observed for the adults and juveniles inhabiting the sediments. Figure 32 illustrates the seasonal cycles for benthic larvae at Smayda's Station 1 at the mouth of Greenwich Bay, Station 2 in the Providence River, Station 4 at Conimicut Point, and his Station 7 in the west passage opposite Wickford Harbor. The same general seasonal pattern is observed throughout the bay (Smayda 1987). Note that pulses of larvae can be very short term, lasting for a few weeks, or less. The zooplankton data reviewed by Durbin and Durbin (1988) show the same pattern. Their data also show that polychaete larvae generally show maximum abundances in the plankton early in the summer, whereas bivalve larvae show a smaller spring peak followed by a larger peak in September.

A summer (July, August, and September) survey of the decapod larvae in the west passage was conducted by Trifan (1987) in 1980. Tows were made weekly for eight weeks. Samples were dominated by the larvae of Pinnixa chaetopterana. The relative abundance of other species are shown in Table 10.

Table 10
Relative Abundance of Decapod Larvae in the West Passage
(Sum of 8 weekly tows expressed as Individuals/m^3 - Trifan 1987)

Pinnixa chaetopterana	12,318
Neopanope sayi	7,260
Pagurus longicarpus	7,071
Pinnotheres maculatus	5,006
Upogebia affinis	4,088
Libinia sp.	3,227
Crangon septemspinosa	2,383
Carcinides maenas	1,209
Ovalipes ocellatus	835
Naushonia crangonoides	608
Pagurus annulipes	491
Polyonyx gibbesi	488
Emerita talpoida	441
Callianassa sp.	344
Cancer sp.	309
Palaemonetes sp.	283

BENTHIC SPECIES OF COMMERCIAL OR RECREATIONAL IMPORTANCE

A number of species living on or in the sediments of the bay are of particular interest due to their commercial and recreational importance. Perhaps the premier example of such a species is the hard clam Mercenaria mercenaria. Other species of importance include the american lobster (Homarus americanus), surf clam (Spisula solidissima), bay scallop (Aequipecten irradians), rock crab (Cancer irroratus), Jonah crab (Cancer borealis), soft shelled clam (Mya arenaria), and the oyster (Crassostrea virginica). The later species is only of historical interest in Narragansett Bay.

It is not my intention to complete a review of the biology of any of these species. Such reviews are readily available from the generally published literature. Rather, my intent is only to briefly present what is known about the distribution of these species within Narragansett Bay. I will also present fisheries catch data compiled by the U.S. National Marine Fisheries Service. The National Marine Fisheries Service has been keeping statistics on fin and shellfish fisheries since approximately 1880 (Lyles 1969). These statistics cannot be used to reveal trends about the natural populations of benthic species within the bay. Fishery catch statistics are sensitive to many factors (number of fisherman, catch effort, choice of equipment, changes in the minimum legal size, market price, etc.) that can have very little to do with changes in natural populations.

Hard Clams - Mercenaria mercenaria:

Without question, the hard clam, or quahog (also spelled quahaug), Mercenaria mercenaria is the most important commercial marine species taken from the bay. The 1986 landing was worth $15.6 million to Rhode Island fisherman, exceeding the value of every other fin or shellfish species. Only lobster landings exceeded that of the hard clam ($16.2 million) and many of the lobsters brought to the Rhode Island market are caught offshore. The Rhode Island market now accounts for roughly 25% of the total U.S. hard clam annual catch (Pratt 1988b).

"The quahog is the most abundant animal of its size in or on the bottom in the estuarine waters of Rhode Island" (Pratt 1953). Pratt (1988b) has recently reviewed what is known concerning the biology and distribution of the hard clam in the bay. Our knowledge of what governs clam distributions has not significantly advanced beyond what Pratt's (1953) earlier survey showed 35 years ago. Quahogs are most abundant in mixed types of sediments (fine sediments with minor constituents of sand, shell, or rocks) and least abundant in clay sediments. "The highest mean concentration of quahogs occur only in the presence of shell, usually accompanied by rocks" (Pratt 1953). Subsequent studies have shown similar distribution patterns (Stickney and Stringer 1957). Further, Pratt (1953) showed that "the main centers of quahog abundance are concentrated in the inner (northern) areas of the bay." Pratt (1953) also showed that sediment type strongly affected growth rates, a subject further studied by Pratt and Campbell (1956).

Table 11
Mercenaria mercenaria Densities In Narragansett Bay
Stringer 1957
Individuals/m^2

		Shell Size			
	Sub	Necks	Large	Broken	Total
Providence River	1.9	9.7	5.1	0.2	16.9
Ohio Ledge	0.5	1.7	2.2	0.2	5.2
East Passage	0.5	1.0	0.9	0.1	2.5
Bristol Harbor	1.6	3.7	3.8	0.2	9.3
Mount Hope Bay	0.5	0.9	1.4	0.1	2.9
High Banks	0.2	0.5	2.7	0.3	3.8
Greenwich Bay	0.8	0.8	1.5	0.1	3.1
Upper Bay	0.8	2.0	2.3	0.2	5.3

Sub-legal size - 15 to 46 mm
Neck size - 47 to 66 mm
Large clams - > 66 mm
Broken - Quahogs which were broken and on which no length measurements could be obtained

Pratt's clam survey was bay wide, included 123 stations, and was completed in 1949 to 1950. The next bay wide study was conducted in 1955 to 1956 by the U.S. Fish and Wildlife Service and the Rhode Island Division of Fish and Game. Approximately 2,800 samples were taken and the results summarized in Stringer (1959). The average quahog density reported for various regions of the bay are given in Table 11. Highest densities were found in the Providence River and Bristol Harbor, and lowest densities were found in the East Passage and Greenwich Bay. Subsequent studies continue to show relatively high clam densities in the Providence River (Canario and Kovach 1965; Pratt et al. 1988).

Since the 1955-1956 survey (Stringer 1959), there has been no bay wide effort to assess the abundance of Mercenaria in Narragansett Bay. There have been numerous uncoordinated efforts to assess abundances in restricted regions of the bay and in small coves and embayments (see list of references in Appendix B, Shellfish Surveys, and the review of Pratt 1988), but no synoptic effort. The "big picture" hasn't been put together since 1957, probably because Mercenaria populations are patchy, the patches are changeable due to natural and fishery induced pressures, and there are no quantitative, rapid sampling techniques available.

Table 12
Density of Mercenaria mercenaria in Narragansett Bay
And in Other Estuaries
(Compiled by Doering 1987)

Location	No./m^2	Number of Stations	Reference
Narragansett Bay	0 - 80	20	Phelps 1958
Providence River	0 - 60	121	Saila et al. 1967
West Passage	0 - 24	3	Hale 1974
West Passage	0 - 11	211	Kovach et al. 1968
Quonset Point	0 - 9	-	Pratt 1977
Round Swamp	0 - 161	25	Russell 1973
Brightman's Pond	0 - 23	53	Ganz 1975
Long Island Sound	0.9	-	MacKenzie 1979
Northport Bay, NY	6.5	-	MacKenzie 1979
Great South Bay, NY	18.4	-	MacKenzie 1979
Raritan Bay, NJ	14.0	-	MacKenzie 1979
Lower Little Egg Harbor, NJ	34.0	-	Carriker 1961
Bogue Sound, NC	0.4 - 11.3	57	Peterson 1982
Santee River, SC	18 - 24	-	Rhodes et al. 1977
Wassaw Sound, GA	0.5 - 101	39	Walker et al. 1980

Table 12 is a brief attempt to compare quahog densities in Narragansett Bay with densities in other areas of the east coast. The table was compiled by Doering (1987). Densities in Narragansett Bay are in the range of those observed in other estuaries.

The annual landing statistics for Mercenaria are given in Figure 33. Possible explanations for annual changes have been discussed in Pratt (1988).

In the past, emphasis has been on research investigating the effects of the bay on Mercenaria. The emphasis, however, may be reversed to pose the question - "What are the effects of Mercenaria on Narragansett Bay?" Laboratory, mesocosm, and field studies have demonstrated that benthic communities can significantly alter water column particle dynamics, phytoplankton community structure, and plankton production (Officer et al. 1982; Cloern 1982; Doering et al. 1986). Such alterations may not only be caused by actively pumping filter feeding bivalves, but by the feeding activities of tentaculate polychaetes (Frithsen and Doering 1986) and amphipods (Beatty and Oviatt 1988).

Doering and Oviatt (1987) have made calculations showing that in the summer Mercenaria "may filter the entire bay once every 53 days, consuming about 5% of the annual primary production". In particular areas of the bay, such as Greenwich Bay and the Providence River, "Mercenaria may consume up to 15% of the annual primary production". Doering and Oviatt (1987) concluded the clam filtration rates were "too low to control phytoplankton biomass, but high enough to exert a significant influence on the fate of organic production in Narragansett Bay". Their study demonstrated that need for research addressing the various roles played by benthic communities in the bay.

Other Commercially or Recreationally Important Species:

I could locate no distribution studies for other commercially or recreationally important benthic species in Narragansett Bay. The annual landing statistics for bay scallops (Figure 33), soft shelled clams (Figure 33), oysters (Figure 33), lobsters (Figure 34), whelks (Figure 34), the rock and Jonah crabs (Figure 34), and the green grab (Figure 34) were obtained from NMFS records and are presented here without comment.

Figure 33

RI SHELLFISH STATISTICS - metric tons

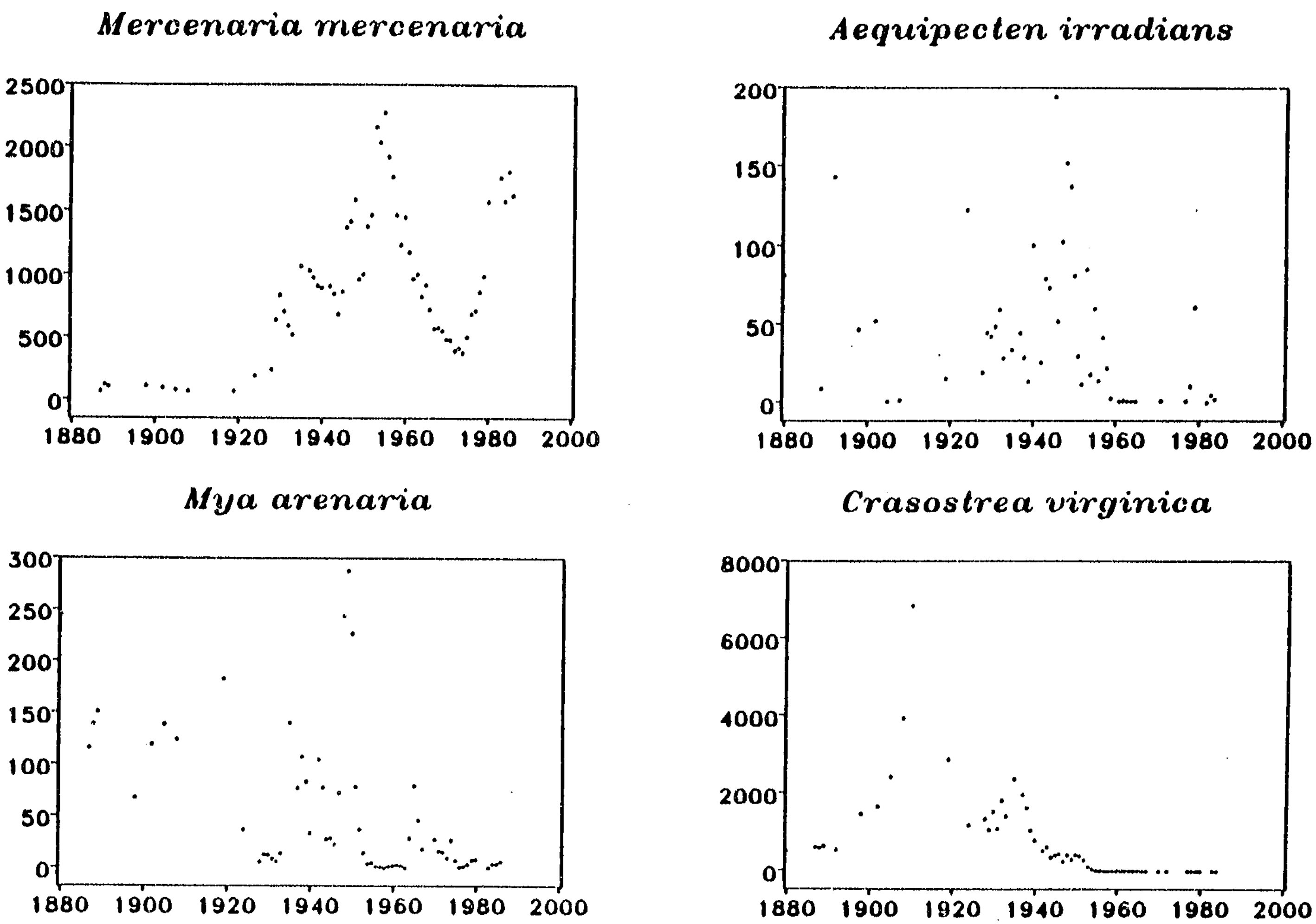
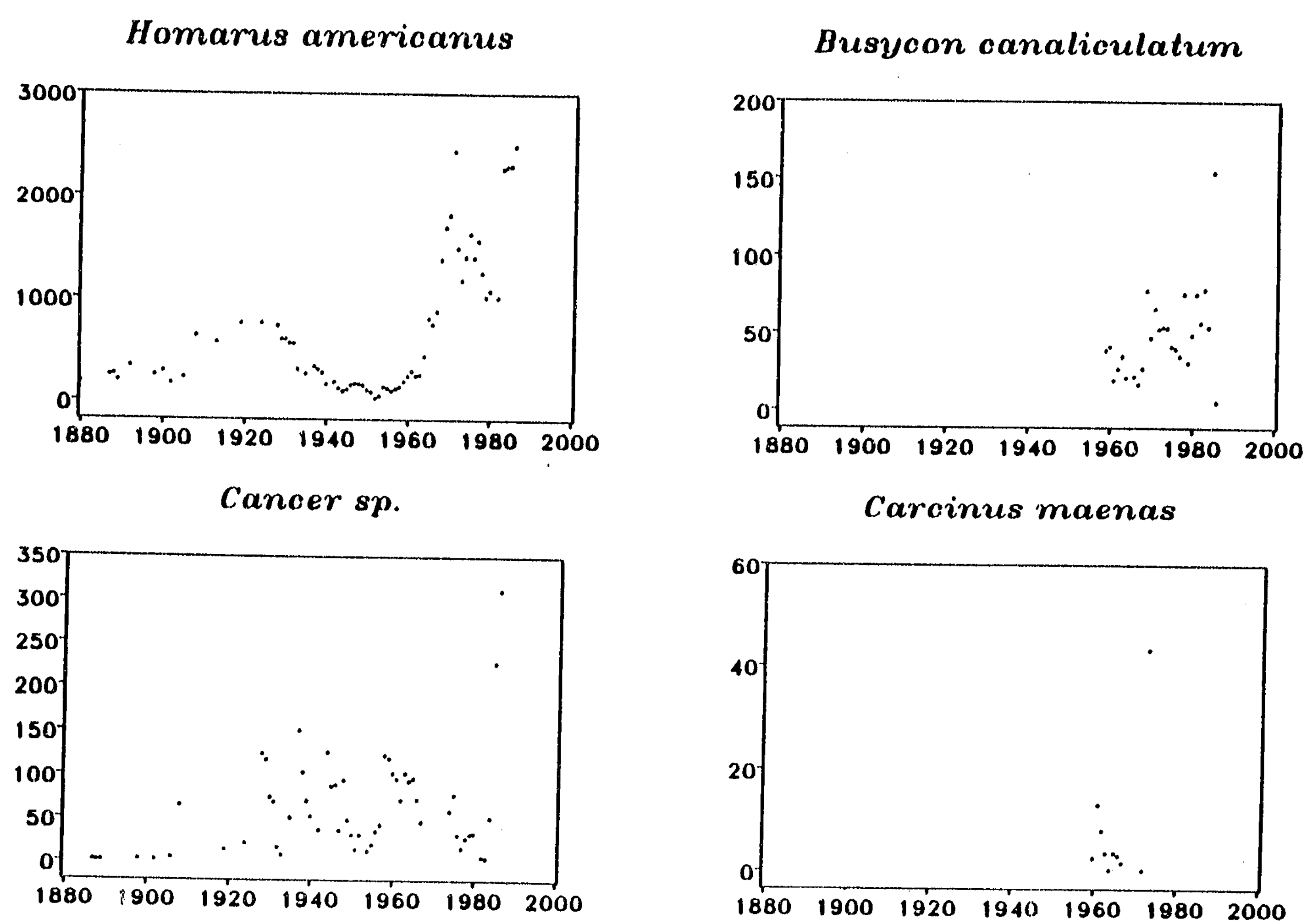


Figure 34

RI SHELLFISH STATISTICS - metric tons



COMPARISONS WITH OTHER COMMUNITIES IN NARRAGANSETT BAY

To compare benthic communities with other communities within Narragansett Bay, I have chosen to look at carbon pools and production. Taking a snap-shot of the bay, the sizes of various carbon reservoirs, both living and non-living, may be compared (Figure 35). The snap-shot represents crude averages and any one number is not known with great certainty. However, it does serve as a basis of comparison.

The benthic macrofauna represent the largest living reservoir of organic carbon in Narragansett Bay. The few biomass measurements that exist indicate macrofaunal biomass is approximately 20 g C/m^2. All other living reservoirs of organic carbon (phytoplankton, zooplankton, water column bacteria, benthic meiofauna and demersal fish) are at least an order of magnitude lower than the biomass of the macrofauna. I could find no biomass numbers for bacteria or pelagic fish in the bay.

It is of interest to note that the three largest carbon reservoirs represented in Figure 35 are non-living. The largest carbon reservoir is the carbon residing in the sediments. Most of this carbon is in the form of recalcitrant organics that are of little nutritive benefit to the organisms inhabiting the sediments. These recalcitrant organics are the products of many cycles of decomposition by microbes and fauna. It is this large background of nonlabile carbon that makes it difficult to trace the fate of phytoplankton produced carbon through the sediments.

Another large pool of carbon in Narragansett Bay is the dissolved inorganic carbon (CO^2, HCO_3^-, $CO_3^=$) in the water column. This carbon is used by phytoplankton to produce organic carbon for consumers in the bay's ecosystem. The third largest carbon pool is in the form of dissolved organic carbon in the water column. Very little is known concerning the composition or lability of this carbon, which is thought to be very important to the pelagic bacteria in the bay.

Although the benthic macrofauna represent the largest reservoir of living carbon, the turnover of this carbon is relatively slow compared to carbon turnover in most other living compartments. In terms of the amount of organic matter respired annually, the macrofauna respire about as much as the zooplankton (Figure 36). Together, the macrofauna and meiofauna respire about 80 g C m^{-2} y^{-1}. Benthic oxygen metabolism measurements (converted to carbon assuming a RQ of 1) indicate the sediment biota consume 110 - 140 g C m^{-2} y^{-1} (Nixon et al. 1976; Oviatt et al. 1981). The remaining respiration (about 30 - 60 g C m^{-2} y^{-1}) is attributed to bacteria. These crude estimates suggest that the metazoan fauna in the sediments of Narragansett Bay annually consume about 29% of the planktonic primary production, and are responsible for about 63% of all benthic oxygen metabolism.

The discussions above demonstrate that the benthic communities within the bay represent an important standing stock of organic carbon and that they exert considerable influence on the fate of phytoplankton derived carbon. Benthic metazoan fauna are major contributors to the metabolic activities that transpire in sediments.

Figure 35 - Legend

All calculations assume a 8.3 m average depth for Narragansett Bay (Pilson 1985). Standing stock carbon values calculated as follows.

1.) (DIC) Dissolved Inorganic Carbon: Assumed 22 mg C/l.

2.) (DOC) Dissolved Organic Carbon: Assumed 5 mg C/l.

3.) (PHYTO) Phytoplankton: Calculated mean chlorophyll concentration using data from all four SINBADD cruises (Pilson and Hunt 1985) and converted chlorophyll to carbon using a ratio of 30 (Parsons et al. 1977).

4.) (ZOOP) Zooplankton: Average dry weight biomass of seven stations sampled by Durbin and Durbin (1981) as reported in Durbin and Durbin (1988). Converted dry weight biomass to carbon by multiplying by 0.45.

5.) (POC) Particulate Organic Carbon: Mean value from SINBADD cruises (Pilson and Hunt 1988).

6.) (BACT) Bacteria: No bacterial biomass numbers found for Narragansett Bay though cell abundances and biovolumes are reported in Sieracki (1985). Valiela (1984) reports a range in seawater of 1 - 200 ug C/l. I used a value of 120 ug/l.

7.) (MACR) Macrofauna: Rudnick et al. (1985) report macrofaunal biomass to be 3.42 g C/m^2. However, many large and deeper living individuals were excluded from their cores. Frithsen et al. (1985) sieved approximately 1 ton (2.52 m^2 X 37 cm deep) sediment through 3.2 mm sieves. Sediment was collected from mid Narragansett Bay and held in mesocosms for approximately 30 months prior to sieving (control mesocosms in Frithsen et al. 1989). Biomass was 33.58 g ash free dry weight/m^2. AFDW was converted to dry weight by multiplying by 1.25 (Ankar and Elmgren 1976) an dry weight was converted to carbon by multiplying by 0.45.

8.) (MEIO) Meiofauna: Biomass as reported in Rudnick et al. (1985).

9.) (SED) Sediments: Assumed 2% total organic carbon (20 mg C/g dry weight sediment), a porosity of 70% and a density for dry sediment of 2.5 (see Frithsen et al. 1985). Carbon content calculated to 10 cm. Note, this is a minimal estimate. Additional carbon is buried below 10 cm and these calculations do not include carbonate carbon.

10.) (FISH) Demersal Fish: Oviatt and Nixon (1973) report biomass as 28.5 lbs/acre wet weight. Wet weight was converted to dry weight by multiplying by 0.20, and dry weight was converted to carbon by multiplying by 0.45.

Figure 35
Units: g C/m² - See legend

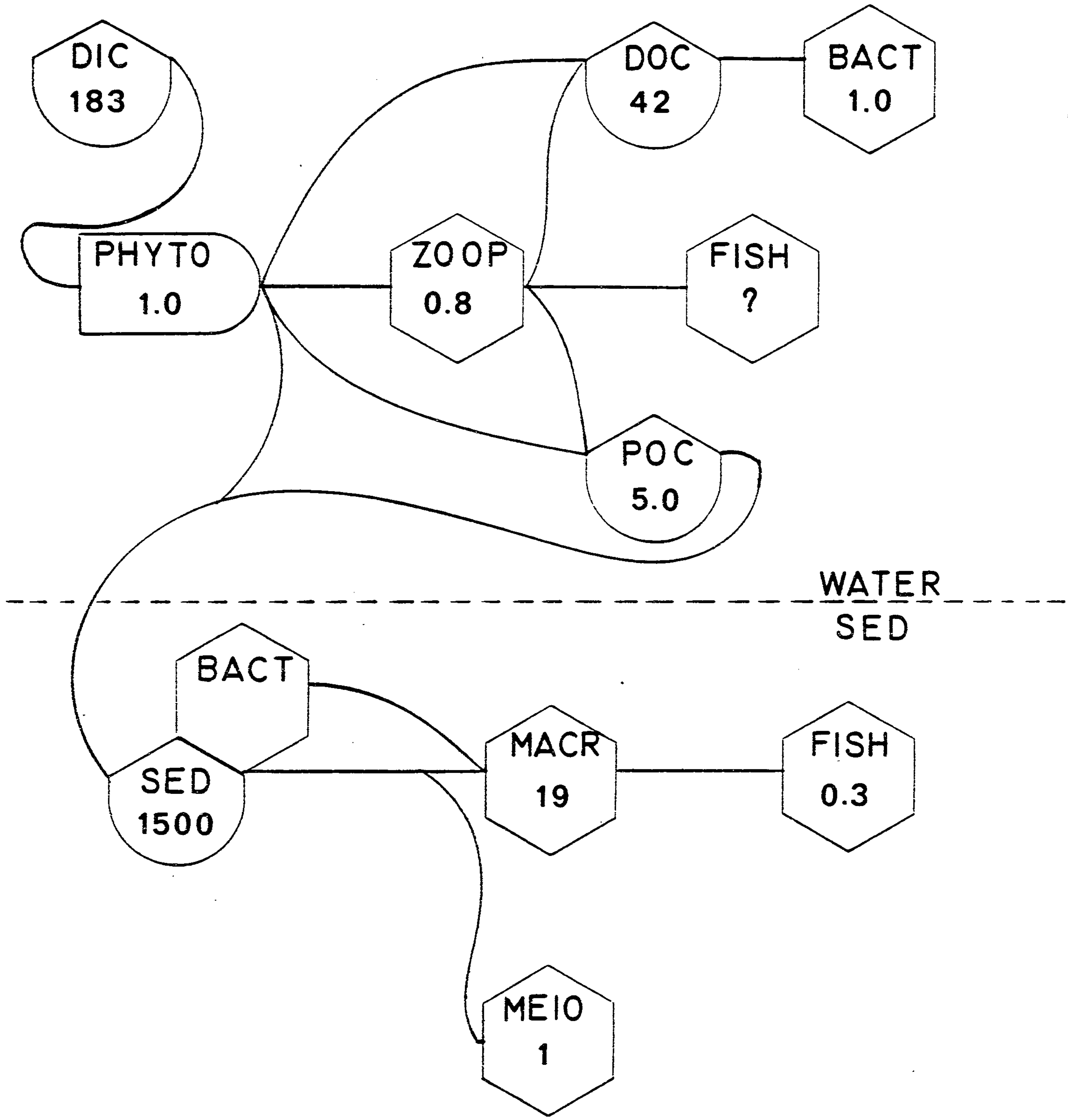


Figure 36 - Legend

Respiration values calculated as follows:

1.) (PHYT) Phytoplankton: Net primary production, not respiration is given as reported in Oviatt et al. (1981).

2.) (BACT) Assumed to be 30% of phytoplankton production after Cole et al. (1988).

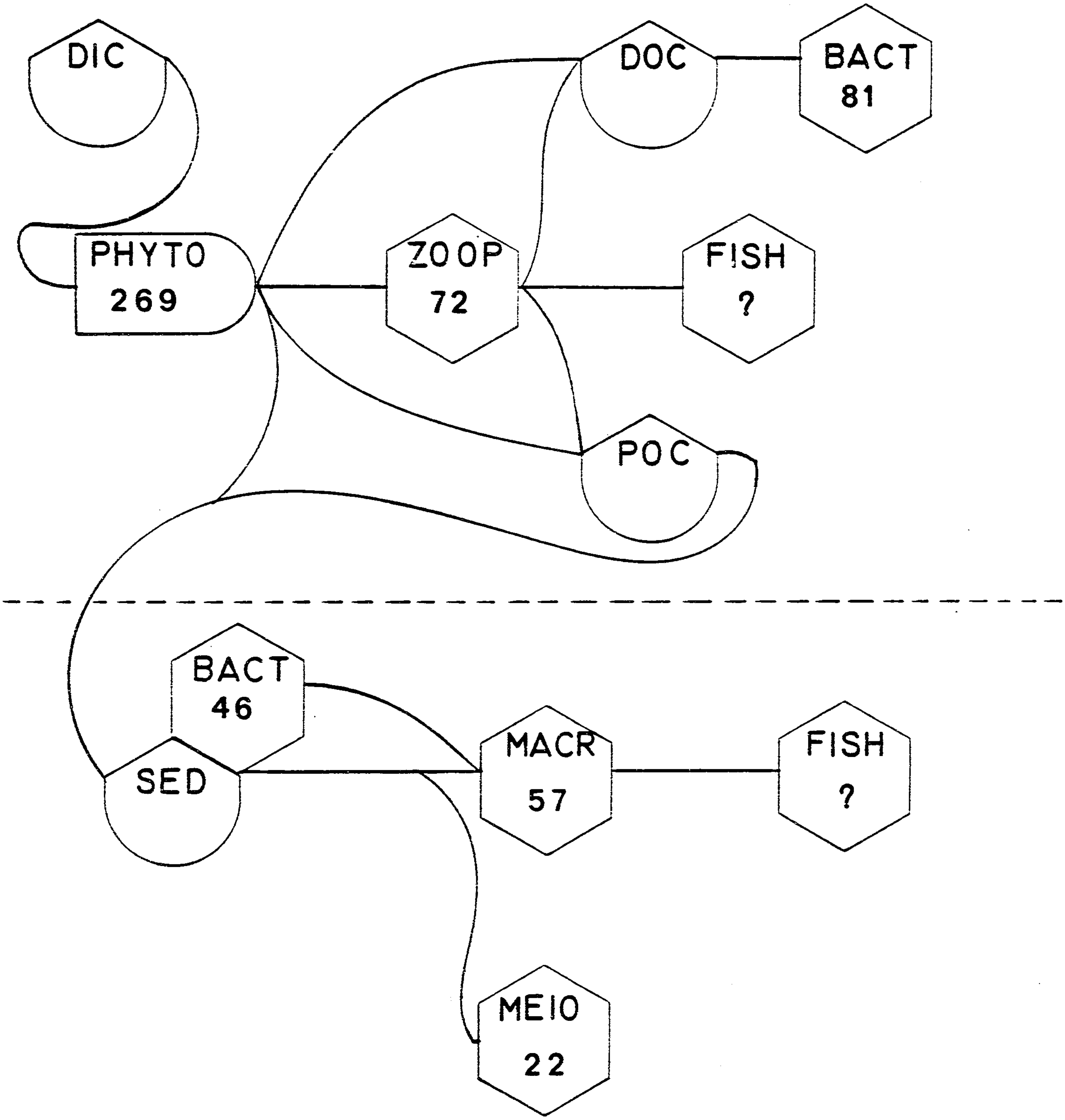
3.) (ZOOP) Zooplankton: From Durbin and Durbin (1981), I averaged daily production estimates for A. hudsonica as Stations 1 and 5 (mean = 9.01 mg C m^{-3} y^{-1}), and for A. tonsa (mean = 20.95 mg C m^{-3} y^{-1}). Then averaged these means and converted to areal units using a mean depth of 8.3 m (Pilson 1985). Production was used to estimate assimilation using a P/A efficiency of 33% and respiration was calculated as R=A-P. Note, this production rate is a maximum estimate since A. tonsa is food limited (Durbin and Durbin 1988).

4.) (MACR) Macrofauna: Rudnick et al. (1985) used an estimated P/B=3 and a P/A=0.33 to calculate R (R=A-P). Since I have included many large and slower growing macrofauna in my biomass estimate, I have used a P/B=1.5, but the same P/A.

5.) (MEIO) Meiofauna: From Rudnick et al. (1985).

6.) (BACT-SED) Used regression: Log (benthic bacterial production) = 0.69 * Log (sediment organic content) - 0.15 (Cole et al. 1988). Assumed a total organic content of 20 mg C/g dry weight sediment. Calculated only for the top 3 cm of sediment.

Figure 36
Units: g C m^{-2} yr^{-1} - See legend



FUTURE DIRECTIONS

1.) Future studies of Narragansett Bay benthic communities must be done using generally agreed upon, standardized methods. Otherwise, comparisons between studies will remain difficult and cumbersome. Similar difficulties are shared with investigators studying the zooplankton (Durbin and Durbin 1988). It is suggested that the Narragansett Bay Project play a major role in seeking agreement for standardization of methods. The manual by Dybern et al. (1976) for the Baltic is perhaps a good model from which to start.

2.) Past studies have been of limited use in establishing a long-term trend for benthic communities. Benthic communities must be included as a component of any long-term monitoring program for the bay. It is suggested that seasonal (with sampling at least four times each year) samples be taken from at least three stations within the bay. Monitored stations could correspond to the three stations established by Grassle and Grassle, but at least one station should be located in the mid bay region north of Conanicut Island.

3.) In order to establish whether the Narragansett Bay benthic communities have undergone significant changes during the past 30 years, Phelps (1958) survey should be repeated using identical methods. A similar approach has been used by Pearson et al. (1985) and Rosenberg et al. (1987) who revisited Petersen's stations in the Baltic and demonstrated eutrophication effects.

4.) Past studies have concentrated on measuring macrofaunal abundance. Few studies have measured biomass. Yet benthic macrofauna represent the largest living pool of carbon in the bay and not one seasonal study of macrobenthic biomass has been conducted in Narragansett Bay. Further, the secondary production of benthic communities in Narragansett Bay has never been measured. Future studies should measure macrofaunal biomass with the aim of making estimates of secondary production. More detailed studies are needed to estimate the secondary production of the more important species.

5.) Information on the abundance, biomass, and feeding behavior of epibenthic predators needs to be compiled in order to better understand the relative importance of food supply and predation as factors limiting benthic communities.

6.) More needs to be known about the effects of benthic organisms on water column processes. Laboratory, mesocosm and field data from other estuaries have indicated that the feeding activities of benthic organisms can influence water column particle dynamics and the structure of phytoplankton communities. However, there have been no measurements of benthic feeding rates, or their effects, within Narragansett Bay. This may be important in shallow, restricted areas of the bay.

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LITERATURE CITED

Ankar, S. and R. Elmgren, 1976. The benthic macro- and meiofauna of the Asko-Landsort Area (Northern Baltic proper): A stratified random sampling survey. Contribution No. 11 from the Asko Laboratory, University of Stockholm, Sweden.

Barnes, E.W. 1905. A preliminary list of the marine mollusca of Rhode Island. Rhode Island Commissioners of Inland Fisheries Annual Report 36:30-37.

Baxter, M.S., J.G. Farmer, I.G. McKinley, D.S. Swan and W. Jack. 1981. Evidence of the unsuitability of gravity coring for collecting sediment in pollution and sedimentation rate studies. Environ. Science and Technology 15:843-846.

Beatty, L.L. and C.A. Oviatt. 1988. The importance of benthic grazing in eutrophied systems. Abstract presented at the ASLO-AGU Ocean Sciences Meeting, January 18-22, 1988, New Orleans, Louisisana.

Bender, K. and W.R. Davis. 1984. The effect of feeding by Yoldia limatula on bioturbation. Ophelia 23: 91-100.

Bockstael, G.E. 1972. Survey of Sheffield Cove. Rhode Island Division of Fish and Wildlife, Leaflet No. 38, September, 1972.

Bousfield, E.L. 1973. Shallow-water Gammaridean Amphipoda of New England. Cornell University Press, Ithaca, NY., 312p.

Brooks, A. L. 1965. On the ecology of Ammonia beccarii (Linne). Ph.D. Dissertation, University of Rhode Island, Kingston, RI.

Burkenroad, M.D. 1957. Intensity of setting of starfish in Long Island Sound in relation to fluctuations of the stock of adult starfish and in the setting of oysters. Ecology 38:164-165.

Burkenroad. M.D. 1946. General discussion of problems involved in starfish utilization. Bull. Bingham Oceanogr. Coll. 9: 44-58.

Campbell, R. (No date). An inventory of the quahaug population of the Providence River and Mount Hope Bay. Rhode Island Division of Fish and Game, Un-numbered leaflet.

Campbell, R. (No date). Quahaug investigations, Nausauket - Buttonwoods, 1955 - 1958 - 1959. Division of Fish and Game, Department of Agriculture and Conservation, Pamphlet No. 1, 8p.

Campbell, R. (No date). Quahaug investigations, Potowomut River, 1959. Leaflet No. 2. Division of Fish and Game, Department of Agriculture and Conservation, 2p.

Campbell, R. (No date). Quahaug investigations, Kickamuit River, 1959. Leaflet No. 3. Division of Fish and Game, Department of Agriculture and Conservation, 2p.

Campbell, R. (No date). The 1961 starfish census of Narragansett Bay. Leaflet No. 10. Division of Fish and Game, Department of Agricutlrue and Conservation, 20p.

Campbell, R. and P. Dalpe. (No date). A report on the 1960 starfish census of Narragansett Bay. Leaflet No. 8. Division of Fish and Game, Department of Agriculture and Conservation, 10p.

Canario, M. 1964. Intertidal soft clam survey. Leaflet No. 14. Division of Fish and Game, Department of Agriculture and Conservation, 2p.

Canario, M. 1963. Shellfish survey of the Kickamuit River. Leaflet No. 12. Division of Fish and Game, Department of Agriculture and Conservation, 14p.

Canario, M.T. 1963. Shellfish survey of Duck Cove, North Kingstown. Rhode Island Division of Fish and Game Leaflet No. 15.

Canario, M. and K. Kovach. 1966. Shellfish survey of the Warren River. Leaflet No. 22. Rhode Island Division of Conservation, Department of Natural Resources, 8p.

Canario, M.T., K.A.M. Kovach and R.A. Green. 1965. Shellfish survey of Bluff Hill Cove, Narragansett, RI. Rhode Island Division of Fish and Game Leaflet No. 18.

Canario, M.T. and K.A.M. Kovach. 1965. Shellfish survey of the Providence River. Rhode Island Division of Conservation Leaflet No. 17.

Canario, M.T. and K.A. Kovach. 1965. Shellfish survey of East Passage Channel. Rhode Island Division of Fish and Game Leaflet No. 16.

Carriker, M.R. 1961. Interrelation of functional morphology, behavior and ecology in the early stages of the bivavle Mercenaria mercenaria. J. Elisha Mitchell Sci. Soc. 77: 168-241.

Chinman, R.A. and S.W. Nixon, 1985. Depth-area-volume relationships in Narragansett Bay. Marine Technical Report 87, Graduate School of Oceanography, University of Rhode Island, Narragansett, RI, 64p.

Chowder and Marching Society 1967. Jiffy Cruise Cruise Report. Graduate School of Oceanography, University of Rhode Island, Kingston, RI, 74p.

City of Fall River, Massachusetts Sewer Commission 1982. Section 301(h) application for modification of secondary treatment requirements for discharges into marine waters. December 1982.

City of Newport, Rhode Island. 1982. Application to the U.S. Environmental Protection Agency for modification of secondary treatment requirements for discharge into marine waters of the east passage of Narragansett Bay for its water pollution control plant. December 29, 1982. Metcalf and Eddy, Inc., Boston.

City of Newport, Rhode Island. 1985. Application for modification of secondary treatment requirements for its water pollution control plant effluent discharge into marine waters. Metcalf and Eddy, Inc. Boston, MA.

Cloern, J.E. 1982. Does the oenthos control phytoplankton biomass in South San Francisco Bay. Mar. Ecol. Prog. Ser. 9: 191-202.

Coastal Resources Center. 1977. The redevelopment of Quonset/Davisville: An environmental Assessment. Prepared for The Rhode Island Department of Economic Development by The Coastal Resources Center, Graduate School of oceanography, University of Rhode Island, Kingston, RI.

Cole, J.J., S. Findlay and M.L. Pace. 1988. Bacterial production in fresh and saltwater ecosystems: a cross-system overview. Mar. Ecol. Prog. Ser. 43: 1-10.

Cook, D.G. and R.O. Brinkhurst. 1973. Marine flora and faun
a of the northeastern United States. Annelida - Oligochaeta. NOAA Technical Report NMFS CIRC-374, 30p.

Crowley, D.J. 1962. The benthic fauna and sediment relationships of eastern Narragansett Bay, Rhode Island. MS Thesis, Brown University, Providence, RI, 65p.

Cullen, J.D. 1984. A biogeochemical survey: Copper and nickel in Mercenaria mercenaria relative to concentrations in the water column in a New England Estuary. MS Thesis, University of Rhode Island, Kingston, RI, 141p.

Culter, E.B. 1977. Marine flora and fauna of the Northeastern United States. Sipuncula. NOAA. Technical Report NMFS CIRC-403. 7p.

Dauer, D.M. 1983. Functional morphology and feeding behavior of Scolelepis squamata (Polychaeta: Spionidae). Marine Biology 77: 279-285.

Dauer, D.M., C.A. Maybury and R.M. Ewing. 1981. Feeding behavior and general ecology of several Spionid polychaetes from the Chesapeake Bay. J. Exp. Mar. Biol. Ecol. 54: 21-38.

Davis, W. Unpublished. Macrobenthic data collected in the west passage, 1969-1972.

De Bovee, F., J. Soyer and Ph. Albert. 1964. The importance of the mesh size for the extraction of the muddy bottom meiofauna. Limnol. Oceanogr. xx:350-354.

Doering, P.H. 1987. Effects of bivalve density on the production and fate of particulate matter. Proposal submitted to the National Science Foundation, September 1987.

Doering, P.H. and C.A. Oviatt. 1987. Consumption of organic carbon by the hard clam Mercenaria mercenaria in Narragansett Bay, Rhode Island. Abstract presented at the Ninth Biennial International Estuarine Research Conference, October 25-29, 1987, New Orleans, Louisiana.

Doering, P.H. and C.A. Oviatt. 1986. Application of filtration rate models to field populations of bivalves: An assessment using experimental mesocosms. Mar. Ecol. Prog. Ser. 31: 265-277.

Doering, P.H., L. Weber, M.M. Warren, G. Hoffman, K. Schweitzer, M.E.Q. Pilson, C.A. Oviatt, J.D. Cullen and C.W. Brown. 1988. Monitoring of the Providence and Seekonk Rivers for trace metals and associated parameters. Data Report, Spray Cruises I, II, and III. Marine Ecosystems Research Laboratory, Graduate School of Oceanography, University of Rhode Island, Narragansett, RI, April 25, 1988, 359p.

Doering, P.H., C.A. Oviatt and J.R. Kelly. 1986. The effects of the filter-feeding clam Mercenaria mercenaria on carbon cycling in experimental marine mesocosms. J. Marine Res. 44:839-861.

Dunn, C.Q., L.Z. Hale and A. Bucci. 1979. The Bay Bib: Rhode Island Marine Bibliography, Revised Edition. Marine Technical Report 70 and 71. University of Rhode Island, Narragansett, RI.

Durbin, A.G. and E.G. Durbin. 1988. Zooplankton and ichthyoplankton in Narragansett Bay: Status and trends. Part 1: Zooplankton. Prepared for the New England Interstate Water Pollution Control Commission, June 30, 1988.

Durbin, A.G. and E.G. Durbin. 1981. Standing stock and estimated production rates of phytoplankton and zooplankton in Narragansett Bay, Rhode Island. Estuaries 4:24-41.

Durbin, E.G., R. W. Krawiec and T. J. Smayda. 1975. Seasonal studies on the relative importance of different size fractions of phytoplankton in Narragansett Bay (USA). Marine Biology 32: 271-287.

Dybern, B.I., H. Ackefors and R. Elmgren. 1976. Recommendations on methods for marine biological studies in the Baltic Sea. The Baltic Marine Biologists, Publication No. 1.

Emerson, W.K. and M.K. Jacobson. 1976. The American Museum of Natural History Guide to shells: Land, freshwater and marine from Nova Scotia to Florida. Knopf, NY, 482p.

Farrington, J.W. 1971. Benthic liquids of Narragansett Bay - fatty acids and hydrocarbons. Ph.D. Thesis, University of Rhode Island, Kingston, RI.

Fauchald, K. 1977. The polychaete worms: Definitions and keys to the orders, families and genera. Natural History Museum of Los Angeles County, Science Series 28: 1-190.

Fauchald, K. and P.A. Jumars. 1979. The diet of worms: A study of polychaete feeding guilds. Oceanogr. Mar. Biol. Ann. Rev. 17: 193-284.

Frithsen, J.B. Unpublished A. Macrofaunal data collected from Greenwich Bay in 1986.

Frithsen, J.B. Unpublished B. Macrofaunal data collected from Seekonk River in 1981.

Frithsen, J.B. 1984. Ecological studies of benthic meiofauna in mesocosms. Ph.D. Dissertation, University of Rhode Island, Kingston, Rhode Island, 450p.

Frithsen, J.B. and P.H. Doering. 1986. Active enhancement of particle removal from the water column by tentaculate benthic polychaetes. Ophelia 25: 169-182.

Frithsen, J.B., D.T. Rudnick and C.A. Oviatt. 1989. Long-term patterns of macrobenthic community responses to nutrient enrichment. Manuscript submitted.

Frithsen, J.B., A.A. Keller and M.E.Q. Pilson. 1985. Effects of inorganic nutrient additions in coastal areas: A mesocosm experiment data report. Volume 3. MERL Series, Report No. 5, The University of Rhode Island, Kingston, RI, 244 pp.

Frithsen, J.B., D.T. Rudnick and R. Elmgren. 1983. A new, flow-through corer for the quantitative sampling of surface sediments. Hydrobiologia 99: 75-79.

Furnas, M.G., G.L. Hitchcock and T.J. Smayda. 1976. Nutrient-phytoplankton relationships in Narragansett Bay during the 1974 summer bloom. In, M.L. Wily (ed) Estuarine Processes, Volume 1, Used, stresses and adaptation to the estuary. Academic Press, NY, pp. 118-134.

Ganz, A. and R. Sisson. 1977. Inventory of the fisheries resources of the Quonset-Davisville Area, North Kingstown, Rhode Island. Leaflet No. 48, Rhode Island Department of Natural Resources, Division of Fish and Wildlife, Marine Fisheries Section, 20p.

Gearing, J.N., P.J. Gearing, D.T. Rudnick, A.G. Requejo and M.J. Hutchins. 1984. Isotopic variability of organic carbon in a phytoplankton-based, temperate estuary. Geochimica et Cosmochimica Acta 48: 1089-1098.

Goldberg, E.D., E. Gamble, J.J. Griffin and M. Koide. 1977. Pollution history of Narragansett Bay as recorded in its sediments. Estuarine and Coastal Marine Science 5: 549-561.

Gordon, R.B. and M.L. Spaulding. 1987. Numerical simulations of the tidal- and wind-driven circulation in Narragansett Bay. Estuarine, Coastal and Shelf Science 24: 611-636.

Gosner, K.L. 1978. A field guide to the Atlantic seashore. The Peterson Field Guide Series: 24. Houghton, Mifflin, Boston, 329p.

Gosner, K.L. 1971. Guide to identification of marine and estuarine invertebrates, Cape Hatteras to the Bay of Fundy. Wiley-Interscience, NY, 693p.

Grassle, J.P. and J.F. Grassle. 1984. The utility of studying the effects of pollutants on single species populations in benthos of mesocosms and coastal ecosystems. In, H.H. White, ed., Concepts in marine pollution measurements, Maryland Sea Grant college, College Park, MD, pp. 621-642.

Grassle, J.F. and J.P. Grassle. 1977. Benthic community structure in experimental ecosystems and the effects of petroleum hydrocarbons. In, Technical Progress Report. Report for EPA Grant _# R803902020, MERL, The University of Rhode Island, Kingston, RI, pp. 364-372.

Grassle, J.F. and J.P. Grassle. 1974. Opportunistic life histories and genetic systems in marine benthic polychaetes. Journal of Marine Research 32: 253-284. R-903, 5/82.

Grassle, J.F., J.P. Grassle, L.S. Brown-Leger, R.F. Petrecca and N.J. Copley. 1985. Subtidal macrobenthos of Narragansett Bay. Field and mesocosm studies of the effects of eutrophication and organic input on benthic populations. In, J.S. Gray and M.E. Christiansen (eds) Marine biology of polar regions and effects of stress on marine organisms. Wiley, N.Y., pp. 421-434.

Grassle, J.F., J.P. Grassle, L.S. Brown-Leger, N.J. Copley and R.F. Petrecca. 1981. Quantitative studies of macrofauna in three benthic communities in experimental ecosystems. In, Fates and Effects of Marine Pollutants and Certain Policy Studies. Report for Year 1 of EPA Cooperative Agreement _# CR 807795, MERL, The University of Rhode Island, Kingston, RI, pp. 38-50a.

Grassle, J.F., R. Elmgren and J.P. Grassle. 1980-81. Response of benthic communities in MERL experimental ecosystems to low level, chronic additions of No. 2 fuel oil. Marine Environmental Research 4:279-297.

Grassle, J.F., J.P. Grassle, L.S. Brown-Leger, N.J. Copley and J.G. Smith Derby. 1980. Quantitative studies on benthic communities in experimental ecosystems. In, The Fate and Effects of Chronic Low Level Pollutants in Marine Ecosystems. Report for Year II of EPA Grant _# 806072020, MERL, The University of Rhode Island, Kingston, RI, pp. 144-168.

Grassle, J.F., J.P. Grassle, L.S. Brown-Leger, C.H. Lanyon-Duncan and N.J. Copley. 1979. Benthic communities in experimental ecosystems and the effects of petroleum hydrocarbons. In, The Use of Large Marine Microcosms to Study the Fates and Effects of Chronic Low Level Pollutants. Report for Year I of EPA Grant _# 806072010, MERL, The University of Rhode Island, Kingston, RI, pp. 201-228.

Grassle, J.F., J.P. Grassle, L.S. Brown-Leger, N.J. Maciolek and C.H. Lanyon-Duncan. 1978. Benthic communities in experimental ecosystems and the effects of petroleum hydrocarbons. In, The use of Large Marine Microcosms to Study the Fates and Effects of Chronic Low Level Pollutants. Report for EPA Grant _# R803902020, MERL, The University of Rhode Island, Kingston, RI, pp. 425-450.

Gray, G.W. 1969. Shellfish survey of the west passage of Narragansett Bay. Rhode Island Division of Fish and Game Leaflet No. 26.

Hale, S.O. 1980. Narragansett Bay: A friend's perspective. Marine Bulletin 42. Marine Advisory Service, University of Rhode Island, Narragansett RI.

Hale, S.S. 1974. The role of benthic communities in the nutrient cycles of Narragansett Bay. MS Thesis, University of Rhode Island, 123p.

Hartman, O. 1947. Polychaetous annelids. Pt. 7. Capitellidae. Allan Hancock Pac. Exped. 10: 391-481.

Hartman, O. 1944. Polychaetous annelids from California including the description of two new genera and nine new species. Allan Hancock Pac. Exped. 10: 239-307.

Hartmann-Schroder, G. 1962. Zweiter Beitrag zur Polychaetenfauna von Peru. Kieler Meeresforsch. 18: 109-147.

Hicks, S.D. 1959. The physical oceanography of Narragansett Bay. Limnol. Oceanogr. 4: 316-327.

Hillman, N.S. 1964. Studies on the distribution and abundance of decapod larvae in Narragansett Bay, Rhode Island, with consideration of morphology and mortality. MS Thesis, University of Rhode Island, Kingston, RI, 74p.

Hinga, K.R., R. Rice, N.F. Lewis, A. Keller and K. Dadey. 1988. A review of Narragansett Bay Phytoplankton Data: Status and trends. Report completed for the Narragansett Bay Project, July 5, 1988.

Hobbie, J.E. and J.J. Cole. 1984. Response of a detrital foodweb to eutrophication. Bull. Mar. Sci. 35: 357-363.

Hoff, J.G. and S.A. Moss. 1976. Final Report: Apponaug Cove - Greenwich Bay Environmental Survey. Contract DACW33-76-M-0050 from the Environmental Analysis Branch, Department of the Army, New England Division Corps of Engineers, Waltham, MA, 44p.

Holland, A.F., A.T. Shaughnessy and M.H. Hiegel. 1987. Long-term variation in mesohaline Chesapeake macrobenthos: Spatial and temporal patterns. Estuaries 10: 227-245.

Hughes, J. Unpublished. Macrofaunal data from mid Narragansett Bay collected 1983 - 1986.

Hurtt, A.C. and J.G. Quinn. 1979. Distribution of hydrocarbons in Narragansett Bay sediment cores. Environmental Science and Technology 13:829-836.

Hyland, J.L. 1981. Comparative structure and response to (petroleum) disturbance in two nearshore infaunal communities. Ph.D. Dissertation. University of Rhode Island, Kingston, RI, 141p.

Iturriaga, R. 1979. Bacterial activity related to sedimenting particulate matter. Mar. Biol. 55: 157-169.

Jeffries, H.P. 1972. A stress syndrome in the hard clam. Mercenaria mercenaria. J. Invertebrate Pathology 20:242-251.

Jeffries, H.P. and M. Terceiro. 1985. Cycle of changing abundances in the fishes of the Narragansett Bay area. Mar. Ecol. Prog. Ser. 25: 239-244.

Jeffries, H.P. and W.C. Johnson. 1974. Seasonal distributions of fishes in the Narragansett Bay area; Seven year variations in abundance of winter flounder (Pseudopleuronectes americanus). Journal Fisheries Research Board of Canada 31: 1057-1066.

Jeffries, H.P., A. Keller and S. Hale. 1986. Catch compilation: A weekly trawl program, Narragansett Bay - Rhode Island Sound, 1966-1985. Graduate School of Oceanography, University of Rhode Island, Kingston, RI.

Karentz, D. and T.J. Smayda. 1984. Temperature and seasonal occurrence patterns of 30 dominant phytoplankton species in Narragansett Bay over a 22-year period (1959-1980). Mar. Ecol. Prog. Ser. 18: 277-293.

Kovach, K.A.M. and M.T. Canario. 1968. Shellfish survey of Quicksand Pond, Little Compton, RI. Leaflet No. 23. Rhode Island Division of Conservation, Department of Natural Resources, 18p.

Kovach, K.A.M. and M.T. Canario. 1968. Shellfish survey of Quonset Point Area. Rhode Island Division of Conservation Leaflet No. 25.

Kovach, K.A.M., M.T. Canario and G. Gray. 1968. Shellfish survey of the west passage of Narragansett Bay, RI. Leaflet No. 26. Rhode Island Division of Conservation, Department of Natural Resources, 13p.

Kremer, J.N. and S.W. Nixon. 1978. A coastal marine ecosystem: Simulation and analysis. Springer-Verlag, NY, 217p.

Landers, W.S. 1954. Seasonal abundance of clam larvae in Rhode Island waters, 1950-1952. U.S. Fish and Wildlife Service Special scientific report - Fisheries No. 117.

Lavoie, D.M. 1970. A survey of benthic fauna in Bissells Cove salt marsh. Project Report, Graduate School of Oceanography, University of Rhode Island, Narragansett, RI, 20 p.

Levine, E.R. and K.E. Kenyon. 1975. The tidal energetics of Narragansett Bay. J. of Geophysical Res. 80: 1783-1688.

Lyles, C.H. 1969. Historical catch statistics (Shellfish). United States Department of the Interior, U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Washington, DC, July 1969, 116p.

McGetchin, T.R. 1961. Bottom sediments and fauna of western Narragansett Bay, Rhode Island. MS Thesis, Brown University, Providence, RI, 107p.

McIntyre, A.D. 1971. Deficiency of gravity corers for sampling meiobenthos and sediments. Nature 231: 260.

McKenna, J.E. 1987. An analysis of potential food limitation in the benthic communities of Narragansett Bay using a numerical simulation model. M.S. Thesis, University of Rhode Island, Kingston, RI.

McMaster, R.L. 1984. Holocene stratigraphy and depositional history of the Narragansett Bay system, Rhode Island, U.S.A. Sedimentology 31:777-792.

McMaster, R.L. 1960. Sediments of Narragansett Bay system and Rhode Island Sound, Rhode Island. J. of Sed. Pet. 30: 249-274.

Mikkelsen, P.S. and P.M. Mikkelsen. 1984. Comparison of Acteocina canaliculata (Say, 1826) A. candei (d'Orbigny, 1841) and A. atrata spec. nov. (Gastropoda: Cephalaspidea). Veliger 27: 164-192.

Mills, E.L. 1963. A new species of Ampelisca (Crustacea: Amphipoda) from Eastern North America, with notes on other species of the genus. Canadian J. Zool. 41: 971-989.

Mills, E.L. 1964. Ampelisca abdita, a new crustacean from eastern North America. Canadian J. Zool. 42: 559-575.

Morton, R.W. 1967. Spatial and temporal observations of suspended sediment; Narragansett Bay and Rhode Island Sound. Tech. Memo. U.S. Naval Under Water Weapons Research and Eng. St., Newport, RI.

Myers, A.C. and D.K. Phelps. 1978. Criteria of benthic health: A transect study of Narragansett Bay, Rhode Island. Final Report. Prepared for the United States Environmental Protection Agency, Environmental Research Laboratory, South Ferry Road, Narragansett, Rhode Island, Under Contract No. P.O. 53203 with the University of Rhode Island Division of Marine Resources, Graduate School of Oceanography, Kingston, Rhode Island, 02881.

1985 National Shellfish Register of Classified Estuarine Waters. 1985.

Newell, R.C., M.I. Lucas, E.A.S. Linley. 1981. Rate of degradation and efficiency of conversion of phytoplankton debris by marine micro-organisms. Mar. Ecol. Prog. Ser. 6: 123-136.

Nichols, F.H. and J.K. Thompson. 1985. Time scales of change in the San Francisco Bay benthos. Hydrobiologia 129: 121-138.

Nixon, S.W. 1988. An extraordinary red tide and fish kill in Narragansett Bay. Unpublished manuscript.

Nixon, S.W. 1981. Remineralization and nutrient cycling in coastal marine ecosystems. In, B.J. Nielson and L.E. Cronin (eds) Estuaries and nutrients, Humana Press, Clifton, NJ. pp.111-138.

Nixon, S.W. and J.N. Kremer. 1977. Narragansett Bay -- The development of a composite simulation model for a New England Estuary. In, C. Hall and J. Day (eds) Ecosystem modeling in theory and practice: An introduction with case histories. Wiley Interscience, NY, pp. 621-634.

Nixon, S.W. and C.A. Oviatt. 1973. Ecology of a New England salt marsh. Ecol. Monogr. 43: 463-498.

Nixon, S.W., C.A. Oviatt, J.B. Frithsen and B. Sullivan. 1986. Nutrients and the productivity of estuarine and coastal marine ecosystems. J. Limnol. Soc. sth. Afr. 12 (1/2): 43-71. MERL.

Nixon, S.W., C.A. Oviatt and S.S. Hale. 1976. Nitrogen regeneration and the metabolism of coastal marine bottom communities. In, J.M. Anderson and A. Macfadyen (eds) The role of terrestrial and aquatic organisms in decomposition processes. Blackwell Scientific, London, pp. 269-283.

Office, C.B., T.J. Smayda and R. Mann. 1982. Benthic filter feeding: A natural eutrophication control. Mar. Ecol. Prog. Ser. 9: 203-210.

Olsen, S. and V. Lee. 1979. A summary and preliminary evaluation of data pertaining to the water quality of upper Narragansett Bay. URI Coastal Resources Center Report to EPA Region 1, Narragansett RI.

Olsen, S. and G.L. Seavey. 1983. The State of Rhode Island Coastal Resources Management Program, as amended June 28, 1983. Document prepared for the Coastal Resources Management Council. The Coastal Resources Center, University of Rhode Island, Kingston, RI, 127p.

Olsen, S., D.D. Robadue and V. Lee. 1980. An interpretive atlas of Narragansett Bay. Coastal Resources Center, University of Rhode Island Marine Bulletin 40.

Oviatt, C.A. 1981. Some aspects of water quality in and pollution sources to the Providence River. Report for Region I, EPA, September 1979 - September 1980, Contract #68-04-1002, 236p.

Oviatt, C.A. and S.W. Nixon. 1975. Sediment resuspension and deposition in Narragansett Bay. Estuarine and Coastal Mar. Sci. 3:201-217.

Oviatt, C.A. and S.W. Nixon. 1973. The demersal fish of Narragansett Bay: An analysis of community structure, distribution and abundance. Estuarine and Coastal Marine Science 1:361-378.

Oviatt, C.A., A.A. Keller, P.A. Sampou and L.L. Beatty. 1986. Patterns of productivity during eutrophication: A mesocosm experiment. Mar. Ecol. Prog. Ser. 28: 69-80.

Oviatt, C., B. Buckley and S. Nixon. 1981. Annual phytoplankton metabolism in Narragansett Bay calculated from survey field measurements and microcosm observations. Estuaries 4: 167-175.

Oviatt, C.A., S.W. Nixon, E. Evans and B. Wicklow. 1977. Environmental assessment of a plan for improved boating and boating facilities at Brush Neck Cove, Greenwich Bay, Rhode Island. Prepared for Gordon R. Archibald. Undated. 59 p.

Pearson, T.H. and R. Rosenberg. 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanogr. Mar. Biol. Ann. Rev. 16: 229-311.

Pearson, T.H., A.B. Josefson and R. Rosenberg. 1985. Petersen's benthic stations revisited. I. Is the Kattegatt becoming eutrophic. J. Exp. Mar. Biol. Ecol. 92: 157-206.

Petersen, C.G. Joh. 1911. Valuation of the sea. I. Animal life of the level sea bottom, its food and quantity. Rep. Danish biol. Sta. 20: 74p.

Peterson, C.H. 1982. Clam predation by whelks (Busycon spp): Experimental tests of importance of prey size, prey density, and sea grass cover. Mar. Biol. 66: 159-170.

Pettibone, M.H. 1963. Marine polychaete worms of New England region, Part 1. Aphroditoidea through Trochaetidae. Bull. U.S. Nat. Mus. 227: 1-356.

Phelps, D.K. 1958. A quantitative study of the infauna of Narragansett Bay in relation to certain physical and chemical aspects of their environment. MS Thesis, University of Rhode Island, 56p.

Pilson, M.E.Q. 1985. On the residence time of water in Narragansett Bay. Estuaries 8: 2-14.

Pilson, M.E.Q. and C.D. Hunt. 1988. Water quality survey of Narragansett Bay: A summary of results from the SINBADD Cruises 1985-1986. Report submitted to the Rhode Island Department of Environmental Management, July 1988. 103p.

Pratt, D.M. 1965. The winter-spring diatom flowering in Narragansett Bay. Limnol. Oceanogr. 10: 173-184.

Pratt, D.M. 1959. The phytoplankton of Narragansett Bay. Limnol. Oceanogr. 4: 425-440.

Pratt, D.M. 1953. Abundance and growth of Venus mercenaria and Callocardia morrhuana in relation to the character of bottom sediments. J. Mar. Res. 12: 60-74.

Pratt, D.M. and D.A. Campbell. 1956. Environmental factors affecting growth in Venus mercenaria. Limnol. Oceanogr. 1:2-17.

Pratt, S.D. Unpublished. Invertebrates recovered from the upper Kickimuit River, Rhode Island, December 29, 1983.

Pratt, S.D. 1988a. Benthos from the historic Rhode Island Sound dredged material disposal area sampled October 1987. Report for Science Applications International Corporation, Newport, RI, 13p.

Pratt, S.D. 1988b. Status of the hard clam fishery in Narragansett Bay. Report Prepared for the Narragansett Bay Project, January 1988, 89p.

Pratt, S.D. 1977a. Biology and geology: Additional data pertinent to Fall River Channel dredging and Browns Ledge spoil disposal. In, A study and report on oceanographic conditions in the vicinity of Browns Ledge, Rhode Island Sound, Report No. 2, Final Report on Job Change _#4 to Contract No. DACW33-75-C-0066, New England Division, Corps of Engineers, U.S. Army. Cover page says by Division of Marine Resources, Graduate School of Oceanography, University of Rhode Island, May 1977, unpaginated.

Pratt, S.D. 1977b. Benthic biology of areas adjacent to the Quonset/Davisville base. In, The redevelopment of Quonset/Davisville: An environmental Assessment. Technical Appendix No. 2., 32p.

Pratt, S.D. 1973. Benthic fauna. In, S. Saila (coordinator) Coastal and offshore environmental inventory Cape Hatteras to Nantucket Shoals. Marine Publication Series No. 2, University of Rhode Island, Kingston, RI, pp. 5-1 - 5-70.

Pratt, S.D. 1972. Effects of spoil dumping on the benthic invertebrates of the sound. In, S.B. Saila, S.D. Pratt and T.T. Polgar (eds) Dredge spoil disposal in Rhode Island Sound, Marine Technical Report Number 2, University of Rhode Island, Kingston, RI, pp: 31-42.

Pratt, S.D. and J.J. Bisagni. 1976. Monitoring results - Providence River dredging 1975. Submitted to the New England Division, U.S. Army Corps of Engineers, March 1976. 31p.

Pratt, S.D. and G. L. Seavey. 1981. The environment of Apponaug inner cover and the impact of development on the cove. Prepared for Robinson Green Beretta Corp., Providence, RI. 61p.

Pratt, S.D., B.K. Martin and S.B. Saila. 1988. Status of the hard clam (Mercenaria mercenaria) in the Providence River and Mount Hope Bay. Report to the U.S. Environmental Protection Agency, Region 1, Water Management Division. September 1988.

Reid, R.N. 1979. Long-term fluctuations in the mud-bottom macrofauna of Long Island Sound, 1972-1978. MA Thesis, Boston University, Boston, MA, 36p.

Reid, R.N., A.B. Frame and A.F. Drayler. 1979?. Environmental baselines in Long Island Sound, 1972-1973. NOAA Report. (incomplete reference).

Reid, R. et al., 1981. Northeast Monitoring Program, Annual Report - Benthic Ecology. December 1981.

Rhode Island Division of Conservation. 1968. Management plan and shellfish survey of the west passage and Sakonnet River of Narragansett Bay, RI. Rhode Island Division of Conservation, Department of Natural Resources, 14p.

Rhodes, R.J., W.T. Keith, P.J. Eldridge and V.G. Burrell. 1977. An empirical evaluationf of the Leslie-Delury method applied to stimating hard clam, Mercenaria merçenaria abundance in the Santee River, South Carolina. Proc. Natl. Shellfish Assoc. 67: 44-52.

Rosenberg, R., J.S. Gray, A.B. Josefson and T.H. Pearson. 1987. Petersen's benthic stations revisted. II. Is the Oslofjord and eastern Skagerrak enriched? J. Exp. Mar. Biol. Ecol. 105: 219-251.

Rudnick, D.T. 1988. Time lags between the deposition and meiobenthic assimilation of phytodetritus. Mar. Ecol. Prog. Ser. 50: 231-240.

Rudnick, D.T. 1984. Seasonality of community structure and carbon flow in Narragansett Bay sediments. Ph.D. Dissertation, University of Rhode Island, Kingston, RI, 320p.

Rudnick, D.T. and C.A. Oviatt. 1986. Seasonal lags between organic carbon deposition and mineralization in marine sediments. J. Mar. Res. 44: 815-837.

Rudnick, D.T., R. Elmgren and J.B. Frithsen. 1985. Meiofaunal prominence and benthic seasonality in a coastal marine ecosystem. Oecologia 67:157-168.

Russell, H.J. 1973. The ecology of round Swamp, Jamestown, RI. Leaflet No. 39. Rhode Island Division Fish and Wildlife.

Russell, H.J. 1972. Use of a commercial dredge to estimate a hardshell clam population by stratified random sampling. Journ. Fish. Res. Bd. Canada 29: 1731-1735.

Russell, H.J. 1969. Report of the 1969 hard clam commercial dredge season in the West Passage, Narragansett Bay, Rhode Island. Rhode Island Division of Fish and Wildlife Leaflet No. 31.

SAS Institue Inc. 1985. Sas User's Guide: Basics, Version 5 Edition. Cary, NC, 956p.

Said, R. 1951. Foraminifera of Narragansett Bay. Contr. Cushman Foundation Foraminiferan Research 2: 75-86.

Saila, S.B., J.M. Flowers and M.T. Cannario. 1967. Factors affecting the relative abundance of Mercenaria mercenaria in the Providence River, Rhode Island. Proceedings of the National Shellfisheries Association 57: 83-89.

Sanders, H.L. 1960. Benthic studies in Buzzards Bay. III. The structure of the soft bottom community. Limnol. Oceanogr. 5:138-153.

Sanders, H.L. 1958. Benthic studies in Buzzards Bay I. Animal-sediment relationships. Limnol. Oceanogr. 3:245-258.

Sanders, H.L. 1956. Oceanography of Long Island Sound, 1952-1954. X: The biology of marine bottom communities. Bull. of the Bingham Oceanographic Collection 15:345-414.

Santschi, P.H. 1980. A revised estimate for trace metal fluxes to Narragansett Bay: A comment. Estuarine and Coastal Marine Science 11: 115-118.

Santschi, P.H., S. Nixon, M. Pilson and C. Hunt. 1984. Accumulation of sediments, trace metals (Pb, Cu) and total hydrocarbons in Narragansett Bay, Rhode Island. Estuarine, Coastal and Shelf Science 19:427-449.

Satchwill, R.J., S.P. Turano and R.T. Sisson. 1984. Preliminary assessment of biological and physical characteristics of the Narragansett Bay estuarine sanctuary 1983. Final report to the U.S. Dept. of Commerce, NOAA, Office of Coastal Zone Management, Sanctuary Programs Office. Rhode Island Dept. of Environmental Management, Division of Fish and Wildlife, Providence, RI, unnumbered.

Savage, N.B. 197?. Live molluscs and shell remains in soft bottom samples from West Passage, Narragansett Bay and their bearing on the interpretation of fossil molluscan communities. In, R.L. McMaster (compiler) Geological processes along Washington County shoreline and in Narragansett Bay, Rhode Island. Miscellaneous Term Papers, 1970-1972, Vol. III. Graduate School of Oceanography, University of Rhode Island, Kingston, RI, 21p.

Shonting, D.H. and G.S. Cook. 1970. On the seasonal distribution of temperature and salinity in Rhode Island Sound. Limnol. Oceanogr. 15:100-112.

Sieracki, M.E. 1985. Factors controlling short-term variations in marine bacterial populations. Ph.D. Dissertation, Univ. of Rhode Island, Kingston, RI, 149p.

Sisson, R.T. (No date). Occurrence of bay scallop seed in Rhode Island 1970. Project 3-113-R. Leaflet No. 32. Rhode Island Division of Conservation, Department of Natural Resources, 4p.

Smayda, T.J. 1987. Environmental conditions and plankton dynamics in Narragansett Bay during an annual cycle characterized by a brown-tide. Report completed for the Narragansett Bay Project.

Smayda, T.J. 1973. A survey of phytoplankton dynamics in the coastal waters from Cape Hatteras to Nantucket. In, S.B. Saila (coordinator), Coastal and offshore environmental inventory - Cape Hatteras to Nantucket Shoals. Mar. Pub. Ser. No. 2, University of Rhode Island, Kinston, RI, pp. 3-1 to 3-100.

Smayda, T.J. 1957. Phytoplankton studies in lower Narragansett Bay. Limnol. Oceanogr. 2: 342-359.

Smetacek, V.S. 1985. Role of sinking in diatom life-history cycles: ecological, evolutionary and geological significance. Mar. Biol. 84:239-251.

Smetacek, V. 1980. Annual cycle of sedimentation in relation to plankton ecology in western Kiel Bight. Ophelia (Suppl.) 1:65-76.

Steimle, F.W. 1982. The benthic macroinvertebrates of the Block Island Sound. Estuarine Coastal and Shelf Science 15:1-16.

Stickney, A.P. and L.D. Stringer. 1957. A study of the invertebrate bottom fauna of Greenwich Bay, Rhode Island. Ecology 38: 111-122.

Stringer, L.D. 1959. The population abundance and effect of sediment on the hard clam. In, Hurricane damage control, Narragansett Bay and vicinity, Rhode Island and Massachusetts. A detailed report on Fishery Resources. U.S. Fish and Wildlife service, Appendix E.

Taghon, G.L., A.R.M. Nowell and P.A. Jumars. 1980. Induction of suspension feeding in spionid polychaetes by high particle fluxes. Science 210: 562-564.

Terceiro, M. 1985. Changes in the epibenthic macro-invertebrate and demersal fish assemblages in Narragansett Bay and Rhode Island Sound. Ph.D. Dissertation, University of Rhode Island, Kingston, RI, 122p.

Toner, R.C. 1981. Interrelationships between biological, chemical and physical variables in Mount Hope Bay, Massachusetts. Estuarine, Coastal and Shelf Science 12: 701-712.

Trifan, D. 1987. Depth distribution of Narragansett Bay decapod larvae and the ontogeny of behavioral responses to gravity, light, hydrostatic pressure, and current in Neopanope sayi (Smith). Ph.D. Dissertation, University of Rhode Island, Kingston, RI, 214p.

U.S. Army Corps of Engineers. 1981. Bristol Harbor, Rhode Island Navigation Improvements: Phase I AE&D General Design Memorandum Plan Formulation. Department of the Army, New England Division, Corps of Engineers, Waltham, MA.

U.S. Department of the Interior. 1964, 1959. Hurricane damage control, Narragansett Bay and Vicinity, Rhode Island and Massachusetts: A detailed report on Fishery Resources.

U.S. EPA. 1974. State of Rhode Island Shellfish Atlas. U.S. Environmental Protection Agency and Rhode Island Department of Natural Resources, Division of Fish and Wildlife.

Walker, R.L., M.A. Fleetwood and K.R. Tenore. 1980. The distribution of the hard clam Mercenaria mercenaria (Linne) and clam predators in Wassaw Sound Georgia. Georgia Mar. Sci. Center, Univ. System of Georgia, Skidaway Island, Georgia. Tech. Rept. Ser. 80-8.

Warwick, R.M. 1980. Population dynamics and secondary production of benthos. In, K.R. Tenore and B.C. Coull (eds) Marine benthic dynamics. Belle W. Baruch Library in Marine Science Number 11, University of South Carolina Press, Columbia, SC, pp. 1-24.

Weils, H.W. 1957. Abundance of the hard clam Mercenaria mercenaria in relation to environmental factors. Ecology 38: 123-128.

Wells, H.W. 1957. Status of the name Venus. Ecology 38: 160-161.

Whitehouse, S.T. Unpublished. Data on the distribution of Crangon septemspinosa throughout Narragansett Bay.

Young, D.K. 1971. Effects of infauna on the sediment and seston of a subtidal environment. Vie et Milieu Suppl. 22: 557-571.

Zinn, D.J. 1974. Quahog: Queen of the mudflats. Maritimes 17:4-7.

THE BENTHIC COMMUNITIES WITHIN

NARRAGANSETT BAY

An Assessment Completed
for the
Narragansett Bay Project

Appendices A and B

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THE BENTHIC COMMUNITIES WITHIN

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APPENDIX A

Taxonomic Checklist for Narragansett Bay Benthic Species

Introduction

This appendix contains a list of those species or groups of species identified in the studies included in this report. 546 categories were used. Some only identify specimens to the phylum level (.e.g. Sipuncula); most include taxonomic definition to the level of species.

With few exceptions, I have chosen to report all species as they were identified in the original data sets. Venus mercenaria, listed in the Stickney-Stringer data sets, was changed to Mercenaria mercenaria to agree with current naming (Wells 1957). In those cases where species names have changed through the years, each name might occur in the species list although they refer to the same species. Where possible, I have made note of these changes at the end of the table. The list of changes is by no means complete.

The following references were used as guides to prepare the list: Pettibone (1963), Gosner (1971, 1978), Bousfield (1973), Cook and Brinkhurst (1973), Emerson and Jacobson (1976), Cutler (1977) and Fauchald (1977). In addition to these, Fauchald and Jumars (1979) was used to identify feeding types. Information concerning the feeding behavior for most species is not available and classifications were generally made on the basis of descriptions given for the entire family. Further uncertainty is introduced for those species that have been demonstrated to have a certain amount of feeding plasticity. For example, many spionid polychaetes can be both surface deposit and suspension feeders depending upon current flow, density and food supply (Dauer 1983; Dauer et al. 1981; Taghon et al. 1980; Frithsen and Doering 1986). Feeding classifications should be used with caution given the above caveats.

All publications referred to in this Appendix are listed in the 'Literature Cited' section of the report.

TABLE 1
Species and Species Groups Identified
in Narragansett Bay Benthic Data Sets

GROUP	FAMILY	GENUS	SPECIES	FEEDING TYPE+
Polychaeta	Ampharetidae	Ampharete	acutifrons	DS
			arctica	DS
			spp.	DS
		Amphicteis	gunneri	DS
		Asabellides	oculata	DS
		Hypaniola	grayi	
		Unknown	Unknown	DS
	Aphroditidae	Aphrodite	hastata	P
	Arabelli^ae	Arabella	iricolor	P
			opalina	P
			spp.	P
		Drilonereis	longa	P
			magna	P
			spp.	P
		Unknown	Unknown	P
	Astartidae	Unknown	Unknown	
	Biomass	Unknown	Unknown	
	Capitellidae	Capitella	spp.	D
		Heteromastus	filiformis	D
		Mediomastus	ambiseta	DSS
			californiensis	DSS
		Notomastus	luridus	D
		Unknown	Unknown	D
	Chaetopteridae	Chaetopterus	varicpedatus	S
		Spiochaetopterus	costarum	S
			oculatus	S
	Cirratulidae	Chaetozone	spp.	DS
		Cirratulus	cirratus	DS
			grandis	DS
		Dodecaceria	concharum	DS
		Tharyx	acutus	DS
			marioni	DS
			spp.	DS
		Unknown	Unknown	DS
	Cossuridae	Cossura	delta	
			spp.	
		Unknown	Unknown	
	Diastylidae	Diastylis	quadrispinosa	
	Dorvilleidae	Dorvillea	socialis	P
		Ophryotrocha	puerilis	P
		Protodorvillea	kefersteini	P
	Eunicidae	Marphysa	belli	
	Flabelligeridae	Brada	villosa	DS
		Flabelligera	affinis	DS
		Pherusa	affinis	DS

TABLE 1 (CONTINUED)

GROUP	FAMILY	GENUS	SPECIES	FEEDING TYPE
Polychaeta	Flabelleridae	Trophonia	affinis[5]	DS
		Unknown	Unknown	DS
	Glyceridae	Glycera	americana	P
		Glycera	capitata	P
			dibranchiata	P
			spp.	P
	Goniadidae	Glycinde	solitaria	P
		Goniada	maculata	P
		Goniadella	gracilis	P
		Ophioglycera	gigantea	P
		Unknown	Unknown	P
	Hesionidae	Gyptis	yittata	D
		Microphthalmus	aberrans	D
			sczelkowii	D
			spp.	D
		Podarke	obscura	D
		Unknown	Unknown	D
	Larvae	Unknown	Unknown	
	Lumbrineridae	Lumbrineris	fragilis	P
			spp.	P
			tenius	P
		Ninoe	nigripes	P,DS
		Unknown	Unknown	P,D
	Magelonidae	Magelona	spp.	DS
	Maldanidae	Asychis	carolinae	DSS
			elongata	DSS
			spp.[10]	DSS
		Clymenella	mucosa	DSS
			spp.	DSS
			torquata	DSS
			zonalis	DSS
		Euclymene	reticulata	DSS
			spp.	DSS
		Gravierella	spp.	DSS
		Macroclymene	zonalis	DSS
		Maldane	sarsi	DSS
		Maldanopsis	elongata[10]	DSS
		Microclymene	zonalis	DSS
		Rhodine	attenuata	DSS
		Unknown	Unknown	DSS
	Nephtydae	Aglaophamus	spp.	P
			verrilli	P
	Nephtyidae	Nephtys	caeca	P
			ciliata	P
			incisa	P
			ingens	P
			picta	P
			spp.	P
	Nereidae	Neanthes	virens	O
		Nereis	acuminata	O

TABLE 1 (CONTINUED)

GROUP	FAMILY	GENUS	SPECIES	FEEDING TYPE
Polychaeta	Nereidae	Nereis	arenaceodentata	O
			lamellosa	O
			limbata	O
			pelagica	O
			spp.	O
			succinea	O
			virens	O
		Unknown	Unknown	O
	Onuphidae	Diopatra	cuprea	O
			spp.	O
		Onuphis	spp.	O
		Unknown	Unknown	O
	Opheliidae	Ammotrypane	aulogaster	D
		Ophelina	spp.	D
		Travisia	carnea	D
		Unknown	Unknown	D
	Orbiniidae	Haploscoloplos	fragilis	D
			robustus	D
			spp.	D
		Scoloplos	acutus	D
			armiger	D
			fragilis	D
			robustus	D
			spp.	D
		Unknown	Unknown	D
	Oweniidae	Myriochele	heeri	D
	Paraonidae	Aricidea	catharinae	D
			jeffreysii	D
			longicinata	D
			spp.	D
			suecica	D
		Cirrophorus	americanus	D
			furcatus	D
			spp.	D
		Paraonella	spp.	D
		Paraonis	fulgens	D
			gracilis	D
			spp.	D
		Tauberia	gracilis	D
		Unknown	Unknown	D
	Pectinariidae	Pectinaria	gouldii[11]	DSS
	Pheliidae	Phelinia	abranchiata	
	Phyllodocidae	Anaitides	mucosa	P
			spp.	P
		Eteone	heteropoda	P
			lactea	P
			longa	P
			spp.	P
		Eulalia	bilineata	P
			spp.	P
			viridis	P

TABLE 1 (CONTINUED)

GROUP	FAMILY	GENUS	SPECIES	FEEDING TYPE
Polychaeta	Phyllodocidae	Eumida	sanquinea	P
		Paranaitis	speciosa	P
		Phyllodoce	arenae	P
			groenlandica	P
			maculata	P
			mucosa	P
			spp.	P
		Unknown	Unknown	P
	Poecilochaetidae	Unknown	Unknown	DS,S
	Polygordiidae	Polygordius	spp.	D
	Polynoidae	Gattyana	cirrhosa	P
		Harmothoe	extenuata	P
			imbricata	P
			spp.	P
		Lepidametria	spp.	P
		Lepidonotus	squamatus	P
			sublevis	P
		Unknown	Unknown	P
	Sabellariidae	Sabellaria	vulgaris	S
		Unknown	Unknown	
	Sabellidae	Chone	americana	S
		Euchone	incolor	S
			spp.	
		Jasmineira	spp.	S
		Lanonome	kroyen	S
		Manayunkia	spp.	S
		Potamilla	myriops	S
			neglecta	S
		Pseudopotamilla	reniformis	S
		Sabella	microphthalma	S
			spp.	S
		Unknown	Unknown	S
	Scalibregmidae	Scalibregma	inflatum	D
	Serpulidae	Hydroides	dianthus	S
			uncinata	S
		Spirorbis	spp.	S
		Unknown	Unknown	S
	Sigalionidae	Pholoe	minuta	P
		Stenelais	boa	P
			spp.	P
		Sthenelais	limicola	P
		Unknown	Unknown	P
	Spaerodoridae	Ephesiella	minuta	D
		Sphaerodorum	gracilis	D
	Spionidae	Anaspio	spp.	DS,S
		Boccardia	hamata	DS,S
		Dispio	uncinata	DS,S
		Minuspio	spp.	DS,S
		Polydora	caulleri	DS,S
			ciliata	DS,S

TABLE 1 (CONTINUED)

GROUP	FAMILY	GENUS	SPECIES	FEEDING TYPE
Polychaeta	Spionidae	Polydora	ligni	DS,S
			socialis	DS,S
			spp.	DS,S
		Prionospio	heterobranchia	DS,S
			spp.	DS,S
			steenstrupi	DS,S
		Pseudopolydora	spp.	DS,S
		Scolecolepides	texana	DS,S
			viridis	DS,S
		Scolelepis	bousfieldi	DS,S
			squamata	DS,S
		Spio	filicornis	DS,S
			pettiboneae	DS,S
			setosa	DS,S
			spp.	DS,S
		Spiophanes	bombyx	DS,S
		Streblospio	benedicti	DS,S
		Unknown	Unknown	DS,S
	Stenothoidae	Stenothoe	gallensis	
	Sternaspidae	Sternaspis	spp.	
	Syllidae	Autolytus	cornutus	P
			emertoni	P,H
			fasciatus	P
			prismaticus	P
			prolifera	P
			spp.	P
		Brania	clavata	P
			wellfleetensis	P
		Exogone	dispar	D
			hebes	D
			verugera	D
		Odontosyllis	fulgurans	P
		Parapionosyllis	longicirrata	P
		Syllides	longocirrata	D
		Syllis	cornuta	P
		Unknown	Unknown	P
	Terebellidae	Amphitrite	ornata	DS
		Pista	cristata	DS
			spp.	DS
		Polycirrus	eximius	DS
			phosphoreus	DS
			spp.	DS
		Thelepus	cincinnatus	DS
		Unknown	Unknown	DS
	Trichobranchidae	Terebellides	stroemii	DS
	Trochochaetidae	Trochochaeta	multisetosa	DS
		Unknown	Unknown	DS
	Unknown	Unknown	Unknown	
Archiannelida	Nerillidae	Nerilla	spp.	

TABLE 1 (CONTINUED)

GROUP	FAMILY	GENUS	SPECIES	FEEDING TYPE
Archiannelida	Nerillidae	Unknown	Unknown	
Oligochaeta	Tubificidae	Limnodriloides	medioporus	D
		Peloscolex	gabriellae	D
		Tubificoides	spp.	D
	Unknown	Unknown	Unknown	D
Bivalvia	Anomiidae	Anomia	simplex	F
			squamata	F
	Arcidae	Anadara	transversa	F
	Astartidae	Astarte	spp.	
			undata	
	Cardiidae	Cardium	pinnulatum	
		Cerastoderma	pinnulatum	
		Laevicardium	mortoni	
	Carditidae	Cardita	borealis	
	Corbulidae	Corbula	contracta	
	Hiatellidae	Hiatella	arctica	
	Leptonidae	Rochefortia	cunata[9]	
		Unknown	Unknown	
	Lyonsiidae	Lyonsia	arenosa	
			hyalina	
	Mactridae	Mulinia	lateralis	F
	Montacutidae	Mysella	spp.	
	Myidae	Mya	arenaria	F
	Mytilidae	Crenella	decussata	F
			glandula	F
			spp.	F
		Modiolaria	lateralis[6]	F
		Modiolus	demissus	F
			spp.	F
		Mytilus	edulis	F
			spp.	F
		Unknown	Unknown	F
	Nuculanidae	Unknown	Unknown	D
		Yoldia	limatula	D
			sapotilla	D
	Nuculidae	Nucula	annulata	D
			delphinodonta	D
			proxima	D
	Ostreidae	Crassostrea	virginica	F
	Pandoridae	Pandora	gouldiana	F
	Pectinidae	Aequipecten	irradians	F
	Periplomatidae	Periploma	fragilis	
			papyratium	
	Petricolidae	Petricola	pholadiformis	F
	Pinnidae	Unknown	Unknown	
	Solecurtidae	Tagelus	spp.	
	Solemyacidae	Solemya	velum	D
	Solenidae	Ensis	directus	F
		Solen	viridis	

TABLE 1 (CONTINUED)

GROUP	FAMILY	GENUS	SPECIES	FEEDING TYPE
Bivalvia	Tellinidae	Macoma	balthica	DS,S
			tenta	DS,S
		Tellina	agilis	D
			spp.	D
			tenera	D
	Thraciidae	Unknown	Unknown	
	Unknown	Unknown	Unknown	
	Veneridae	Callocardia	morrhuana[3]	F
		Gemma	gemma	F
		Mercenaria	mercenaria	F
		Pitar	morrhuana	F
Gastropoda	Acteonidae	Acteon	punctostriatus	D
		Rictaxis	punctostriatus	D
	Aeolidiidae	Aeolis	spp.	
	Calyptraeidae	Crepidula	convexa	F
			fornicata	F
			plana	F
			spp.	F
	Cerithiidae	Cerithiopsis	columnum	
	Columbellidae	Anachis	lafresnayi	
		Columbella	lunata[7]	
			spp.	
		Mitrella	lunata	
	Cuthonidae	Tergipes	spp.	
	Cylichnidae	Cylichnella	canaliculata[1]	P
	Diaphanidae	Diaphana	minuta	
	Epitoniidae	Epitonium	spp.	
	Hydrobiidae	Hydrobia	minuta	D
			salsa	D
			spp.	D
			totteni	D
	Melongenidae	Busycon	canaliculatum	
	Muricidae	Eupleura	caudata	P
		Urosalpinx	cinerea	P
	Nassariidae	Ilyanassa	obsoleta	D
		Nassa	spp.[8]	D
		Nassarius	obsoletus	D
			spp.	D
			trivittatus	D
	Naticidae	Lunatia	heros	
		Polinices	duplicata	
			heros	
			spp.	
			triseriata	
Gastropoda	Pyramidellidae	Odostomia	dealbata	
			giblzesa	
			sumneri	
			spp.	

TABLE 1 (CONTINUED)

GROUP	FAMILY	GENUS	SPECIES	FEEDING TYPE
Gastropoda	Pyramidillidae	Odostomia	trifida	
		Sayella	fusca	
		Turbonilla	elegantula	DS
			interrupta	DS
			spp.	DS
	Retusidae	Retusa	canaliculata[1]	P
			obtusa	
	Rissoidae	Alvania	excrata	
	Scaphandridae	Acteocina	canaliculata[1]	P
		Cylichna	oryza	P
			spp.	P
		Tornatina	canaliculata[1]	P
	Solecurtidae	Tagelus	divisus	
Gastropoda	Trichotropidae	Trichotropis	conica	
	Turritellidae	Turritella	spp.	
	Unknown	Unknown	Unknown	
Arachnida	Pellenidae	Callipallene	brevirostris	P
Arachnida	Tanystylidae	Tanystylum	orbiculare	P
Pycnogonida	Unknown	Unknown	Unknown	
Merostomata	Limulidae	Limulus	polyphemus	
Insecta	Unknown	Unknown	Unknown	
Crustacea	Larvae	Unknown	Unknown	
	Unknown	Unknown	Unknown	
Amphipoda	Ampeliscidae	Ampelisca	abdita	D,S
			agassizi	D,S
			macrocephala	D,S
			spinipes[2]	D,S
			spp.	D,S
			vadorum	D,S
			verrilli	D,S
		Byblis	serrata	D,S
	Ampithoidae	Ampithoe	spp.	
			valida	
	Aoridae	Lembos	websteri	
		Leptocheirus	pinguis	S
			plumulosus	S
		Microdeutopus	anomalus	
			gryllotalpa	D
		Unciola	irrorata	D
	Argissidae	Arigissa	hamatipes	
	Bateidae	Batea	catharinensis	
	Biomass	Unknown	Unknown	
	Caprellidae	Aeginina	longicornis	
		Caprella	penantis	
			septentrionalis	
			unica	
		Luconacia	incerta	
		Paracaprella	tenuis	
		Unknown	Unknown	
	Corophiidae	Corophium	acherusicym	DS

TABLE 1 (CONTINUED)

GROUP	FAMILY	GENUS	SPECIES	FEEDING TYPE
Amphipoda	Corophiidae	Corophium	acutum	DS
			cylindricum	DS
			spp.	DS
		Erichthonius	rubricornis	DS
		Unciola	serrata	DS
		Unknown	Unknown	DS
	Eggs	Unknown	Unknown	
	Gammaridae	Carinogammarus	mucronatus	
		Elasmopus	laevis	
		Gammarus	mucronatus	
			spp.	
		Melita	nitida	
		Unknown	Unknown	
	Ischyroceridae	Ischyrocerus	anguipes	
		Jassa	falcata	
	Larvae	Unknown	Unknown	
	Liljeborgiidae	Idunella	spp.	
	Lilljeborgiidae	Listriella	barnardi	
	Lysianassidae	Lysianopsis	alba	P
		Orchomonella	minuta	P
	Melitidae	Casco	bigelowi	
	Oedicerotidae	Monoculodes	edwardsi	
			spp.	
	Photidae	Photis	macrocoxa	
	Phoxocephalidae	Paraphoxus	spinosus	
		Phoxocephalus	holbolli	
	Pleustidae	Stenopleustes	gracilis	
			inermis	
	Podoceridae	Dulichia	monacantha	S
			porrecta	S
	Stenothoidae	Stenothoe	spp.	D
	Stenothoidea	Parametopella	cypris	D
	Unknown	Unknown	Unknown	
Isopoda	Anthuridae	Cyathura	polita	P,D
			spp.	P,D
		Ptilanthura	tenuis	P,D
	Idoteidae	Edotea	montosa	P
			spp.	P
			triloba	P
		Erichsonella	filiformis	P
		Idotea	balthica	P
Tanaidacea	Paratanaidae	Leptochelia	savignyi	
Cumacea	Diastylidae	Diastylis	polita	S
			sculpta	S
			spp.	S
		Leptosylis	longimana	S
		Oxyurostylis	smithi	S
	Leuconidae	Eudorella	spp.	S
		Leucon	americana	S

TABLE 1 (CONTINUED)

GROUP	FAMILY	GENUS	SPECIES	FEEDING TYPE
Cumacea	Unknown	Unknown	Unknown	S
Mysidacea	Mysidae	Heteromysis	formosa	O
			odontops	O
		Mysis	stenolepis	O
		Neomysis	americana	O
			spp.	O
	Unknown	Unknown	Unknown	O
Decapoda	Axiidae	Axius	serratus	
	Brachyura	Unknown	Unknown	
	Callianassidae	Callianassa	atlantica	O
	Cancridae	Cancer	irroratus	P
			spp.	P
		Unknown	Unknown	P
	Caridea	Unknown	Unknown	O
	Crangonidae	Crangon	septemspinosa	P,O
	Hippolytidae	Eualus	pusiolus	O
	Majidae	Libinia	dubia	P
			emarginata	P
			spp.	P
	Paguridae	Pagurus	longicarpus	O
			pollicaris	P
			spp.	O
		Unknown	Unknown	O
	Palaemonidae	Palaemonetes	pugio	O
		Paleomonetes	vulgaris	O
	Pinnotheridae	Pinnixa	chaetopterana	O
			sayana	O
		Pinnotheres	maculatus	O
			ostreum	O
	Portunidae	Carcinus	maenas	O
		Ovalipes	ocellatus	O
	Upogebiidae	Upogebia	affinis	S
	Xanthidae	Neopanope	texanasayi	P
Cirripedia	Balanidae	Balanus	balanoides	S
			crenatus	F
Ostracoda	?	Cylindroleberis	mariae	P
	Unknown	Unknown	Unknown	P
Stomatopoda	Leuconidae	Eudorella	pusilla	P
	Squillidae	Squilla	empusa	P
Turbellarian	Leptoplanidae	Leptoplana	spp.	P
	Sylochidae	Stylochus	ellipticus	P
	Unknown	Unknown	Unknown	P
Hydrozoa	Campanulariidae	Obelia	spp.	S
	Hydractiniidae	Hydractinia	spp.	S
	Tubulariidae	Tubularia	spp.	S
	Unknown	Unknown	Unknown	S
Anthozoa	Astrangiidae	Astrangia	danae	
	Cereianthidae	Cerianthiopsis	americanus	P
	Edwardsiidae	Edwardsia	sipunculoides	P

TABLE 1 (CONTINUED)

GROUP	FAMILY	GENUS	SPECIES	FEEDING TYPE
Anthozoa	Edwardsiidae	Edwardsia	spp.	P
		Unknown	Unknown	P
	Sagartidae	Actinithoe	spp.	P
		Sagartia	modesta	P
	Unknown	Unknown	Unknown	P
Ctenophora	Mnemiidae	Mnemiopsis	leidyi	F
Foraminifera	Unknown	Unknown	Unknown	
Porifera	Heterocoelidae	Scypha	ciliata	F
			spp.	F
	Microcionidae	Microciona	prolifera	F
Bryozoan	Cheiloporinidae	Cryptosula	pallasiana	S
		Lepralia	pallasiana	S
	Membraniporidae	Membranipora	spp.	S
	Schizoporellidae	Schizoporella	spp.	S
	Unknown	Unknown	Unknown	S
	Vesicularidae	Bowerbankia	gracilis	S
Nemertea	?	Rhynchocoela	spp.	P
	Amphiporidae	Amphiporus	bioculatus	P
			ochraceus	P
	Cephalothricidae	Procephalothrix	spiralis	P
	Lineidae	Cerebratulus	lacteus	P
		Micrura	leidyi	P
			spp.	P
		Unknown	Unknown	P
	Tubulanidae	Tubulanus	pellucidus	P
	Unknown	Unknown	Unknown	P
Phoronida	None designated	Phoronis	architecta	S
	Unknown	Unknown	Unknown	S
Sipuncula	Golfingiidae	Phascolion	strombi	D
	Unknown	Unknown	Unknown	D
Holothurian	Cucumariidae	Cucumaria	pulcher	D
	Molpadiidae	Molpadia	spp.	D
	Sclerodactylidae	Thyone	briareus	D
	Synaptidae	Leptosynapta	spp.	D
			tenuis	D
	Unknown	Unknown	Unknown	D
Echinoidea	Asteriidae	Asterias	forbesi	P
		Unknown	Unknown	P
	Unknown	Unknown	Unknown	
Ophiuroidea	Ophiuridae	Unknown	Unknown	
Hemichordata	Harrimaniidae	Saccoglossus	kowalewskyi	
Ascidiacea	Molgulidae	Molgula	arenata	F
			manhattensis	F
			spp.	F
		Unknown	Unknown	F
	Unknown	Unknown	Unknown	F
Unknown	?	Anxiothella	spp.	
		Carizziella	spp.	
		Cyclocardia	borealis	

TABLE 1 (CONTINUED)

GROUP	FAMILY	GENUS	SPECIES	FEEDING TYPE
Unknown	?	Gani	spp.	
		Lestrigonus	bengalensis	
		Megalomma	spp.	
		Proboloides	holmesi	
		Spadella	spp.	
	Unknown	Unknown	Unknown	

Table Notes:

\+ Feeding types classif_ed using categories of Fauchald and Jumars 1979.

D = Deposit Feeder
DS = Surface Deposit Feeder
DSS = Sub-surface Deposit Feeder
S or F = Suspension or Filter Feeder
P = Predator or Carnivore
O = Omnivore
H = Herbivore

1 Tornatina canaliculata, Cylichnella canaliculata and Retusa canaliculata have all been used at one time or another to refer to the species Acteocina canaliculata (see Mikkelsen and Mikkelsen 1984).

2 Ampelisca vadorum and Ampelisca abdita were previously mistaken for the european species Ampelisca spinipes (Mills 1963; Mills 1964).

3 Callocardia morrhuana is an obsolete name for Pitar morrhuana.

4 Venus mercenaria is an obsolete name for Mercenaria mercenaria.

5 Trophonia affinis is an obsolete name for Pherusa affinis.

6 The genus Modiolaria is obsolete. See Musculus.

7 Columbella lunata is an obsolete name for Mitrella lunata.

8 The genus Nassa is obsolete. See Nassarius.

9 The genus Rochefortia is obsolete. See Mysella.

10 The genus Maldanopsis is obsolete. See Asychis

11 Pectinaria gouldii is an obsolete name for Cistenides gouldii.

Table 4
City of Newport 1982

Kind of data: Descriptive: 301(h) waiver application

Data set description: See below.

Sampling locations: East Passage off of Newport

Principal Investigator(s): Metcalf and Eddy, Inc.
P.O. Box 4043
Woburn, MA 01888-4043

Study used in benthic characterization project: No.

Investigator(s) contacted for characterization project: No.

Funding institution: City of Newport, RI

Citation for published data: City of Newport, Rhode Island. 1982. Application to the U.S. Environmental Protection Agency for modification of secondary treatment requirements for discharge into marine waters in the east passage of Narragansett Bay for its water pollution control plant. December 29, 1982. Metcalf and Eddy, Inc., Boston, MA.

Location of original raw data: Unknown.

Person to contact for original raw data: Unknown.

Computer status of original data set: Unknown.

Addition comments: Background information given for application to EPA for a 301(h) waiver. Incidental descriptions of benthic infauna and shellfish. No raw data given.

Table 5
City of Newport 1985

Kind of Data: Benthic macrofaunal abundance

Data Set Description: Number of sample stations: 11
Sample period: 84092 - 84245
Sample frequency: 3 times
Sample type: Van Veen Grab
Number of replicates: 5
Area of individual samples: 0.05 m^2
Sediment depth sampled: 0-2 cm
Lowest sieve size used: 500 um
Number of species or species groups identified: 246
Number of dominant species or species groups: 16

Sample Locations: East Passage, Narragansett Bay
See below.

Principal Investigator(s): Metcalf and Eddy, Inc.
P.O. Box 4043
Woburn, MA 01888-4043

Study used in benthic characterization project: Yes.

Investigator(s) contacted for characterization project: Yes.

Funding Institution: City of Newport, RI

Citation for published data: City of Newport. 1985. Application for modification of seconday treatment requirements for its water pollution control plant effluent discharge into marine waters. Metcalf and Eddy, Inc. Boston, MA.

Location of original raw data: Unknown

Person to contact for original data set: Unknown

Computer status of original data set: Unknown

Additional Comments: Publication presents data as the mean of 5 replicate cores. Attempts were made to obtain data for individual cores but a complete data set was not available at the time this report was completed. Samples taken by Metcalf and Eddy, Inc., and processed by Cove Corporation, Lusby, MD. In a review of the the Newport 301(h) application (Tetra Tech, Inc. 1985), sample dates were listed as April, June and September 1984. However, in a partial set of raw data sheets provided by Metcalf and Eddy, sample dates were given as May and July. I assumed sample dates in the computerized data set to be 1 April, 1 June and 1 September 1984.

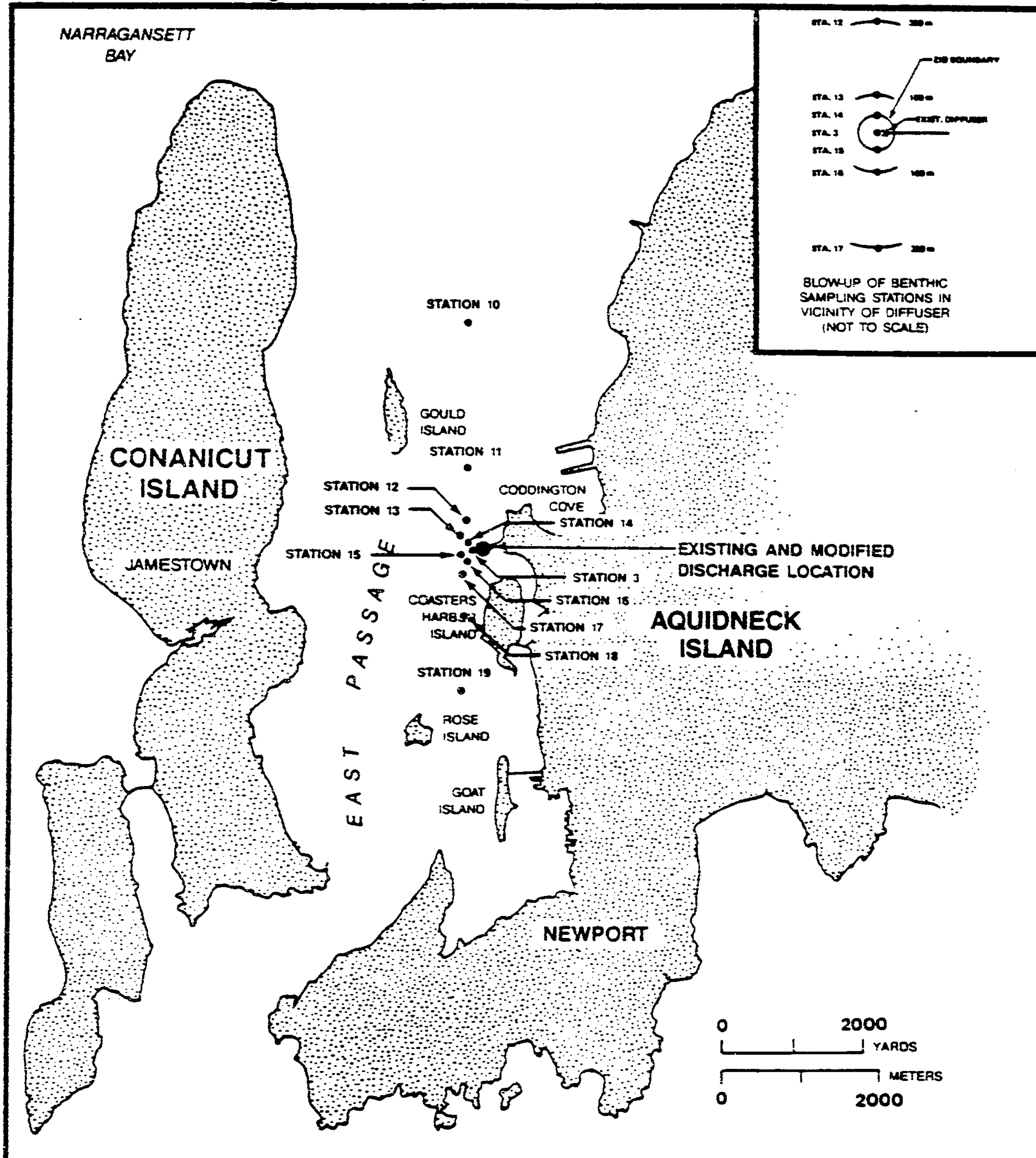
Table 5 (Continued)
City of Newport 1985

Station Locations: Sample locations were given relative to the diffuser of the discharge pipe from the Newport sewage treatment plant. The diffuser is located at: 41 51 06 N, 71 19 59 W. Station 3 was at the mouth of the discharge. Station 14 was 50 m north of the discharge, Station 13 was 100 m north, Station 12 was 300 m north, Station 10 was 1040 m north, and Station 11 was 2960 m north of the discharge. Station 15 was 50 m south, Station 16 was 100 m south, Station 17 was 300 m south, Station 18 was 880 m south, and Station 19 was 1920 m south of the discharge.

Station Locations

Station	Latitude	Longitude
Station 3:	41 31 08 N	71 19 59 W
Station 14:	41 31 06 N	71 20 01 W
Station 13:	41 31 10 N	71 20 03 W
Station 12:	41 31 14 N	71 20 01 W
Station 10:	41 32 38 N	71 20 02 W
Station 11:	41 31 39 N	71 20 02 W
Station 15:	41 31 02 N	71 20 04 W
Station 16:	41 30 59 N	71 20 02 W
Station 17:	41 30 53 N	71 20 02 W
Station 18:	41 30 35 N	71 20 01 W
Station 19:	41 29 29 N	71 20 01 W

Figure 2 - City of Newport 1985 - Station Locations



REFERENCE: FIGURE II.C.1-1 OF THE UPDATED APPLICATION.

Benthic sampling stations in East Passage in 1984.

Table 6
Crowley 1962

Kind of data: Benthic macrofaunal survey

Data set description: Number of Sample Stations: 60
Sample Period: 61153 - 61213
Sample Frequency: Once
Sample Type: Modified Petersen Grab
Number of Replicates: 1
Area of individual samples: Unknown
Lowest sieve size used: 1.59 mm

Sampling Locations: Eastern side of Narragansett Bay
See below.

Principal Investigator(s): Mr. Donald Joe Crowley
Department of Geology
Brown University
Providence, RI

Study used in benthic characterization project: Yes

Investigator(s) contacted for characterization project: No

Funding institution: Unknown

Citation for published data: Crowley, D.J. 1962. The benthic fauna and sediment relationships of eastern Narragansett Bay, Rhode Island. MS Thesis, Brown University, Providence, RI, 65p.

Location of original raw data: Publication.

Person to contact for original raw data: Unknown.

Computer status of original data set: Unknown. Not entered into data files for this project.

Additional comments: This study was a qualitative study of benthic communities with the aim to relate community composition to various sediment parameters. Only benthic organisms that had hard shells (bivalves and gastropods, for examples) or made inorganic biotic structures (worm tubes, for example), were included in the study since no preservative agents were used. Samples were allowed to air dry prior to analysis and no distinctions were made between material that was living or dead at the time of collection.

This thesis, and that of McGetchin 1961, were completed in the laboratory of Dr. Leo F. Laporte of Brown University with considerable help from Dr. Robert L. McMaster, University of Rhode Island.

Table 6 (Continued)
Crowley 1962 - Station Locations

Station	Latitude Degrees	Latitude Minutes	Latitude Seconds	Longitude Degreees	Longitude Minutes	Longitude Seconds
101	41	29	35	71	14	21
102	41	29	30	71	13	26
103	41	29	37	71	12	16
104	41	31	27	71	12	41
105	41	31	53	71	13	11
106	41	32	17	71	13	51
107	41	33	55	71	12	55
108	41	34	21	71	13	26
109	41	34	56	71	14	3
110	41	35	54	71	12	37
111	41	36	11	71	13	5
112	41	36	56	71	14	12
113	41	38	8	71	12	54
114	41	38	26	71	15	25
115	41	38	40	71	14	8
116	41	39	18	71	14	34
117	41	39	52	71	14	55
118	41	39	14	71	13	0
119	41	39	26	71	12	38
121	41	40	39	71	13	54
122	41	41	30	71	14	15
123	41	42	15	71	13	48
124	41	41	46	71	13	0
126	41	41	57	71	11	14
127	41	42	36	71	11	56
128	41	43	28	71	12	55
129	41	42	40	71	10	21
130	41	43	8	71	9	55
131	41	33	17	71	18	35
132	41	34	2	71	18	57
133	41	34	38	71	19	19
134	41	34	35	71	17	31
135	41	35	24	71	17	54
136	41	35	52	71	18	10
137	41	35	54	71	16	57
138	41	37	3	71	17	28
139	41	37	42	71	18	3
140	41	38	9	71	16	48
141	41	38	32	71	15	58
142	41	40	32	71	16	57
143	41	39	23	71	16	35
144	41	39	14	71	17	25
146	41	38	29	71	19	46
147	41	41	27	71	17	50
148	41	40	48	71	19	31

Table 6 (Continued)
Crowley 1962 - Station Locations

Station	Latitude Degrees	Latitude Minutes	Latitude Seconds	Longitude Degreees	Longitude Minutes	Longitude Seconds
149	41	40	29	71	20	39
150	41	40	19	71	21	34
151	41	42	3	71	21	13
152	41	42	47	71	20	23
153	41	43	30	71	18	32
154	41	42	42	71	17	35
155	41	43	48	71	22	9
156	41	44	19	71	21	50
157	41	44	39	71	20	46
158	41	45	54	71	21	29
159	41	46	27	71	22	34
160	41	47	33	71	22	10

Table 7
Davis Unpublished

Kind of data: Benthic macrofaunal abundance

Data set description: Number of sample stations: 6
Sample period: 1969-1973
Sample frequency: Irregular
Sample type: Forester Anchor Dredge
Number of replicates: 3
Area of individual samples: 600 cm^2
Sediment depth sampled: 0-10 cm
Lowest sieve size used: 2 mm
Number of species or species groups identified: 34
Number of dominant species or species groups: 18

Sampling locations: Station A: West Passage, GSO Dock
41 29 35 N 71 24 55 W
Station B: West Passage, Greene Pt.
41 27 17 N 71 24 46 W
Station C: West Passage, Lone Tree Pt.
41 33 30 N 71 25 14 W
Station D: North of Hope Island
41 36 56 N 71 22 08 W

Principal Investigator(s): Dr. Wayne Davis
Environmental Protection Agency
Environmental Research Laboratory
Narragansett, RI 02882-1197
401-782-3065

Study used in benthic characterization project: Yes

Investigator(s) contacted for characterization project: Yes

Funding institution: Environmental Protection Agency

Citation for published data: Not published.

Location of original raw data: EPA - Narragansett

Person to contact for original raw data: Dr. Wayne Davis

Computer status of original data set: Fully entered into labeled SAS data sets residing on the GSO Computer Center's Micro-VAX II.

Person to contact for computer data set: Dr. Jeffrey B. Frithsen

Additional comments: Stations E and G deleted from data base because locations were unknown.

Figure 3 - Davis Unpublished - Station Locations

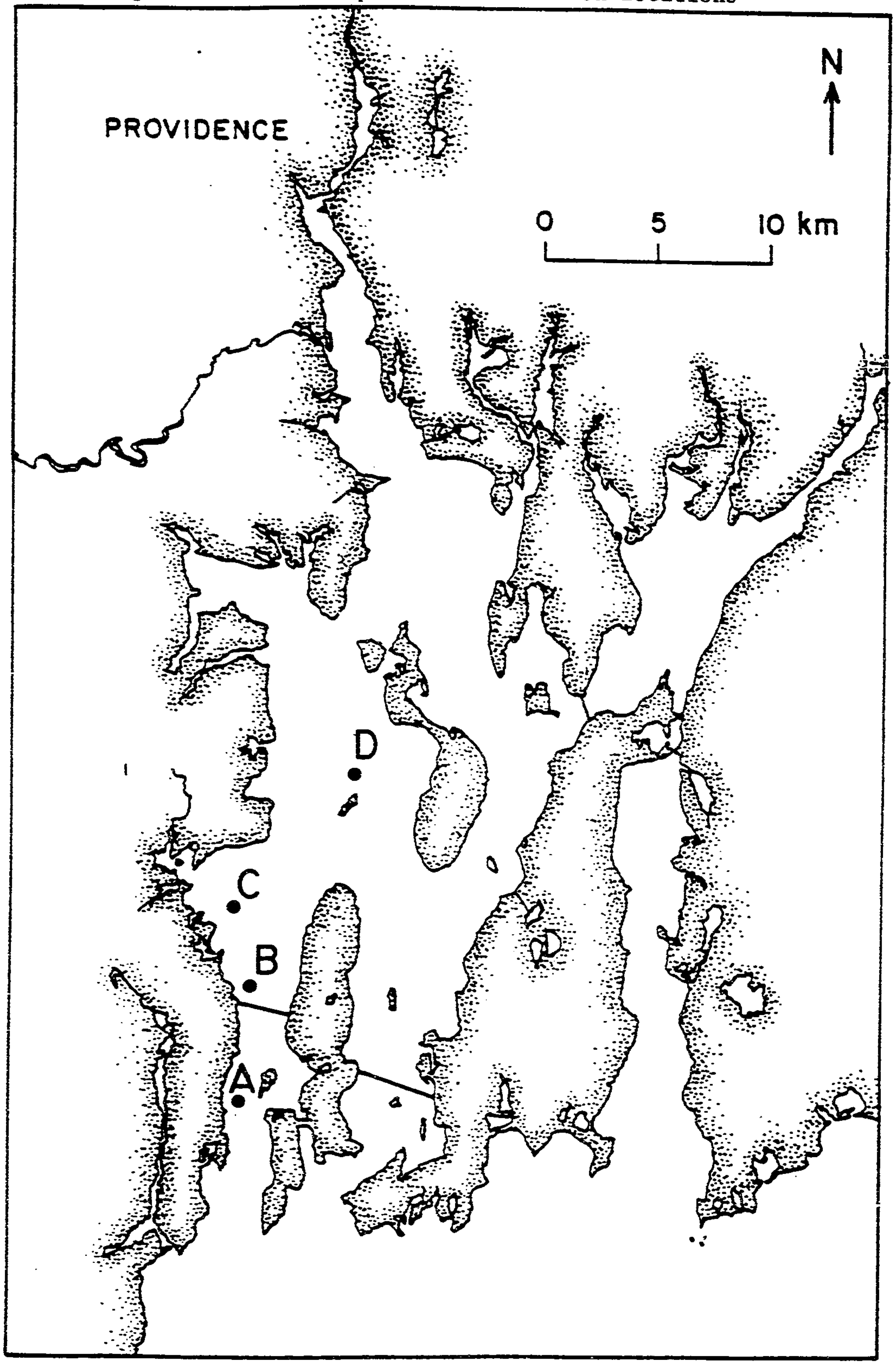


Table 8
Frithsen Unpublished A

Kind of data: Benthic macrofaunal abundance

Data set description: Number of sample station: 1
Sample period: 86169
Sample frequency: Once
Sample type: Diver cores
Number of replicates: 2
Area of individual samples: 35.3 cm^2
Lowest sieve size used: 300 um
Number of species or species groups identified: 15
Number of dominant species or species groups: 6

Sampling locations: Greenwich Bay 41 40 57 N 71 25 38 W

Principal Investigator: Dr. Jeffrey B. Frithsen
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882-1197
401-792-6712

Study used in benthic characterization project: Yes

Investigator(s) contacted for characterization project: Yes

Funding Institution: Environmental Protection Agency

Citation for published data: None.

Location of original raw data: Marine Ecosystems Research Laboratory, Graduate School of Oceanography, University of Rhode Island, Narragansett, RI

Person to contact for original raw data: Dr. Jeffrey B. Frithsen

Computer status of original data set: Fully entered into labeled SAS data sets residing on the GSO Computer Center's Micro-VAX II.

Additional comments:

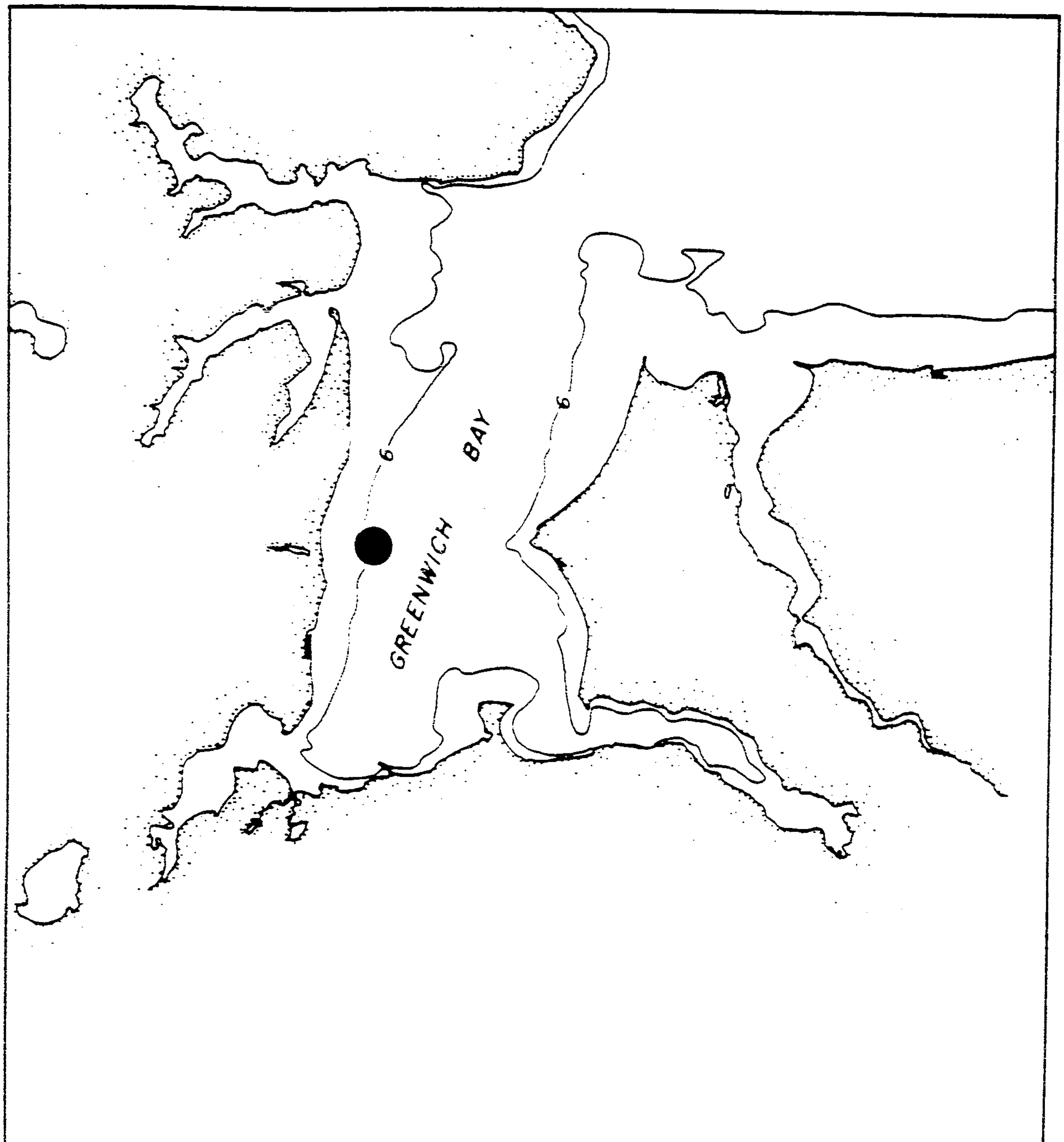


Figure 4 - Frithsen Unpublished - Station Locations

Table 9
Ganz and Sisson 1977

Kind of data: Shellfish Survey

Data set description: Number of sample stations: 175
Sample period: Unknown
Sample frequency: Once
Sample type: Digging
Number of replicates: 1
Area of individual samples: 1 m^2
Lowest sieve size used: 12,700 um

Sampling locations: Quonset - Davisville Area.

Principal Investigator(s): Arthur Ganz and Richard Sisson

Study used in benthic characterization project: No.

Investigator(s) contacted for characterization project: No.

Funding institution: Coastal Resources Center, University of Rhode Island.

Citation for published data: Ganz, A. and R. Sisson. 1975. Inventory of the fisheries resources of the Quonset-Davisville Area, North Kingstown, Rhode Island. Leaflet No. 48, Rhode Island Department of Natural Resources, Division of Fish and Wildlife, Marine Fisheries Section, 20p.

Location of original raw data: Unknown, not in publication

Person to contact for original raw data: Unknown.

Computer status of original data set: Unknown.

Additional comments: Description of shell and finfish of the Quonset/Davisville area of Narragansett Bay. No date given and no raw data included for specific station locations.

Table 10
Grassle and Grassle Unpublished Data

Kind of data: Benthic macrofaunal abundance

Data set description: Number of sample stations: 4
Sample period: 77153-80177
Sample frequency: Irregular
Sample type: Diver cores
Number of replicates: Usually 10
Area of individual samples: 34.2-35.3 cm^2
Lowest sieve size used: 300 um
Number of species or species groups identified: 167
Number of dominant species or species groups: 13

Sampling locations: Station 91: Mid-Bay MERL Station No. 1, north of Conanicut Island 41 34 57 N 71 22 19 W
Station 92: Mid-Bay MERL Station No. 2, north of Conanicut Island 41 35 02 N 71 22 19 W
Station 95: Providence River 41 43 25 N 71 21 52 W
Station 96: Rhode Island Sound 41 25 06 N 71 24 34 W

Principal Investigator(s): Dr. J. Frederick Grassle
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
617-548-1400 X2338
Dr. Judith Grassle
Marine Biological Laboratory
Woods Hole, MA 02543
617-548-3705

Study used in benthic characterization project: Yes

Investigator(s) contacted for characterization project: Yes

Funding institution: Environmental Protection Agency

Citation for published data: See comments below.

Location of original raw data: Woods Hole Oceanographic Institution, Woods Hole, MA, and the Ecosystems Research Laboratory, University of Rhode Island, Narragansett, RI.

Person to contact for original raw data: Dr. J. Frederick Grassle

Computer status of original data set: Original data at MERL entered but only part of original data located at MERL. Remainder was unavailable for use by this project.

Table 10 (Continued)
Grassle and Grassle Unpublished

Additional comments: The work of Grassle et al. have been published in part in various publications and technical reports. The entire raw data set was not made available by the principal investigators for this project. For this reason, only those data previously published could be included. Grassle et al. publications pertaining to Narragansett Bay benthic communities are listed below:

Grassle, J.F., J.P. Grassle, L.S. Brown-Leger, R.F. Petrecca and N.J. Copley. 1985. Subtidal macrobenthos of Narragansett Bay. Field and mesocosm studies of the effects of eutrophication and organic input on benthic populations. In, J.S. Gray and M.E. Christiansen (eds) Marine biology of polar regions and effects of stress on marine organisms. Wiley, NY, pp. 421-434.

Grassle, J.P. and J.F. Grassle. 1984. The utility of studying the effects of pollutants on single species populations in benthos of mesocosms and coastal ecosystems. In, H.H. White (ed) Concepts in marine pollution measurements, Maryland Sea Grant college, College Park, MD, pp. 621-642.

Grassle, J.F., J.P. Grassle, L.S. Brown-Leger, N.J. Copley and R.F. Petrecca. 1981. Quantitative studies of macrofauna in three benthic communities in experimental ecosystems. In, Fates and Effects of Marine Pollutants and Certain Policy Studies. Report for Year 1 of EPA Cooperative Agreement # CR 807795, MERL, The University of Rhode Island, Kingston, RI, pp. 38-50a.

Grassle, J.F., R. Elmgren and J.P. Grassle. 1980-81. Response of benthic communities in MERL experimental ecosystems to low level, chronic additions of No. 2 fuel oil. Marine Environmental Research 4:279-297.

Grassle, J.F., J.P. Grassle, L.S. Brown-Leger, N.J. Copley and J.G. Smith Derby. 1980. Quantitative studies on benthic communities in experimental ecosystems. In, The Fate and Effects of Chronic Low Level Pollutants in Marine Ecosystems. Report for Year II of EPA Grant # 806072020, MERL, The University of Rhode Island, Kingston, RI, pp. 144-168.

Grassle, J.F., J.P. Grassle, L.S. Brown-Leger, C.H. Lanyon-Duncan and N.J. Copley. 1979. Benthic communities in experimental ecosystems and the effects of petroleum hydrocarbons. In, The Use of Large Marine Microcosms to Study the Fates and Effects of Chronic Low Level Pollutants. Report for Year I of EPA Grant # 806072010, MERL, The University of Rhode Island, Kingston, RI, pp. 201-228.

Table 10 (Continued)
Grassle and Grassle Unpublished

Grassle, J.F., J.P. Grassle, L.S. Brown-Leger, N.J. Maciolek and C.H. Lanyon-Duncan. 1978. Benthic communities in experimental ecosystems and the effects of petroleum hydrocarbons. In, The use of Large Marine Microcosms to Study the Fates and Effects of Chronic Low Level Pollutants. Report for EPA Grant # R803902020, MERL, The University of Rhode Island, Kingston, RI, pp. 425-450.

Grassle, J.F. and J.P. Grassle. 1977. Benthic community structure in experimental ecosystems and the effects of petroleum hydrocarbons. In, Technical Progress Report. Report for EPA Grant # R803902020, MERL, The University of Rhode Island, Kingston, RI, pp. 364-372.

Figure 5 - Grassle and Grassle Unpublished - Station Locations

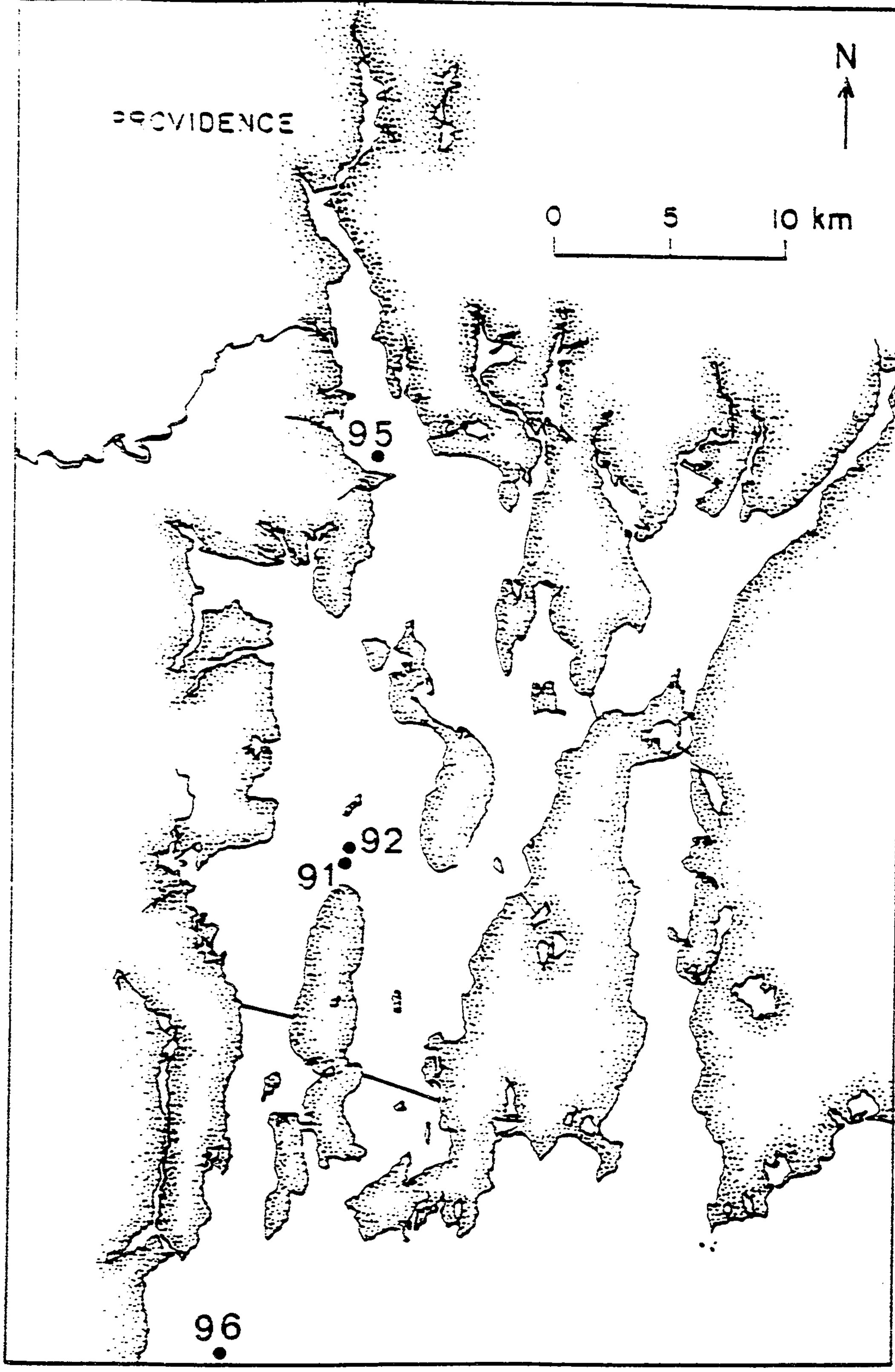


Table 11
Hale 1974

Kind of data: Benthic macrofaunal abundance and biomass

Data set description: Number of sample stations: 3
Sample period: 74305
Sample frequency: Once
Sample type: Smith-McIntyre Grab
Number of replicates: 3
Area of individual samples: 1000 cm^2
Lowest sieve size used: 750 um
Number of species or species groups identified: 46
Number of dominant species or species groups: 9

Sampling locations: Station A: Mouth of Greenwich Bay
41 39 12 N 71 23 0 W
Station B: Mid-Bay, north of Conanicut Island
41 34 48 N 71 22 6 W
Station C: West Passage, GSO Dock
41 29 36 N 71 25 12 W

Principal Investigator(s): Mr. Steve Hale
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882-1197
401-792-6617

Study used in benthic characterization project: Yes.

Investigator(s) contacted for characterization project: Yes.

Funding institution: Unfunded.

Citation for published data: Hale, S.S. 1974. The role of benthic communities in the nutrient cycles of Narragansett Bay. MS Thesis, University of Rhode Island, Kingston, RI, 123p.

Location of original raw data: Publication.

Person to contact for original raw data: Mr. Steve Hale

Computer status of original data set: Fully entered into labeled SAS data sets residing on the GSO Computer Center's Micro-VAX II.

Additional comments: Publication gives mean of the 3 replicates taken per station

Figure 6 - Hale 1974 - Station Locations

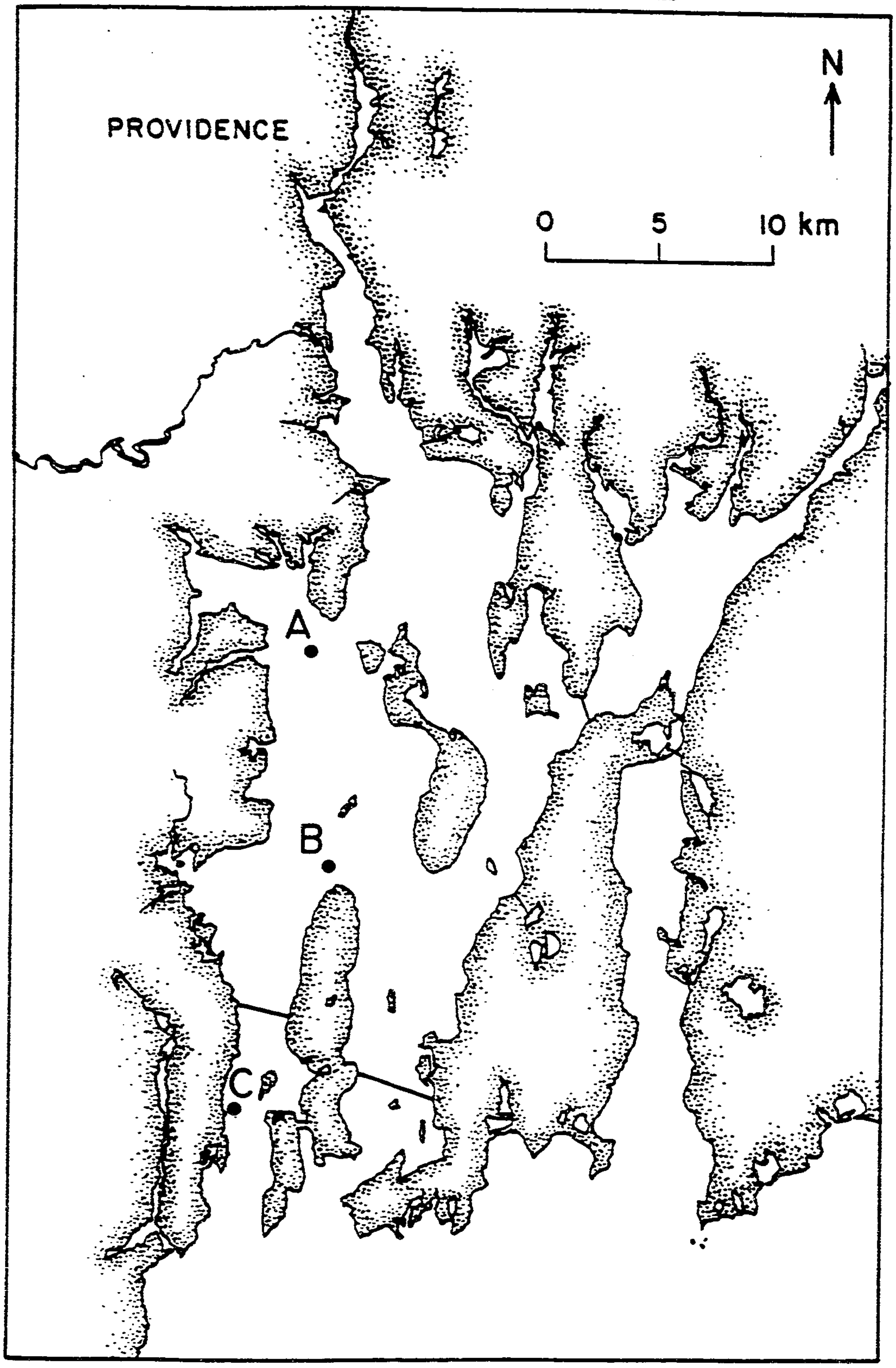


Table 12
Hoff and Moss 1976

Kind of data: Benthic Macrofaunal Abundance

Data set description: Number of sample stations: 116
Sample period: 75213
Sample frequency: Once
Sample type: Ekman dredge or Van Veen grab
Number of replicates: 1
Area of individual samples: 500 cm^2 or 1000 cm^2
Lowest sieve size used: 1000 um
Number of species or species groups identified: 66
Number of dominant species or species groups: 10

Sampling locations: Providence River, Apponaug Cove and Greenwich Bay
116 stations along 20 transects.

Principal Investigator(s): Dr. James G. Hoff
Dr. Sanford A. Moss
Biology Department, Southeastern
Massachusetts University
North Dartmouth, MA 02747

Study used in benthic characterization project: Yes.

Investigator(s) contacted for characterization project: No.

Funding institution: U.S. Army Corps of Engineers

Citation for published data: Hoff, J.G. and S.A. Moss. 1976. Final Report: Apponaug Cove - Greenwich Bay Environmental Survey. Contract DACW33-76-M-0050 from the Environmental Analysis Branch, Department of the Army, New England Division Corps of Engineers, Waltham, MA, 44p.

Location of original raw data: Publication.

Person to contact for original raw data: Unknown.

Computer status of original data set: Fully entered into labeled SAS data sets residing on the GSO Computer Center's Micro-VAX II.

Additional comments:

Table 13
Hughes Unpublished

Kind of data: Benthic Macrofaunal Abundance

Data set description: Number of sample stations: 3
Sample period: 83237-86118
Sample frequency: Irregular
Sample type: Diver or remote cores
Number of replicates: Usually 10
Area of individual samples: 35.3 cm^2 or 17.35 cm^2
Lowest sieve size used: 300 um
Number of species or species groups identified: 182
Number of dominant species or species groups: 5

Sampling locations: Station 91: Mid-bay MERL Station No. 1, north of Conanicut Island 41 34 57 N 71 22 19 W
Station 92: Mid-bay, west of north tip of Conanicut Island 41 34 17 N 71 22 53 W
Station 93: South of Hope Island 41 35 20 N 71 22 14 W

Principal Investigator(s): Mr. Jeffrey Hughes
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 022882-1197
401-792-6673

Study used in benthic characterization project: Yes.

Investigator(s) contacted for characterization project: Yes.

Funding institution: Unfunded research

Citation for published data: None.

Location of original raw data: MERL

Person to contact for original raw data: Mr. Jeffrey Hughes

Computer status of original data set: Fully entered into labeled SAS data sets residing on the GSO Computer Center's Micro-VAX II.

Additional comments: Not all species were sorted from each core. Many cores were sorted only to get abundance for the dominant polychaete, *Mediomastus ambiseta*.

Figure 7 - Hughes Unpublished - Station Locations

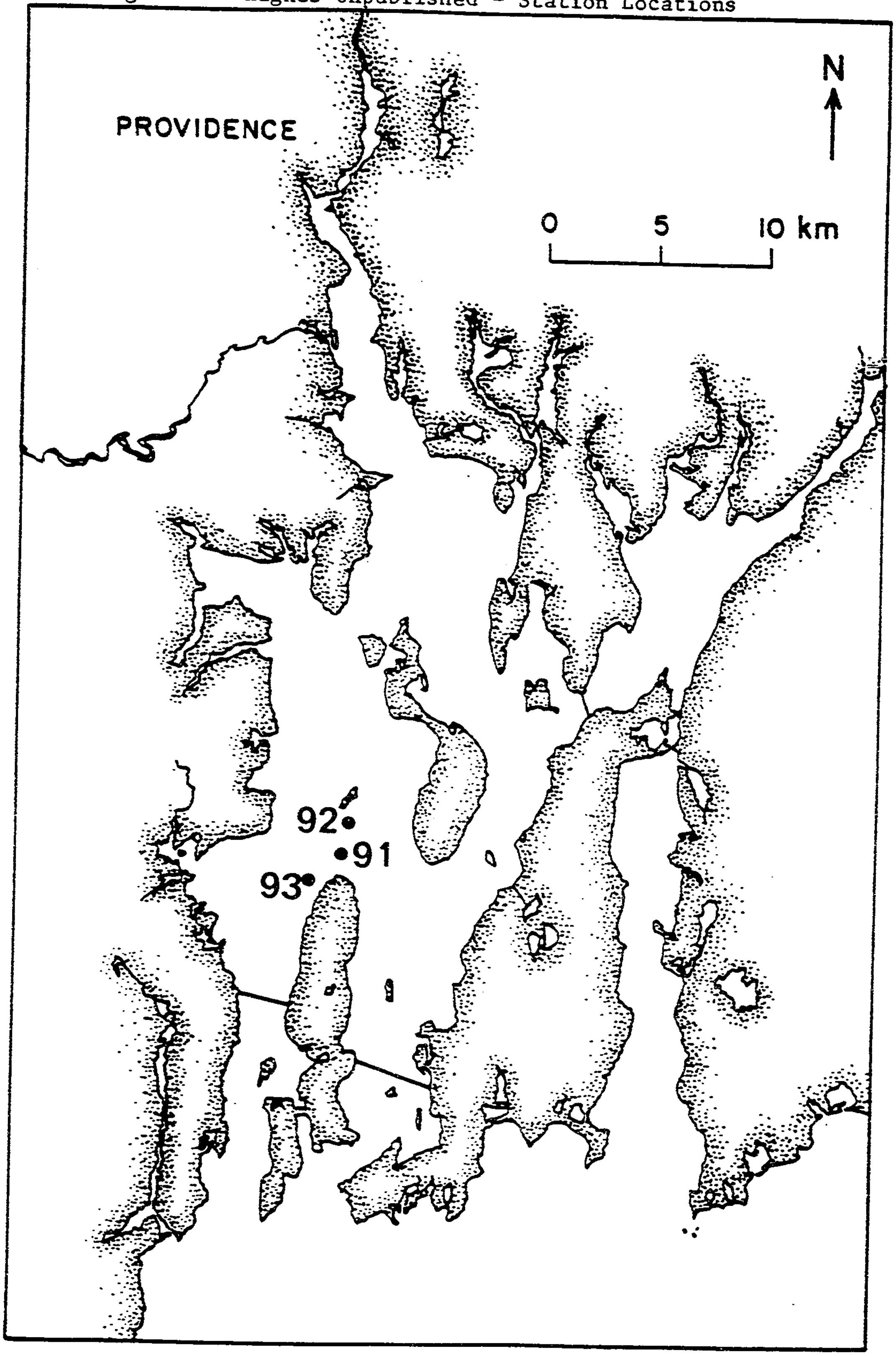


Table 14
Lavoie 1980

Kind of data: Benthic Meiofaunal Survey

Data set description: Number of sample stations: 6
Sample period: October 1970
Sample frequency: Once
Sample type: Hand cores
Number of replicates: 1
Area of individual samples: 24.6 cm^2 (rounded to 25 cm^2 in study)
Lowest sieve size used: Not applicable

Sampling locations: Bissells Cove - Station locations given in publication.

Principal Investigator(s): Mr. Dennis Lavoie

Study used in benthic characterization project: No.

Investigator(s) contacted for characterization project: No.

Funding institution: Unknown.

Citation for published data: Lavoie, D.M. 1970. A survey of benthic fauna in Bissells Cove salt marsh. Project Report, Graduate School of Oceanography, University of Rhode Island, Narragansett, RI, 20p.

Location of original raw data: Publication.

Person to contact for original raw data: Unknown.

Computer status of original data set: Unknown - data not entered for this project.

Additional comments: Elutriation method used for extracting meiofaunal organisms from sediments is not considered as efficient as direct counts. Meiofaunal densities were an order of magnitude lower than those reported for mid-Narragansett Bay by Rudnick et al. 1985).

Table 15
McGetchin 1961

Kind of data: Benthic Macrofaunal Survey

Data set description: Number of sample stations: 46
Sample period: 60246
Sample frequency: Once
Sample type: Modified Petersen Grab
Number of Replicates: 1
Area of individual samples: Unknown
Lowest sieve size used: 1.59 mm

Sampling locations: All stations south of Warwick Point and west of Prudence Island and extend south through both the east and west passages to the border with Rhode Island Sound.

Principal Investigator(s): Mr. Thomas Richard McGetchin
Department of Geology
Brown University
Providence, RI

Study used in benthic characterization project: Yes

Investigator(s) contacted for characterization project: No

Funding Institution: Unknown

Citation for published data: McGetchin, T.R. 1961. Bottom sediments and fauna of western Narragansett Bay, Rhode Island. MS thesis, Brown University, Providence, RI, 107p.

Location of original raw data: Raw data partly given in thesis.

Person to contact for original raw data: Unknown

Computer status of original data set: Unknown - data not entered for this project.

Additional Comments: This study concentrated upon the occurrence of hard bodied benthic fauna (bivalves and gastropods). Abundance was expressed on a relative basis only (very abundant >50, abundant 20-50, common 6-20, rare 1- 5). Since the use of preservative agents was not mentioned, it is not clear the investigator made distinctions between whole, live organisms, and shell remains. Taxonomic identifications are uncertain. For example, some specimens reported as *Nucula proxima* are no doubt *Nucula annulata*.

This thesis, and that of Crowley 1962, were completed in the laboratory of Dr. Leo F. Laporte of Brown University with considerable help from Dr. Robert L. McMaster, University of Rhode Island.

Table 15 (Continued)
McGetchin 1961 - Station Locations

Station	Latitude Degrees	Latitude Minutes	Latitude Seconds	Longitude Degreees	Longitude Minutes	Longitude Seconds
1	41	34	37	71	26	6
2	41	34	39	71	25	9
3	41	34	13	71	23	15
4	41	32	11	71	23	43
5	41	32	6	71	24	30
6	41	32	11	71	25	3
7	41	29	42	71	25	23
8	41	29	44	71	24	24
9	41	28	7	71	24	8
10	41	28	6	71	24	59
11	41	28	7	71	25	42
12	41	28	13	71	26	0
13	41	26	41	71	26	19
14	41	26	37	71	25	13
15	41	26	37	71	24	8
16	41	26	37	71	22	59
17	41	26	33	71	21	45
18	41	28	19	71	22	39
19	41	28	35	71	22	59
20	41	28	59	71	23	2
21	41	29	16	71	23	11
22	41	29	32	71	21	45
23	41	29	48	71	20	59
24	41	30	0	71	19	59
25	41	32	30	71	18	50
26	41	32	31	71	19	54
27	41	32	29	71	21	48
28	41	34	13	71	21	42
29	41	35	7	71	20	15
30	41	37	35	71	19	43
31	41	37	12	71	20	39
32	41	37	0	71	22	2
33	41	37	8	71	23	8
34	41	37	23	71	24	8
35	41	38	52	71	24	27
36	41	38	43	71	23	16
37	41	39	8	71	22	41
38	41	39	19	71	22	19
39	41	39	27	71	22	3
40	41	40	17	71	23	33
41	41	40	3	71	24	13
46	41	34	48	71	20	41
47	41	32	29	71	21	15
49	41	29	42	71	21	22
50	41	28	9	71	22	3

Table 16
Myers and Phelps 1978

Kind of data: Benthic Macrofaunal Abundance

Data set description:
Number of sample stations: 8
Sample period: 75205-76195
Sample frequency: Irregular
Sample type: Diver cores
Number of replicates: 3
Area of individual samples: 175 cm^2 or 322 cm^2
Lowest sieve size used: 500 um
Number of species or species groups identified: 71
Number of dominant species or species groups: 17

Sampling locations:
Station 1: Mid-bay, north of Conanicut Island
41 34 55 N 71 22 17 W
Station 2: Warwick Neck
41 38 00 N 71 22 50 W
Station 2A: Warwick Neck
41 38 00 N 71 23 45 W
Station 3: Ohio Ledge
41 40 32 N 71 19 30 W
Station 4: Rumstick
41 42 21 N 71 19 42 W
Station 5: Conimicut Point
41 43 40 N 71 22 03 W
Station 6: Sabin Point
41 44 54 N 71 22 08 W

Principal Investigator(s):
Dr. Alan Myers
RFDA 3, Box 2550
Waterville, ME 04901
207-872-9052
Dr. Donald Phelps
Environmental Protection Agency
Environmental Research Laboratory
Narragansett, RI 02882
401-782-3077

Study used in benthic characterization project: Yes.

Investigator(s) contacted for characterization project: No.

Funding institution:
Division of Marine Resources
Graduate School of Oceanography
University of Rhode Island

Table 16 (continued)
Myers and Phelps 1978

Citation for published data: Myers, A.C. and D.K. Phelps. 1977. Criteria of benthic health: A transect study of Narragansett Bay, Rhode Island. Final Report. Prepared for the United States Environmental Protection Agency, Environmental Research Laboratory, South Ferry Road, Narragansett, Rhode Island, Under Contract No. P.O. 53203 with the University of Rhode Island, Division of Marine Resources, Graduate School of Oceanography, Kingston, RI.

Location of original raw data: Publication.

Person to contact for original raw data: Dr. Donald K. Phelps

Computer status of original data set: Fully entered into labeled SAS data sets residing on the GSO Computer Center's Micro-VAX II.

Additional comments: On Page B-86 of Myers and Phelps (1978), two cores from Station 2 are dated September 1975 with no mention of the specific date of sampling. In the entire data set, sampling was conducted on the 2nd and the 23rd of September 1975. Since the 2 September 1975 cores are specifically labeled, I have assumed that the cores not having specific sample dates were sampled on the 23rd.

Figure 8 - Myers and Phelps 1978 - Station Locations

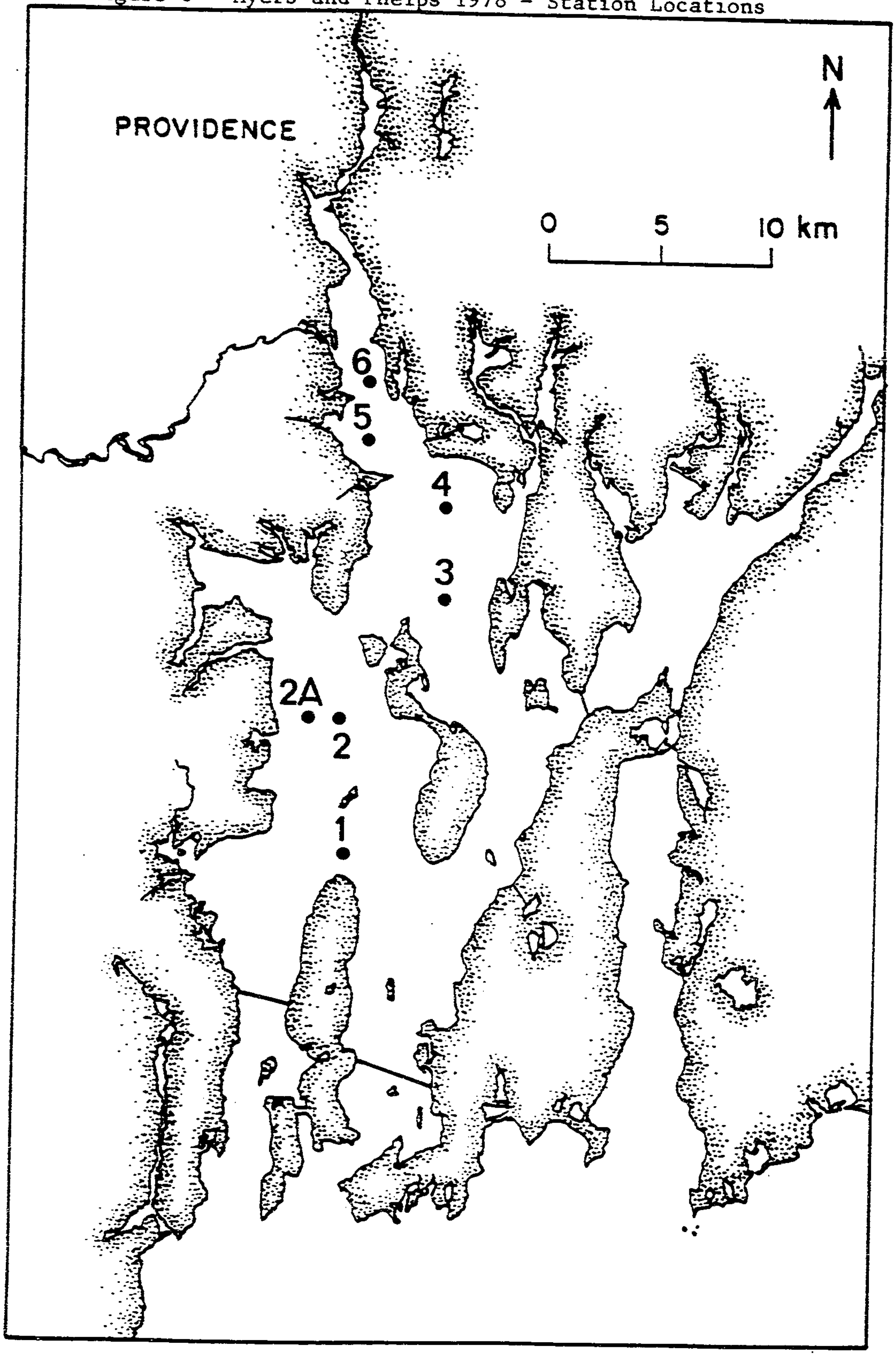


Table 17
Oviatt et al. 1977

Kind of data: Benthic macrofaunal abundance

Data set description: Number of sample stations: 5
Sample period: Unknown, assumed to be 77182
Sample frequency: Once
Sample type: Box core
Number of replicates: 2
Area of individual samples: 300 cm^2
Lowest sieve size used: 500 um
Number of species or species groups identified: 32
Number of dominant species or species groups: 17

Sampling locations: Brush Neck Cove
Station 1: 41 41 54 N 71 25 2 W
Station 2: 41 41 51 N 71 24 52 W
Station 3: 41 41 40 N 71 24 27 W
Station 4: 41 41 22 N 71 24 17 W
Station 5: 41 41 10 N 71 24 11 W

Principal Investigator(s): Dr. Candace A. Oviatt
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882-1197
401-792-6132

Study used in benthic characterization project: Yes.

Investigator(s) contacted for characterization project: Yes.

Funding institution: Mr. Gordon R. Archibald
200 Main Street
Pawtucket, RI

Citation for published data: Oviatt, C.A., S.W. Nixon, E. Evans and B. Wicklow. 1977. Environmental assessment of a plan for improved boating and boating facilities at Brush Neck Cove, Greenwich Bay, Rhode Island. Prepared for Gordon R. Archibald. 59p.

Location of original raw data: Publication

Person to contact for original raw data: Dr. Candace A. Oviatt

Computer status of original data set: Fully entered into labeled SAS data sets residing on the GSO Computer Center's Micro-VAX II.

Additional comments:

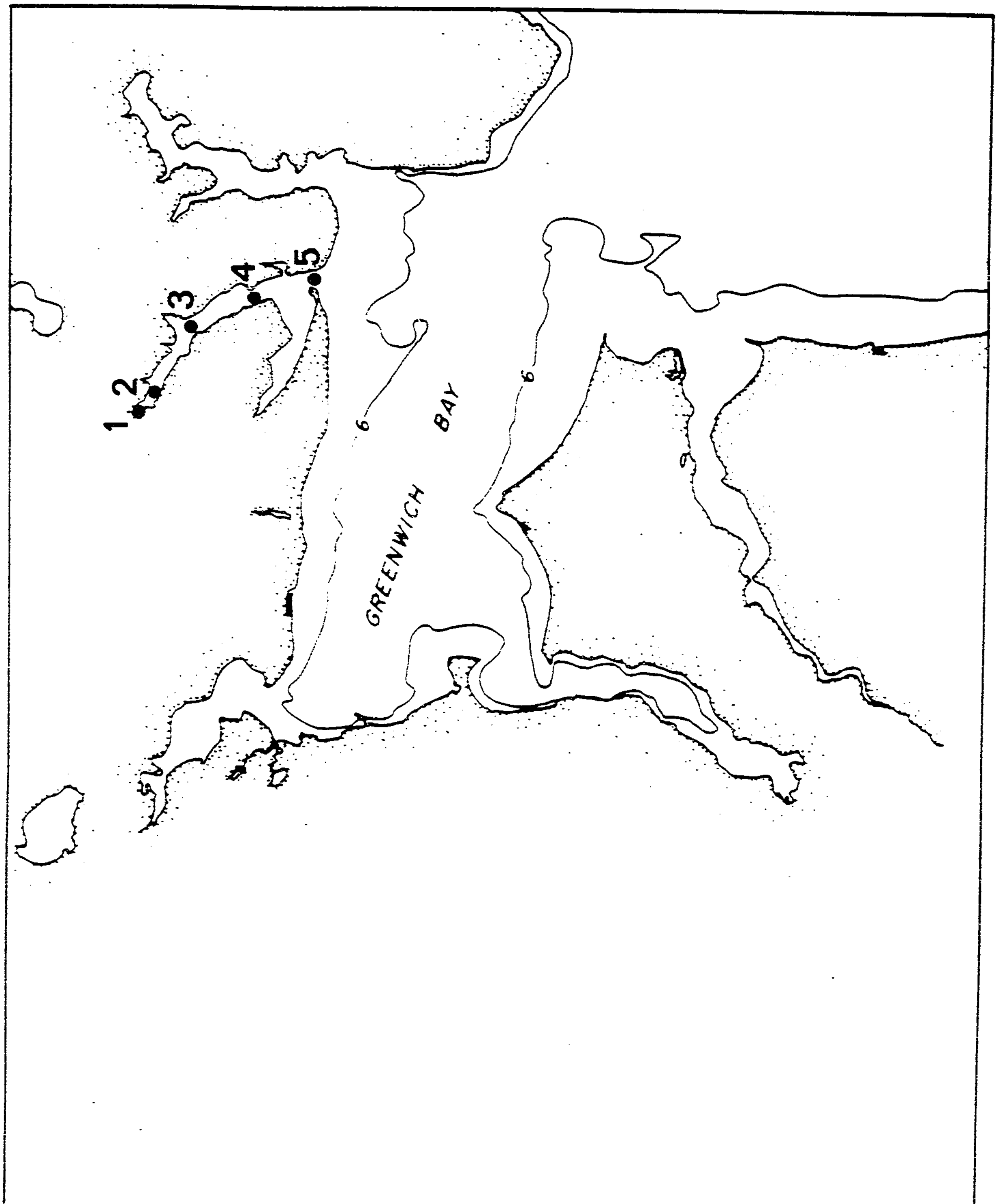


Figure 9 - Oviatt et al. 1977 - Station Locations

Table 18
Phelps 1958

Kind of data: Benthic macrofaunal abundance

Data set description: Number of sample stations: 22
Sample period: 57060
Sample frequency: Once
Sample type: Clam shell bucket
Number of replicates: 1
Area of individual samples: 2000 cm^2
Lowest sieve size used: 500 um
Number of species or species groups identified: 42
Number of dominant species or species groups: 20

Sampling locations: 22 Stations: locations listed separately

Principal Investigator(s): Dr. Donald K. Phelps
Environmental Protection Agency
Environmental Research Laboratory
Narragansett, RI 02882
401-782-3077

Study used in benthic characterization project: Yes.

Investigator(s) contacted for characterization project: No.

Funding institution:

Citation for published data: Phelps, D.K. 1957. A quantitative study of the infauna of Narragansett Bay in relation to certain physical and chemical aspects of their environment. MS Thesis, University of Rhode Island, 56p.

Location of original raw data: Publication

Person to contact for original raw data: Dr. Donald K. Phelps

Computer status of original data set: Fully entered into labeled SAS data sets residing on the GSO Computer Center's Micro-VAX II.

Person to contact for computer data set: Dr. Jeffrey B. Frithsen

Additional Notes:

Table 18 (Continued)
Phelps 1958 - Station Locations

Station	General Location	Latitude	Longitude
Station 2:	Conimicut Point	41 43 21 N	71 20 41 W
Station 2A:	Rocky Point	41 40 52 N	71 21 43 W
Station 2B:	North of Prudence Island	41 40 29 N	71 20 34 W
Station 3:	Rumstick Point	41 42 31 N	71 19 7 W
Station 4:	Mt. Hope Bay	41 39 17 N	71 14 13 W
Station 6:	Warwick Neck	41 39 38 N	71 22 35 W
Station 7:	Popasquash Neck	41 38 53 N	71 18 45 W
Station 8A:	Hog Island	41 37 56 N	71 16 49 W
Station 8B:	Bristol Harbor	41 39 46 N	71 16 59 W
Station 9:	North Sakonnet River	41 36 38 N	71 13 8 W
Station 10:	North of Hope Island	41 37 9 N	71 22 28 W
Station 11:	Dyer Island	41 35 50 N	71 17 52 W
Station 12A:	South of Prudence Island	41 33 35 N	71 19 10 W
Station 13A:	Conanicut Point	41 34 22 N	71 23 42 W
Station 13B:	North of Fox Island	41 33 55 N	71 24 45 W
Station 13C:	Rome Point	41 32 49 N	71 24 5 W
Station 14:	South of Gould Island	41 31 13 N	71 20 43 W
Station 16A:	West of Bevertail Point	41 27 5 N	71 24 37 W
Station 16B:	Bonnet Point	41 28 2 N	71 25 23 W
Station 16C:	Whale Rock	41 26 11 N	71 25 18 W
Station 17:	Castle Hill	41 27 20 N	71 22 6 W
Station 18:	South Sakonnet River	41 28 57 N	71 13 10 W
Station 19:	Mid-Sakonnet River	41 33 18 N	71 13 32 W

Figure 10 - Phelps 1958 - Station Locations

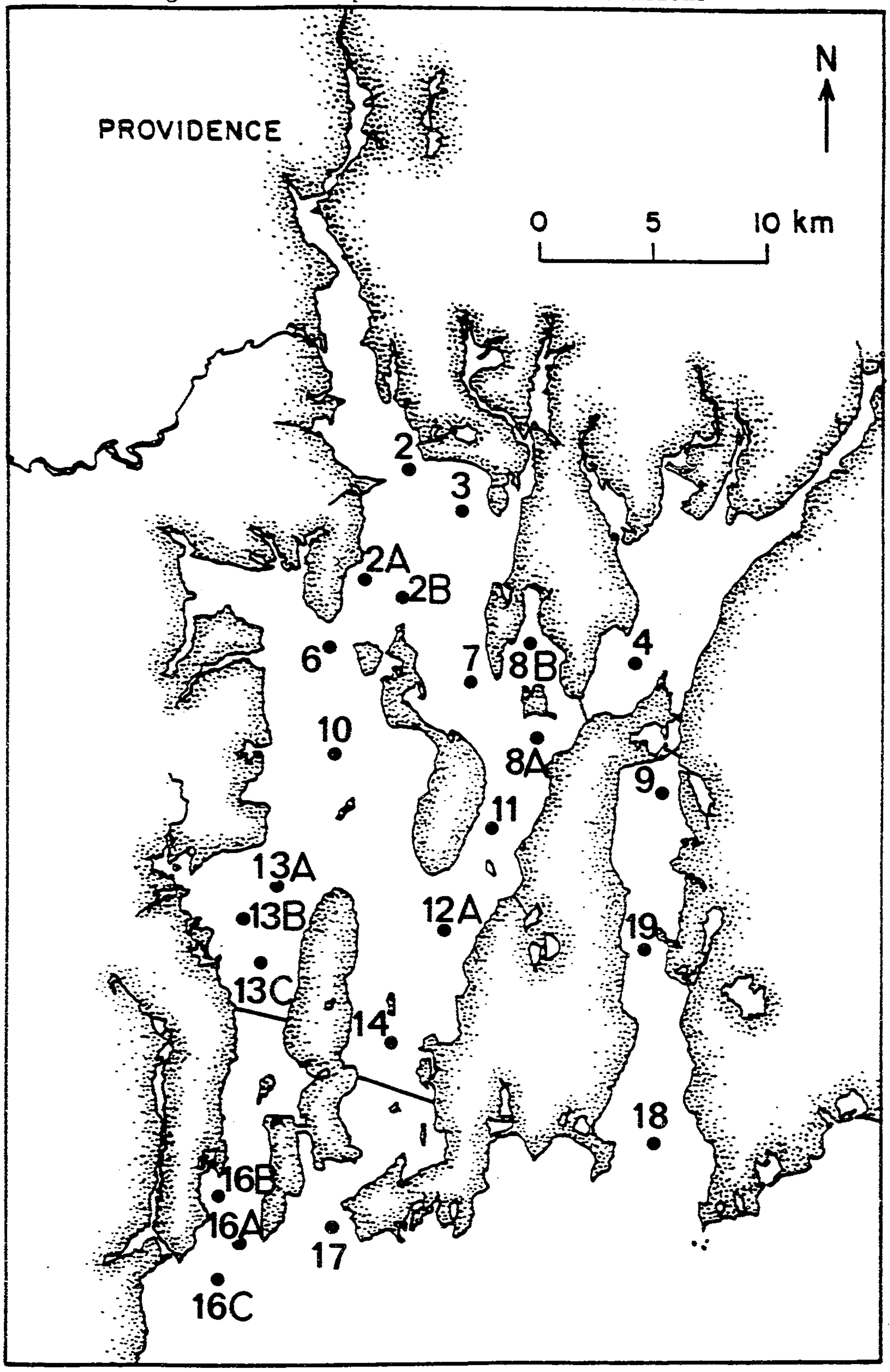


Table 19
Pratt 1985

Kind of data: Benthic macrofaunal abundance

Data set description: Number of sample stations: 10
Sample period: 85121
Sample frequency: Once
Sample type: Ponar grab
Number of replicates: 1
Area of individual samples: 530 cm^2
Lowest sieve size used: 1000 um
Number of species or species groups identified: 48
Number of dominant species or species groups: 7

Sampling locations: All stations at Quonset Point along a transect from Station 1 at 41 35 06 N 71 24 52 W to Station 10 at 41 34 40 N 71 24 25 W.

Principal Investigator(s): Mr. Sheldon Pratt
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882-1197
401-792-6699

Study used in benthic characterization project: Yes.

Investigator(s) contacted for characterization project: Yes.

Funding institution: Applied Science Associates, Inc.,
Narragansett, RI 02882

Citation for published data: Pratt, S.D. 1985. Benthos south of Quonset Point Rhode Island. Submitted to Applied Science Associates, Inc., Wakefield, RI 8p.

Location of original raw data: Publication

Person to contact for original raw data: Mr. Sheldon Pratt

Computer status of original data set: Fully entered into labeled SAS data sets residing on the GSO Computer Center's Micro-VAX II.

Additional comments:

Figure 11 - Pratt 1985 - Station Locations

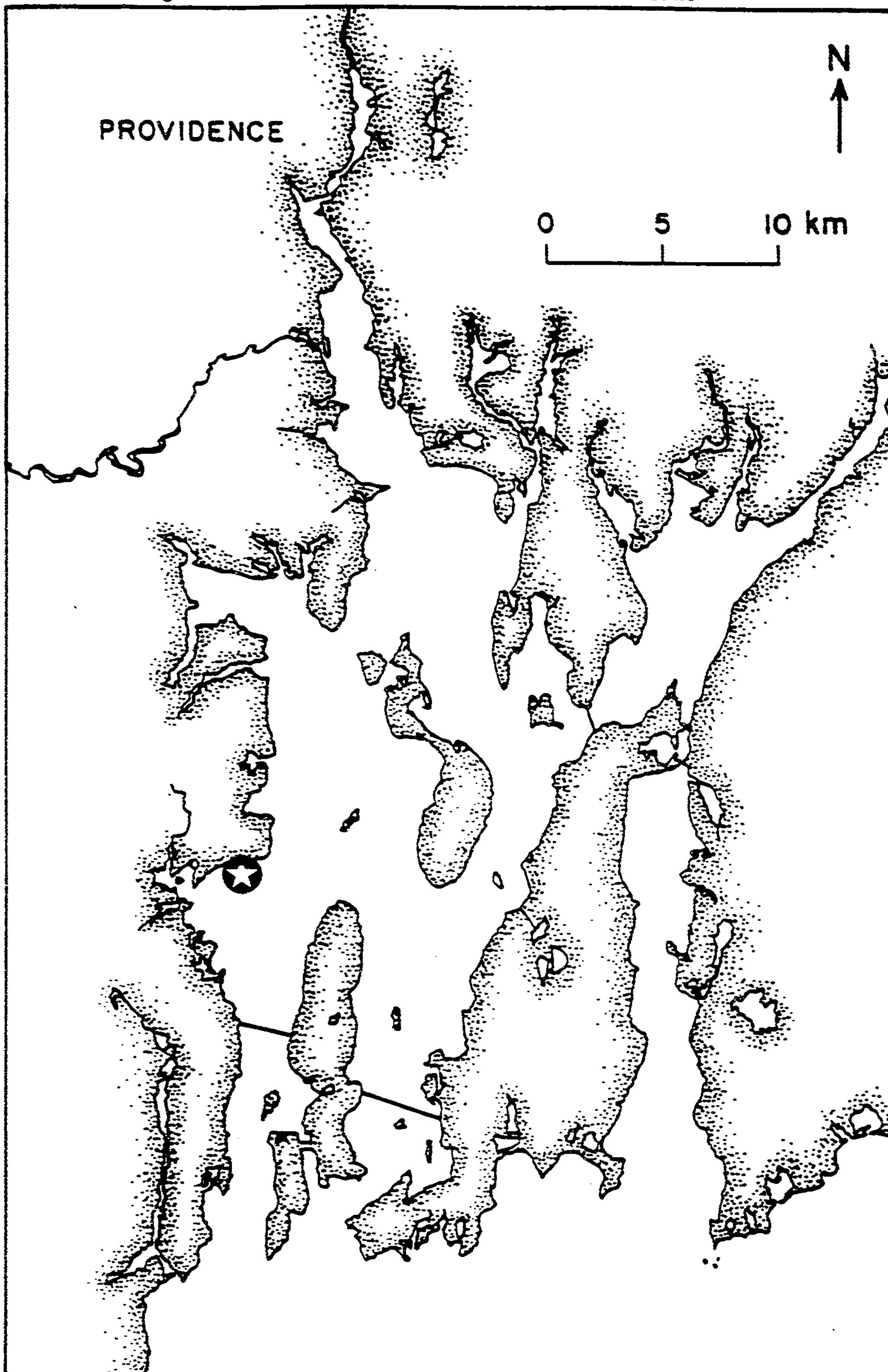


Table 20
Pratt 1977a

Kind of data: Benthic macrofaunal abundance

Data set description: Number of sample stations: 4
Sample period: 76177
Sample frequency: Once
Sample type: Ponar grab
Number of replicates: 1
Area of individual samples: 530 cm^2
Lowest sieve size used: 750 um
Number of species or species groups identified: 36
Number of dominant species or species groups: 8

Sampling locations: Taunton River
Station 1: 41 48 33 N 71 7 8 W
Station 2: 41 47 26 N 71 7 12 W
Station 3: 41 45 45 N 71 7 49 W
Station 4: 41 44 30 N 71 8 30 W

Principal Investigator(s): Mr. Sheldon Pratt
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882-1197
401-792-6699

Study used in benthic characterization project: Yes.

Investigator(s) contacted for characterization project: No.

Funding institution: U.S. Army Corps of Engineers

Citation for published data: Pratt, S.D. 1977. Biology and geology: Additional data pertinent to Fall River Channel dredging and Browns Ledge spoil disposal. In, A study and report on oceanographic conditions in the vicinity of Browns Ledge, Rhode Island Sound, Report No. 2, Final Report on Job Change 4 to Contract No. DACW33-75-C-0066, New England Division, Corps of Engineers, U.S. Army.

Location of original raw data: Publication

Person to contact for original raw data: Mr. Sheldon Pratt

Computer status of original data set: Fully entered into labeled SAS data sets residing on the GSO Computer Center's Micro-VAX II.

Additional comments:

Figure 12 - Pratt 1977a - Station Locations

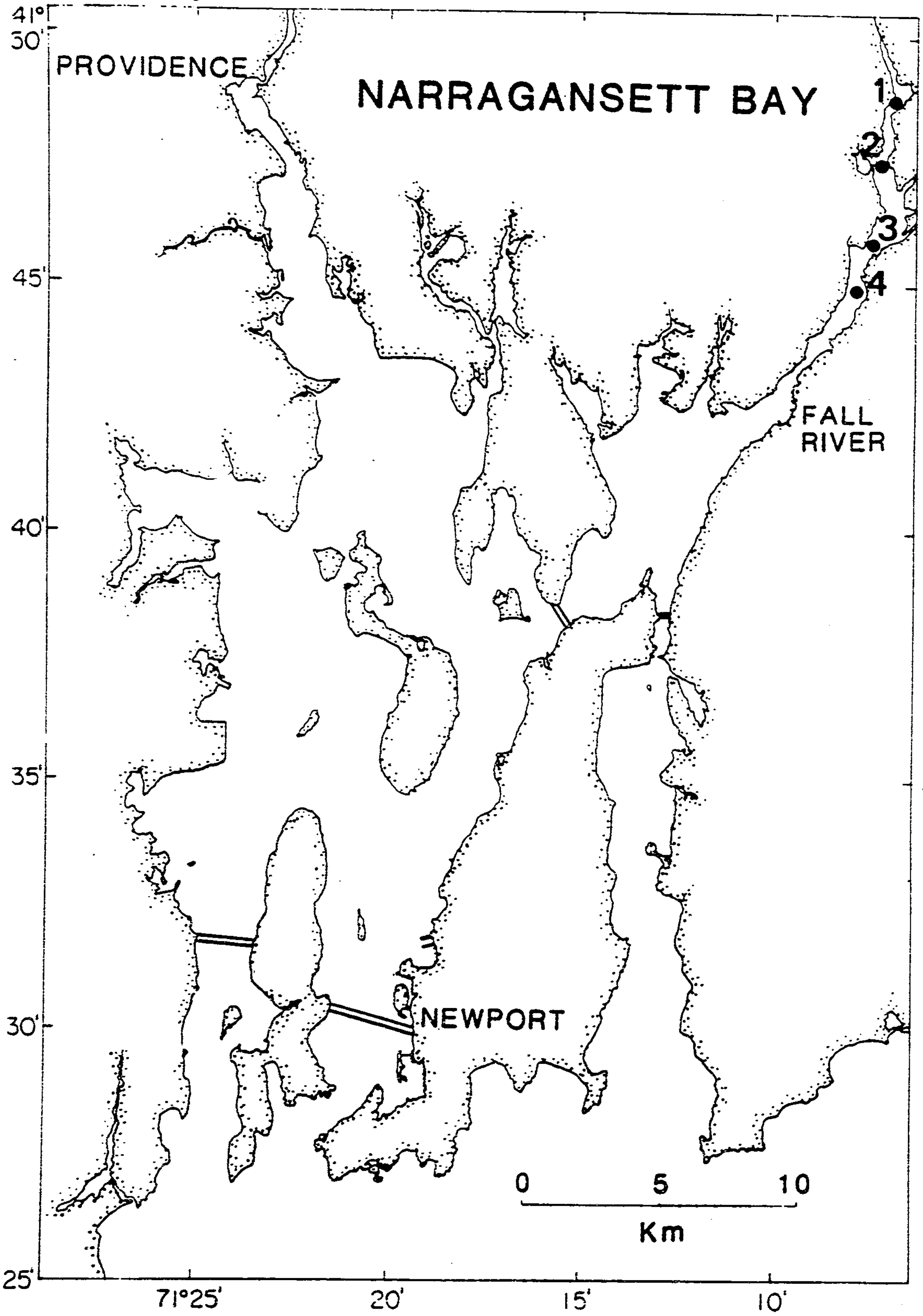


Table 21
Pratt 1977b

Kind of data: Benthic Macrofaunal abundance

Data set description: Number of sample stations: 30
Sample period: 76275
Sample frequency: Once
Sample type: Smith-McIntyre grab
Number of replicates: 1
Area of individual samples: 1000 cm^2
Lowest sieve size used: 1000 um
Number of species or species groups identified: 91
Number of dominant species or species groups: 12

Sampling locations: Quonset-Davisville Area

Principal Investigator(s): Mr. Sheldon Pratt
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882-1197
401-792-6699

Study used in benthic characterization project: Yes.

Investigator(s) contacted for characterization project: Yes

Funding institution: National Oceanic and Atmospheric Administration

Citation for published data: Pratt, S.D. 1977. Benthic biology of areas adjacent to the Quonset/Davisville base. In, The redevelopment of Quonset/Davisville: An environmental Assessment. Technical Appendix No. 2., 32p.

Location of original raw data: Mr. Sheldon Pratt

Person to contact for original raw data: Mr. Sheldon Pratt

Computer status of original data set: Fully entered into labeled SAS data sets residing on the GSO Computer Center's Micro-VAX II.

Additional comments: Data also published in part in Pratt 1985.

Table 22
Pratt 1972

Kind of data: Benthic macrofaunal abundance

Data set description: Number of sample stations: 7
Sample period: 70244 and 70030
Sample frequency: Once
Sample type: Smith-McIntyre grab
Number of replicates: 1 to 3
Area of individual samples: 1000 cm^2
Lowest sieve size used: 750 um
Number of species or species groups identified: 29
Number of dominant species or species groups: 11

Sampling locations: Providence River

Station PG2:	41 48 26 N	71 23 20 W
Station PG4:	41 48 52 N	71 23 32 W
Station PG6:	41 48 08 N	71 22 49 W
Station PS1:	41 45 38 N	71 21 55 W
Station PS3:	41 45 23 N	71 22 30 W
Station PS4:	41 46 37 N	71 22 41 W
Station PS5:	41 44 40 N	71 22 11 W

Principal Investigator(s): Mr. Sheldon Pratt
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882-1197
401-792-6699

Study used in benthic characterization project: Yes.

Investigator(s) contacted for characterization project: Yes..

Funding institution: Rhode Island Sea Grant

Citation for published data: Pratt, S.D. 1972. Effects of spoil dumping on the benthic invertebrates of the sound. In, S.B. Saila, S.D. Pratt and T.T. Polgar (eds) Dredge spoil disposal in Rhode Island Sound, Marine Technical Report Number 2, University of Rhode Island, Kingston, RI, pp: 31-42.

Location of original raw data: Publication

Person to contact for original raw data: Mr. Sheldon Pratt

Computer status of original data set: Fully entered into labeled SAS data sets residing on the GSO Computer Center's Micro-VAX II.

Additional comments:

Figure 13 - Pratt 1972 - Station Locations

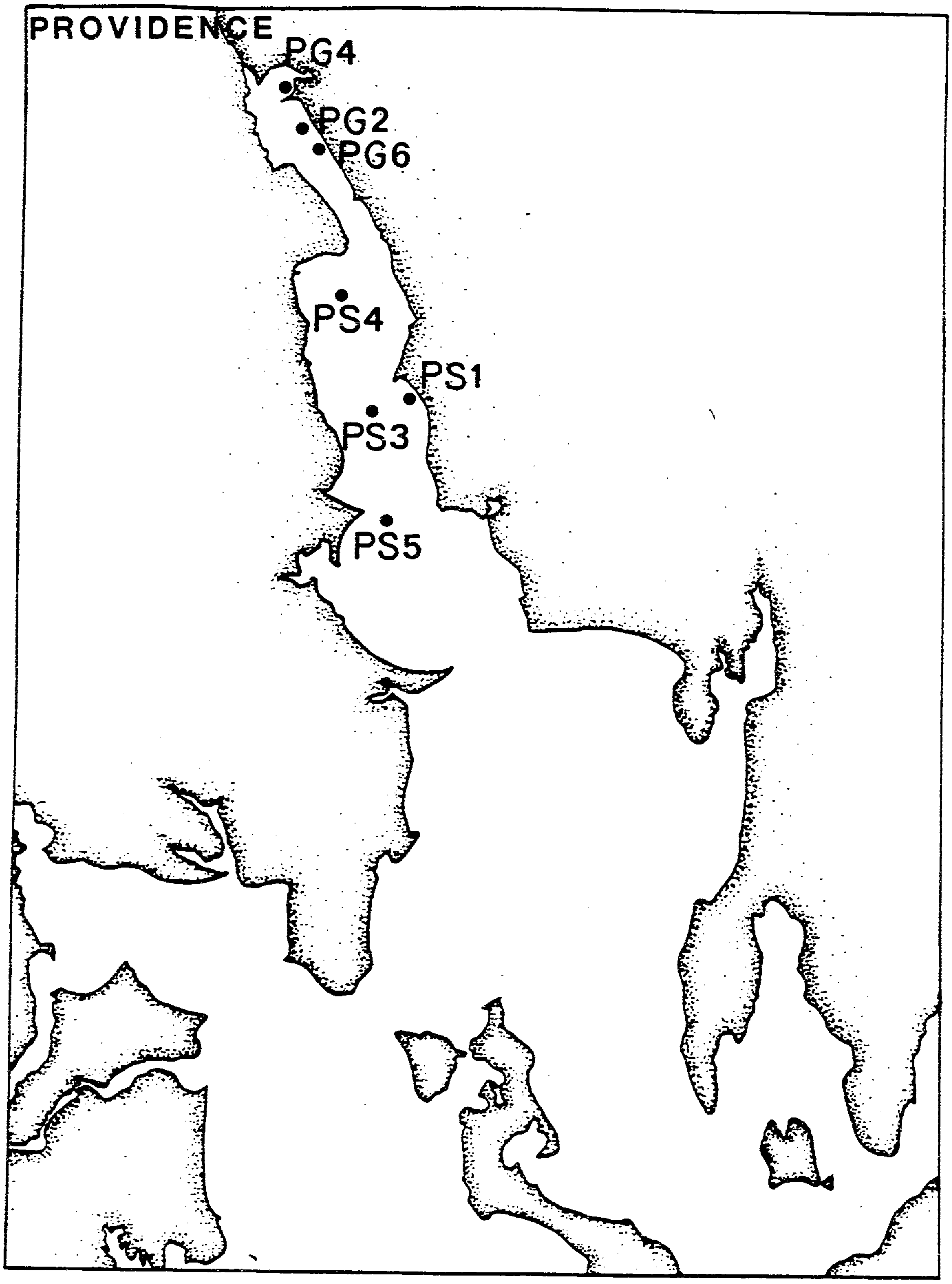


Table 23
Pratt Unpublished

Kind of data: Benthic macrofaunal abundance

Data set description: Number of sample stations: 13
Sample period: 83363
Sample frequency: Once
Sample type: Gas can sampler and Ekman Dredge
Number of replicates: 1
Area of individual samples: 180 cm^2 and 520 cm^2
Lowest sieve size used: 1000 um
Number of species or species groups identified: 50
Number of dominant species or species groups: 17

Sampling locations: Stations from Upper Kickimuit River, no specific sample locations given

Principal Investigator(s): Mr. Sheldon Pratt
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882-1197
401-792-6699

Study used in benthic characterization project: Yes.

Investigator(s) contacted for characterization project: Yes.

Funding institution: Unfunded.

Citation for published data: Unpublished.

Location of original raw data: Mr. Sheldon D. Pratt

Person to contact for original raw data: Mr. Sheldon D. Pratt

Computer status of original data set: Fully entered into labeled SAS data sets residing on the GSO Computer Center's Micro-VAX II.

Additional comments:

Figure 14 - Pratt Unpublished - Station Locations

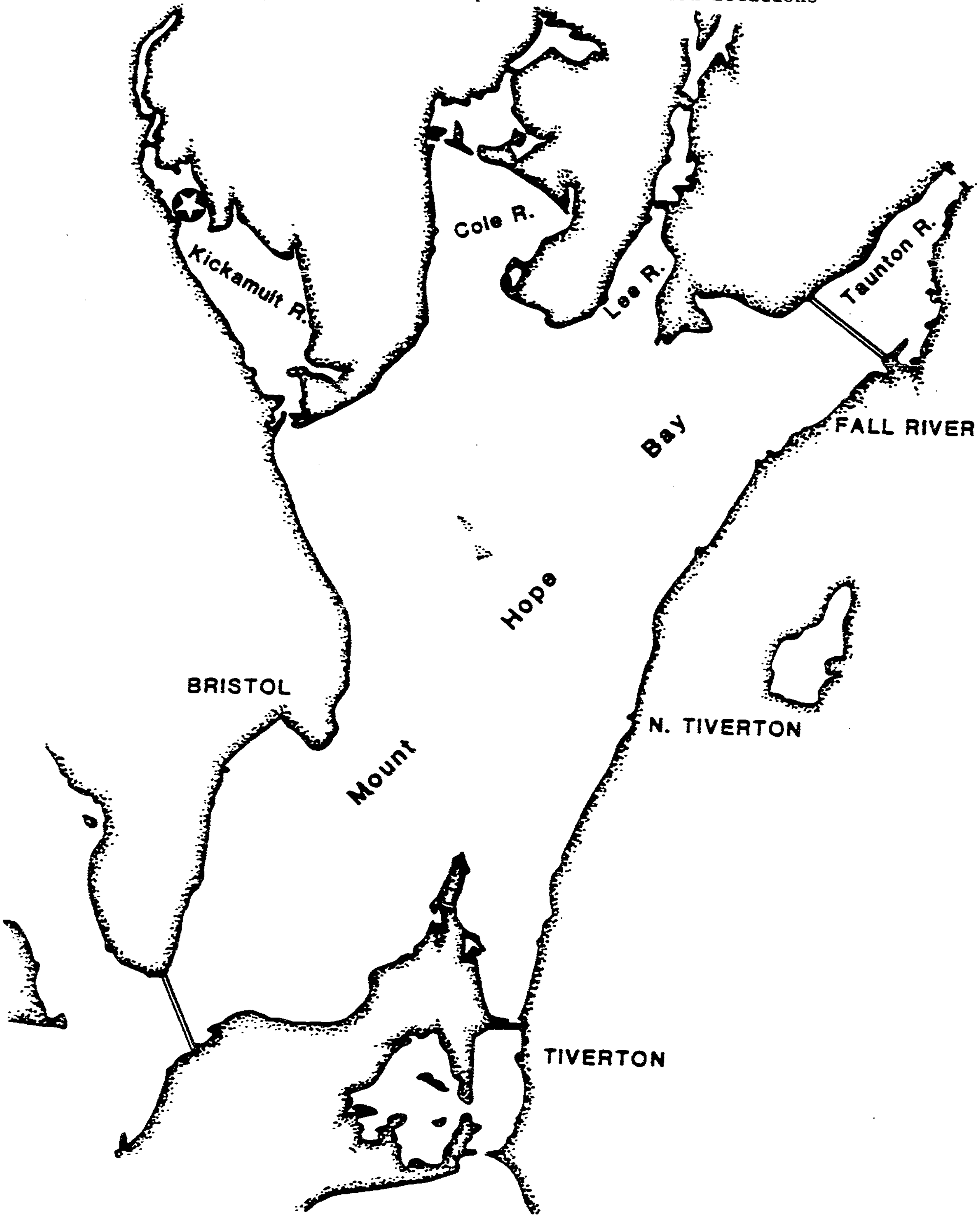


Table 24
Pratt and Bisagni 1976

Kind of data: Benthic macrofaunal abundance

Data set description:
Number of sample stations: 6
Sample period: 75192
Sample frequency: Once
Sample type: Grab samples
Number of replicates: 1
Area of individual samples: 400 cm^2
Lowest sieve size used: 750 um
Number of species or species groups identified: 52
Number of dominant species or species groups: 10

Sampling locations: Providence River and Upper Narragansett Bay
Station 6: 41 41 58 N 71 19 21 W
Station 7: 41 42 19 N 71 20 12 W
Station 9: 41 42 56 N 71 20 29 W
Station 11: 41 43 41 N 71 21 47 W
Station 12: 41 44 50 N 71 22 25 W
Station 13: 41 45 33 N 71 22 35 W

Principal Investigator(s): Mr. Sheldon Pratt
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882-1197
401-792-6699

Study used in benthic characterization project: Yes.

Investigator(s) contacted for characterization project: Yes.

Funding institution: U.S. Army Corps of Engineers

Citation for published data: Pratt, S.D. and J.J. Bisagni. 1976. Monitoring results - Providence River dredging 1975. Submitted to the New England Division, U.S. Army Corps of Engineers, March 1976. 31p.

Location of original raw data: Publication

Person to contact for original raw data: Mr. Sheldon Pratt

Computer status of original data set: Fully entered into labeled SAS data sets residing on the GSO Computer Center's Micro-VAX II.

Additional comments:

Figure 15 - Pratt and Bisagni 1976 - Station Locations

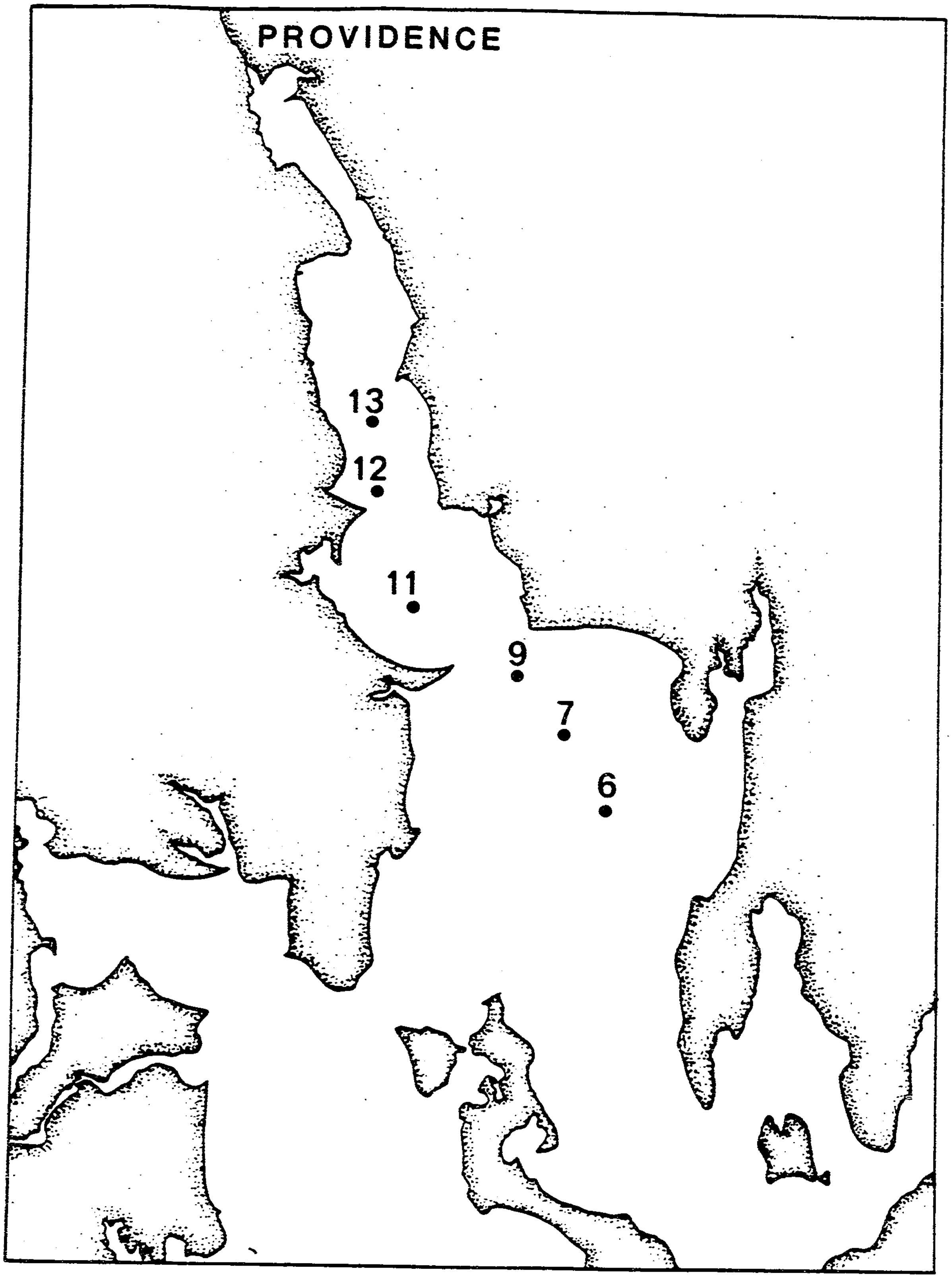


Table 25
Pratt and Seavey 1981

Kind of data: Benthic macrofaunal abundance

Data set description: Number of sample stations: 17
Sample period: 80275
Sample frequency: Once
Sample type: Hand corer and Ekman dredge
Number of replicates: 1
Area of individual samples: 180 cm^2 and 524 cm^2
Lowest sieve size used: 750 um and 2000 um
Number of species or species groups identified:
750 um sieve: 23
2000 um sieve: 13
Number of dominant species or species groups:
750 um sieve: 14
2000 um sieve: 8

Sampling locations: Stations all within Apponaug Cove

Principal Investigator(s): Mr. Sheldon Pratt
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882-1197
401-792-6699

Study used in benthic characterization project: Yes.

Investigator(s) contacted for characterization project: Yes.

Funding institution: Robinson Green Beretta Corp.,
Providence, RI

Citation for published data: Pratt, S.D. and G.L. Seavey. 1981. The environment of Apponaug inner cove and the impact of development on the cove. Prepared for Robinson Green Beretta Corp., Providence, RI. 61p.

Location of original raw data: Publication

Person to contact for original raw data: Mr. Sheldon Pratt

Computer status of original data set: Fully entered into labeled SAS data sets residing on the GSO Computer Center's Micro-VAX II.

Additional comments:

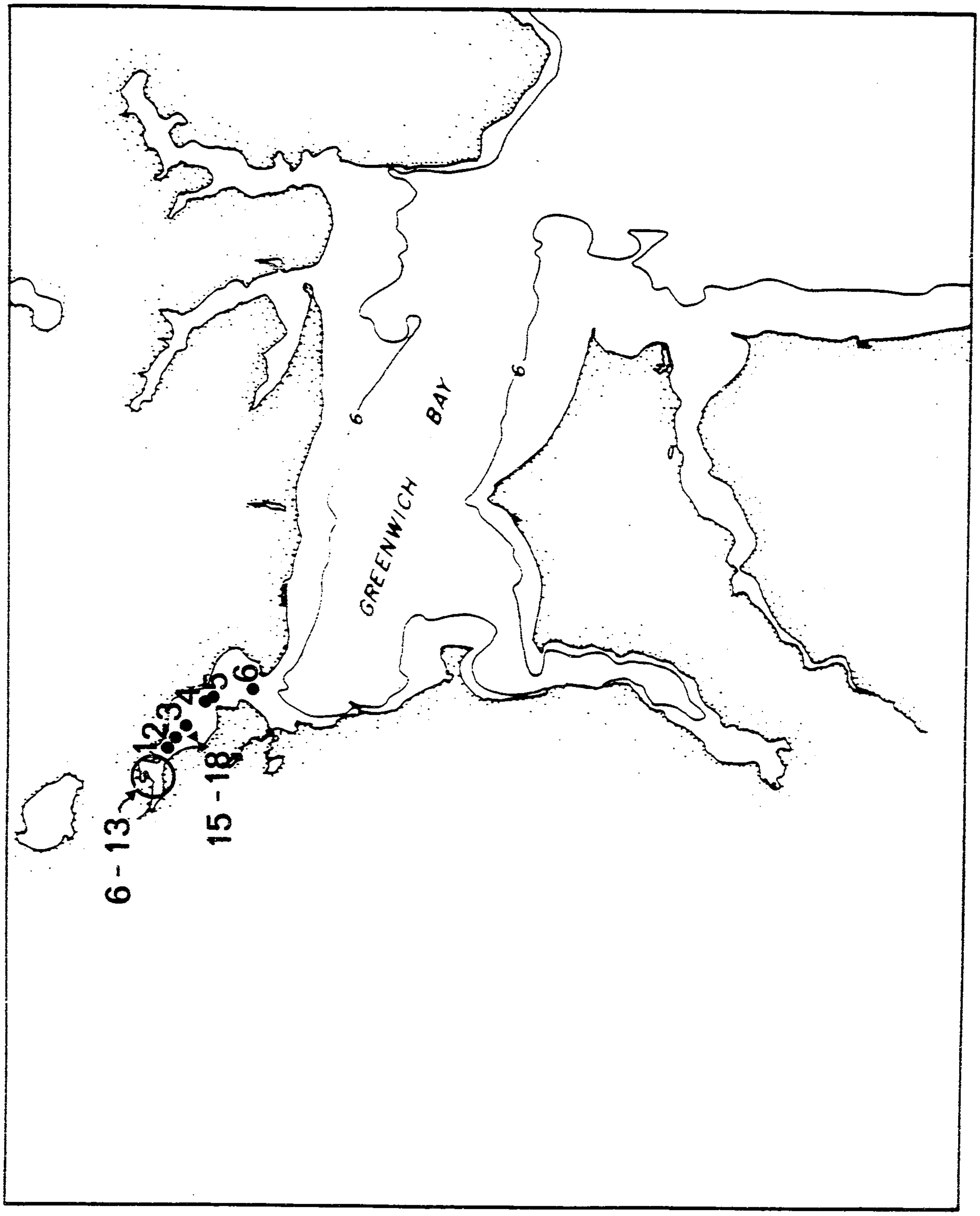


Figure 16 - Pratt and Seavey 1981 - Station Locations

Table 26
Rudnick 1984

Kind of data: Benthic Macrofaunal and Meiofaunal Abundance

Data set description: Number of sample stations: 4
Sample period: 77181 - 80177
Sample frequency: Irregular
Sample type: Diver collected Cores
Number of replicates: 1 to 6
Area of individual samples: 35.3 cm^2
Lowest sieve size used: 40 um

Sampling locations: Station 1: Mid-Bay MERL Station No. 1, north of Conanicut Island 41 34 57 N 71 22 19 W
Station 1A: Mid-Bay Station, north of Conanicut Island 41 35 40 N 71 21 09 W
Station PR: Providence River 41 43 25 N 71 21 52 W
Station SB: Rhode Island Sound 41 25 06 N 71 24 34 W

Principal Investigator(s): Dr. David T. Rudnick
Cornell University
Ecosystems Research Center
Biological Sciences Building
Ithaca, NY 14853
607-255-3746

Study used in benthic characterization project: Yes.

Investigator(s) contacted for characterization project: Yes.

Funding Institution: Environmental Protection Agency

Citation for published data: Rudnick, D.T. 1984. Seasonality of community structure and carbon flow in Narragansett Bay sediments. Ph.D. Dissertation, University of Rhode Island, Kingston, RI, 320p.

Location of original raw data: Marine Ecosystems Research Laboratory, Graduate School of Oceanography, University of Rhode Island, Narragansett, RI, 02882-1197.

Person to contact for original raw data: Dr. Jeffrey B. Frithsen

Computer status of original data set: Unknown. Data in publication were not entered into computer data sets as part of project but do exist as SAS data sets.

Additional comments:

Figure 17 - Rudnick 1984 - Station Locations

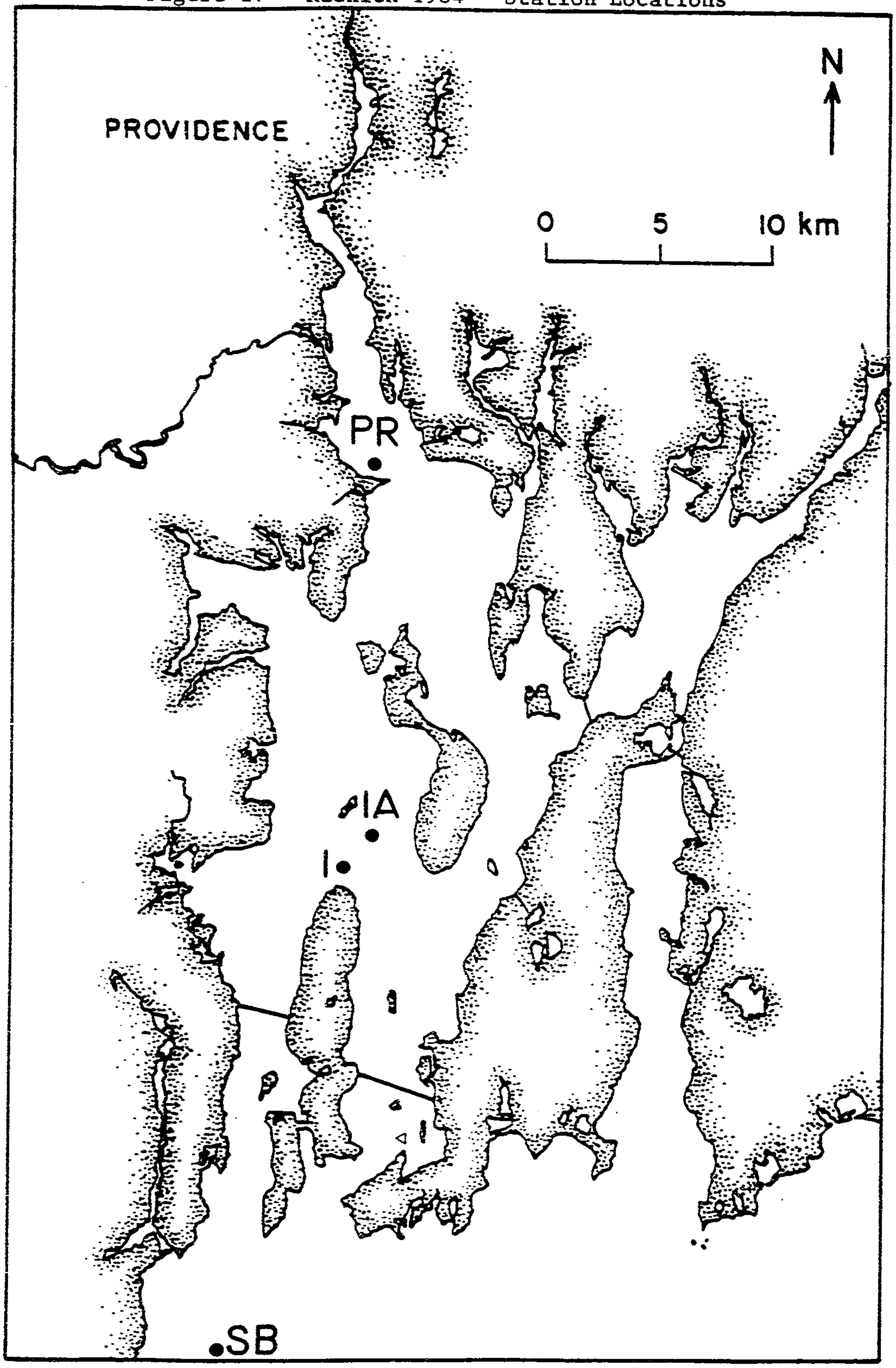


Table 27
Said 1951

Kind of data: Benthic survey of Foraminifera

Data set description: Number of sample stations: 34
Sample period: Summer 1950
Sample frequency: Once
Sample type: Hough coring tube or Orange peel grab
Number of replicates: 1
Area of individual samples: Core=57 cm^2
Grab=Unknown
Lowest sieve size used: 70 um
Number of species or species groups identified: 55*
Number of dominant species or species groups: 25*
* Numbers from publication

Sampling locations: See below

Principal Investigator(s): Dr. Rushdi Said

Study used in benthic characterization project: No.

Investigator(s) contacted for characterization project: No.

Funding Institution: Unknown.

Citation for published data: Said, R. 1951. Foraminifera of Narragansett Bay. Contr. Cushman Foundation Foramin. Res. 2: 75-86.

Location of original raw data: Unknown.

Person to contact for original raw data: Unknown.

Computer status of original data set: Unknown. Data in publication were not entered into computer data sets as part of project.

Additional comments: No distiction was made between living and dead foram assemblages. Reported abundances were approximately 10-100 times less than those of Rudnick et al. 1985.

Table 27 (Continued)
Said 1951

Station	Latitute	Longitude
1	41 25 40 N	71 25 10 W
2	41 25 40 N	71 22 40 W
3	41 25 30 N	71 19 40 W
4	41 26 20 N	17 17 00 W
5	41 29 20 N	71 13 30 W
6	41 34 10 N	71 13 00 W
7	41 37 00 N	71 13 40 W
8	41 39 30 N	71 14 50 W
9	41 36 25 N	71 23 00 W
10	41 38 30 N	71 22 00 W
11	41 38 30 N	71 23 40 W
12	41 40 40 N	71 25 00 W
13	41 40 50 N	71 25 00 W
14	41 41 00 N	71 18 00 W
15	41 41 20 N	71 21 20 W
16	41 42 40 N	71 20 00 W
17	41 38 30 N	71 19 40 W
18	41 38 30 N	71 17 00 W
19	41 36 00 N	71 17 30 W
20	41 34 30 N	71 18 00 W
21	41 31 40 N	71 20 00 W
22	41 31 40 N	71 21 30 W
23	41 31 40 N	71 23 40 W
24	41 31 40 N	71 24 00 W
25	41 30 20 N	71 23 40 W
26	41 27 30 N	71 25 10 W
27	41 27 50 N	71 24 20 W
28	41 27 30 N	71 22 30 W
29	41 20 30 N	71 20 30 W
30	41 30 40 N	71 20 40 W
31	41 33 30 N	71 20 40 W
32	41 34 30 N	71 21 30 W
33	41 34 30 N	71 23 00 W
34	41 34 30 N	71 24 40 W

Table 28
Satchwill et al. 1984

Kind of data: Shellfish Survey

Data set description: Number of sample stations: Unknown
Sample period: 1983
Sample frequency: Once
Sample type: Serber samples
Number of replicates: 1
Area of Individual samples: 0.5 m^2
Lowest sieve size used: Unknown

Sampling locations: Narragansett Bay Estuarine Sanctuary

Principal Investigator(s): Richard J. Satchwill
Steven P. Turana
Richard T. Sisson
Rhode Island Department of Environmental Management

Study used in benthic characterization project: No.

Investigator(s) contacted for characterization project: No.

Funding institution: NOAA

Citation for published data: Satchwill, R.J., S.P. Turano and R.T. Sisson. 1984. Preliminary assessment of biological and physical characteristics of the Narragansett Bay estuarine sanctury 1983. Final report to the U.S. Department of Commerce, NOAA, Office of Coastal Zone Management, Sanctuary Programs Office. Rhode Island Department of Environmental Management, Division of Fish and Wildlife, Providence, RI.

Location of original raw data: Unknown.

Person to contact for original raw data: Unknown.

Computer status of original data set: Unknown.

Additional comments: Benthic survey of the Narragansett Bay Estuarine Sanctuary. Distributional maps of *Mercenaria mercenaria*, *Mya arenaria*, *Ensis directus* and *Mytilus edulis* drawn from DEM survey completed in 1983?. No raw data given in report.

Table 29
Stickney and Stringer Unpublished

Kind of data: Benthic macrofaunal abundance

Data set description: Number of sample stations: 213 in 1951
226 in 1952
Sample period: 1951-1952
Sample frequency: Twice
Sample type: Clamshell bucket
Number of replicates: 1
Area of individual samples: 460 cm^2
Lowest sieve size used: 2000 um
Number of species or species groups identified:
1951: 71 (17 dominant)
1952: 102 (14 dominant)

Sampling locations: See below for station locations

Principal Investigator(s): Mr. Alden Stickney
Southport, MA
207-633-3932
Mr. Louis D. Stringer
129 Sand Hill Cove Rd.
Narragansett, RI 02882
401-789-1621

Study used in benthic characterization project: Yes.

Investigator(s) contacted for characterization project: Yes.

Funding institution: U.S. Fish and Wildlife

Citation for published data: No publication contains the full data. Data were summarized in Stringer and Stringer 1957.

Location of original raw data: Marine Ecosystems Research Laboratory
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882-1197

Person to contact for original raw data: Dr. Jeffrey B. Frithsen

Computer status of original data set: Fully entered into labeled SAS data sets residing on the GSO Computer Center's Micro-VAX II.

Additional comments: Precise quantitative data were not given for all species on some data sheets. In those cases, the terms 'handful', 'some', 'many', and 'moderate' were used. These inexact terms were arbitrarily translated as follows:

Handful of *Crepidula* spp. = 10 individuals
Some of *Bowerbankia gracilis* = 1 individual
Some of *Cryptosula pallasiana* = 1 individual
Some of *Schizoporella* spp. = 1 individual
Some of *Crepidula* spp. = 10 individuals
Many of *Ampelisca spinipes* = 1000 individuals
Moderate of *Ampelisca spinipes* = 500 individuals.

Table 29 (continued)
Station Locations for Stickney and Stringer 1951 Data

Station	Latitude Degrees	Latitude Minutes	Latitude Seconds	Longitude Degrees	Longitude Minutes	Longitude Seconds
A2	41	41	20	71	26	52
A3	41	41	20	71	26	44
B2	41	41	14	71	26	52
B3	41	41	14	71	26	44
B4	41	41	14	71	26	37
C2	41	41	8	71	26	52
C3	41	41	8	71	26	44
C4	41	41	8	71	26	35
C5	41	41	8	71	26	26
D10	41	41	2	71	25	43
D12	41	41	2	71	25	35
D13	41	41	1	71	25	26
D2	41	41	2	71	26	52
D3	41	41	2	71	26	44
D4	41	41	1	71	26	35
D5	41	41	2	71	26	26
D6	41	41	2	71	26	17
D7	41	41	2	71	26	9
D8	41	41	2	71	26	0
D9	41	41	2	71	25	52
E10	41	40	56	71	25	43
E12	41	40	56	71	25	34
E13	41	40	56	71	25	27
E14	41	40	56	71	25	19
E15	41	40	56	71	25	11
E16	41	40	56	71	25	3
E17	41	40	56	71	24	55
E18	41	40	55	71	24	47
E19	41	40	55	71	24	39
E2	41	40	55	71	26	52
E28	41	40	59	71	23	38
E3	41	40	56	71	26	44
E4	41	40	55	71	26	35
E5	41	40	55	71	26	26
E6	41	40	56	71	26	17
E7	41	40	56	71	26	9
E8	41	40	56	71	26	1
E9	41	40	56	71	25	52
F10	41	40	49	71	25	43
F12	41	40	49	71	25	34
F13	41	40	50	71	25	27
F14	41	40	49	71	25	19
F15	41	40	49	71	25	11
F16	41	40	49	71	25	3
F17	41	40	49	71	24	55
F18	41	40	49	71	24	46
F19	41	40	50	71	24	38
F2	41	40	49	71	26	52

Table 29 (continued)
Station Locations for Stickney and Stringer 1951 Data (continued)

Station	Latitude Degrees	Latitude Minutes	Latitude Seconds	Longitude Degrees	Longitude Minutes	Longitude Seconds
F20	41	40	52	71	24	32
F23	41	40	52	71	24	23
F24	41	40	52	71	24	14
F25	41	40	53	71	24	5
F26	41	40	52	71	23	56
F27	41	40	52	71	23	47
F28	41	40	52	71	23	38
F3	41	40	49	71	26	43
F4	41	40	49	71	26	35
F5	41	40	49	71	26	26
F6	41	40	49	71	26	17
F7	41	40	49	71	26	8
F8	41	40	50	71	26	0
F9	41	40	49	71	25	52
G10	41	40	43	71	25	50
G11	41	40	43	71	25	42
G12	41	40	43	71	25	35
G13	41	40	44	71	25	27
G14	41	40	43	71	25	19
G15	41	40	44	71	25	11
G16	41	40	43	71	25	3
G17	41	40	43	71	24	56
G18	41	40	44	71	24	48
G19	41	40	43	71	24	40
G2	41	40	43	71	26	52
G20	41	40	43	71	24	32
G21	41	40	43	71	24	25
G22	41	40	43	71	24	17
G23	41	40	43	71	24	10
G24	41	40	44	71	24	1
G25	41	40	44	71	23	53
G26	41	40	43	71	23	46
G27	41	40	43	71	23	39
G3	41	40	43	71	26	44
G4	41	40	43	71	26	36
G5	41	40	43	71	26	28
G6	41	40	43	71	26	20
G7	41	40	43	71	26	13
G8	41	40	43	71	26	5
G9	41	40	43	71	25	58
GC1	41	40	12	71	26	38
GC2	41	40	12	71	26	44
GC3	41	40	6	71	26	45
GC4	41	40	7	71	26	37
GC5	41	40	0	71	26	44
GC6	41	39	53	71	26	42
GC7	41	39	56	71	26	32

Table 29 (continued)
Station Locations for Stickney and Stringer 1951 Data (continued)

Station	Latitude Degrees	Latitude Minutes	Latitude Seconds	Longitude Degrees	Longitude Minutes	Longitude Seconds
H10	41	40	37	71	25	50
H11	41	40	37	71	25	43
H12	41	40	37	71	25	34
H13	41	40	37	71	25	26
H14	41	40	37	71	25	18
H15	41	40	37	71	25	11
H16	41	40	37	71	25	4
H17	41	40	37	71	24	55
H18	41	40	37	71	24	47
H19	41	40	38	71	24	40
H20	41	40	38	71	24	32
H21	41	40	38	71	24	25
H22	41	40	37	71	24	17
H23	41	40	38	71	24	9
H24	41	40	37	71	24	1
H25	41	40	38	71	23	53
H26	41	40	37	71	23	46
H27	41	40	37	71	23	38
H4	41	40	37	71	26	37
H6	41	40	37	71	26	20
H7	41	40	37	71	26	13
H8	41	40	37	71	26	5
H9	41	40	37	71	25	58
I10	41	40	31	71	25	50
I11	41	40	31	71	25	42
I12	41	40	31	71	25	34
I13	41	40	31	71	25	26
I14	41	40	31	71	25	19
I15	41	40	31	71	25	11
I16	41	40	31	71	25	4
I17	41	40	31	71	24	56
I18	41	40	31	71	24	48
I19	41	40	31	71	24	40
I20	41	40	31	71	24	32
I21	41	40	31	71	24	25
I22	41	40	31	71	24	17
I23	41	40	31	71	24	10
I24	41	40	31	71	24	1
I25	41	40	31	71	23	54
I26	41	40	31	71	23	46
I27	41	40	31	71	23	38
I7	41	40	31	71	26	13
I8	41	40	31	71	26	5
I9	41	40	31	71	25	58
IT1	41	39	49	71	24	43
IT10	41	41	5	71	24	25
IT11	41	41	9	71	24	25
IT12	41	41	2	71	24	2

Table 29 (continued)
Station Locations for Stickney and Stringer 1951 Data (continued)

Station	Latitude Degrees	Latitude Minutes	Latitude Seconds	Longitude Degrees	Longitude Minutes	Longitude Seconds
IT13	41	41	0	71	23	34
IT14	41	41	6	71	23	31
IT2	41	40	15	71	25	39
IT3	41	40	2	71	26	26
IT4	41	40	19	71	26	32
IT5	41	40	30	71	26	43
IT5	41	40	30	71	26	43
IT6	41	41	16	71	26	59
IT7	41	41	19	71	26	57
IT8	41	41	13	71	26	11
IT9	41	41	10	71	25	29
J10	41	40	25	71	25	50
J11	41	40	25	71	25	42
J12	41	40	25	71	25	34
J13	41	40	25	71	25	26
J15	41	40	25	71	25	19
J16	41	40	25	71	25	10
J17	41	40	25	71	25	2
J18	41	40	25	71	24	53
J19	41	40	25	71	24	45
J20	41	40	25	71	24	37
J21	41	40	25	71	24	28
J22	41	40	25	71	24	20
J23	41	40	25	71	24	11
J24	41	40	25	71	24	3
J25	41	40	25	71	23	55
J26	41	40	25	71	23	46
J27	41	40	25	71	23	38
J6	41	40	25	71	26	21
J7	41	40	25	71	26	13
J8	41	40	25	71	26	5
J9	41	40	25	71	25	58
K10	41	40	19	71	25	50
K11	41	40	19	71	25	43
K13	41	40	19	71	25	26
K15	41	40	19	71	25	19
K16	41	40	19	71	25	10
K17	41	40	19	71	25	1
K18	41	40	19	71	24	53
K19	41	40	19	71	24	46
K20	41	40	19	71	24	37
K21	41	40	19	71	24	29
K22	41	40	19	71	24	20
K23	41	40	19	71	24	11
K24	41	40	19	71	24	3
K25	41	40	19	71	23	54
K26	41	40	19	71	23	46
K27	41	40	19	71	23	38

Table 29 (continued)
Station Locations for Stickney and Stringer 1951 Data (continued)

Station	Latitude Degrees	Latitude Minutes	Latitude Seconds	Longitude Degrees	Longitude Minutes	Longitude Seconds
K6	41	40	19	71	26	21
K7	41	40	19	71	26	13
K8	41	40	19	71	26	5
K9	41	40	19	71	25	58
L10	41	40	13	71	25	50
L11	41	40	13	71	25	42
L13	41	40	13	71	25	27
L15	41	40	13	71	25	19
L16	41	40	13	71	25	10
L17	41	40	13	71	25	2
L18	41	40	13	71	24	53
L19	41	40	13	71	24	45
L20	41	40	13	71	24	37
L21	41	40	13	71	24	28
L22	41	40	13	71	24	20
L23	41	40	13	71	24	11
L24	41	40	13	71	24	2
L25	41	40	13	71	23	54
L26	41	40	13	71	23	46
L5	41	40	12	71	26	28
L6	41	40	13	71	26	21
L7	41	40	13	71	26	13
L8	41	40	13	71	26	5
L9	41	40	13	71	25	58
M10	41	40	6	71	25	50
M15	41	40	7	71	25	10
M17	41	40	7	71	24	54
M18	41	40	7	71	24	46
M19	41	40	7	71	24	39
M20	41	40	7	71	24	32
M21	41	40	7	71	24	24
M22	41	40	7	71	24	17
M23	41	40	7	71	24	9
M24	41	40	7	71	24	2
M5	41	40	6	71	26	29
M6	41	40	7	71	26	20
M7	41	40	6	71	26	13
M8	41	40	6	71	26	5
M9	41	40	6	71	25	58
N16	41	40	0	71	25	1
N17	41	40	0	71	24	54
N18	41	40	0	71	24	47
N19	41	40	0	71	24	39
N20	41	40	0	71	24	32
N21	41	40	0	71	24	24
N22	41	40	1	71	24	16
N7	41	40	0	71	26	13

Table 29 (continued)
Station Locations for Stickney and Stringer 1951 Data (continued)

Station	Latitude Degrees	Latitude Minutes	Latitude Seconds	Longitude Degrees	Longitude Minutes	Longitude Seconds
018	41	39	54	71	24	46
019	41	39	54	71	24	39
020	41	39	54	71	24	32
021	41	39	54	71	24	24

Table 29 (continued)
Station Locations for Stickney and Stringer 1952 Data (continued)

Station	Latitude Degrees	Latitude Minutes	Latitude Seconds	Longitude Degrees	Longitude Minutes	Longitude Seconds
B101	41	41	21	71	26	49
B103	41	41	12	71	26	49
B104	41	41	12	71	26	38
B110	41	41	3	71	26	48
B111	41	41	3	71	26	37
B112	41	41	3	71	26	26
B113	41	41	2	71	26	14
B114	41	41	2	71	26	3
B115	41	41	44	71	26	48
B116	41	41	44	71	26	37
B117	41	41	44	71	26	26
B118	41	41	44	71	26	14
B119	41	40	53	71	26	4
B120	41	41	44	71	26	48
B122	41	41	44	71	26	26
B123	41	41	44	71	26	14
B124	41	41	44	71	26	3
B127	41	41	44	71	26	13
B128	41	41	44	71	26	2
B130	41	41	44	71	26	13
B131	41	41	44	71	26	2
B133	41	40	17	71	26	37
B135	41	40	17	71	26	13
B136	41	40	19	71	26	3
B138	41	40	8	71	26	37
B139	41	40	10	71	26	22
B140	41	40	8	71	26	11
B141	41	40	9	71	26	2
B142	41	39	59	71	26	37
B207	41	40	55	71	25	49
B208	41	40	55	71	25	37
B209	41	40	55	71	25	26
B210	41	40	55	71	25	16
B211	41	40	55	71	25	5
B212	41	40	55	71	24	53
B213	41	40	46	71	25	49
B214	41	40	47	71	25	37
B215	41	40	46	71	25	27
B216	41	40	46	71	25	16
B217	41	40	46	71	25	5
B218	41	41	44	71	24	53
B219	41	40	37	71	25	49
B220	41	40	37	71	25	38
B221	41	41	26	71	25	26
B222	41	40	37	71	25	16
B223	41	40	37	71	25	4
B224	41	40	37	71	24	53
B225	41	40	28	71	25	46

Table 29 (continued)
Station Locations for Stickney and Stringer 1952 Data (continued)

Station	Latitude Degrees	Latitude Minutes	Latitude Seconds	Longitude Degrees	Longitude Minutes	Longitude Seconds
B226	41	40	26	71	25	36
B227	41	40	29	71	25	23
B228	41	40	28	71	25	12
B229	41	40	28	71	25	1
B230	41	40	28	71	24	50
B233	41	40	20	71	25	23
B234	41	40	19	71	25	12
B235	41	40	19	71	25	1
B236	41	40	19	71	24	50
B241	41	40	9	71	24	50
B313	41	40	42	71	24	38
B314	41	40	41	71	24	26
B315	41	40	41	71	24	16
B316	41	40	41	71	24	4
B317	41	40	41	71	23	53
B318	41	40	41	71	23	41
B319	41	40	33	71	24	38
B320	41	40	32	71	24	26
B321	41	40	32	71	24	16
B321	41	40	19	71	25	46
B322	41	40	32	71	24	5
B323	41	40	32	71	23	53
B324	41	40	32	71	23	42
B325	41	40	23	71	24	38
B326	41	40	23	71	24	27
B327	41	40	24	71	24	16
B328	41	40	23	71	24	4
B329	41	40	23	71	23	53
B330	41	40	23	71	23	42
B331	41	40	15	71	24	35
B332	41	40	14	71	24	24
B333	41	40	14	71	24	13
B334	41	40	14	71	24	2
B335	41	40	13	71	23	50
B336	41	40	6	71	24	35
B337	41	40	6	71	24	24
B338	41	40	5	71	24	13
B339	41	40	5	71	24	2
B340	41	39	56	71	24	40
B341	41	39	56	71	24	30
IT1	41	41	19	71	26	39
IT10	41	41	10	71	24	26
IT11	41	41	6	71	24	25
IT12	41	41	11	71	25	29
IT13	41	41	14	71	26	10
IT14	41	39	49	71	24	41
IT15	41	40	13	71	25	28
IT16	41	40	17	71	25	39

Table 29 (continued)
Station Locations for Stickney and Stringer 1952 Data (continued)

Station	Latitude Degrees	Latitude Minutes	Latitude Seconds	Longitude Degrees	Longitude Minutes	Longitude Seconds
IT17	41	40	3	71	26	24
IT2	41	41	18	71	26	59
IT3	41	41	44	71	26	53
IT4	41	41	44	71	26	42
IT5	41	40	21	71	26	34
IT6	41	40	14	71	26	49
IT7	41	41	5	71	23	30
IT8	41	41	3	71	23	46
IT9	41	41	4	71	24	4
R101	41	41	20	71	26	48
R103	41	41	11	71	26	48
R104	41	41	11	71	26	37
R109	41	41	1	71	26	46
R110	41	41	1	71	26	34
R111	41	41	1	71	26	23
R112	41	41	2	71	26	11
R113	41	41	1	71	26	1
R114	41	41	44	71	26	46
R115	41	41	44	71	26	34
R116	41	41	44	71	26	23
R117	41	41	44	71	26	12
R118	41	40	52	71	26	1
R119	41	41	44	71	26	46
R121	41	41	44	71	26	23
R122	41	41	44	71	26	12
R123	41	41	44	71	26	1
R126	41	41	44	71	26	12
R127	41	41	44	71	26	2
R129	41	41	44	71	26	12
R130	41	41	44	71	26	2
R132	41	40	16	71	26	37
R134	41	40	16	71	26	13
R135	41	40	16	71	26	3
R137	41	40	7	71	26	37
R138	41	40	7	71	26	26
R139	41	40	7	71	26	16
R140	41	40	7	71	26	6
R141	41	39	58	71	26	37
R204	41	40	58	71	25	44
R205	41	40	58	71	25	32
R206	41	40	58	71	25	19
R207	41	40	58	71	25	8
R210	41	40	49	71	25	44
R211	41	40	49	71	25	31
R212	41	40	48	71	25	19
R213	41	40	49	71	25	7
R214	41	40	49	71	24	55
R215	41	41	44	71	24	43

Table 29 (continued)
Station Locations for Stickney and Stringer 1952 Data (continued)

Station	Latitude Degrees	Latitude Minutes	Latitude Seconds	Longitude Degrees	Longitude Minutes	Longitude Seconds
R216	41	40	40	71	25	44
R217	41	40	40	71	25	32
R218	41	40	40	71	25	19
R219	41	40	40	71	25	7
R220	41	40	40	71	24	55
R221	41	40	40	71	24	43
R222	41	40	29	71	25	42
R223	41	40	34	71	25	30
R224	41	40	33	71	25	19
R225	41	40	32	71	25	7
R226	41	40	31	71	24	56
R227	41	40	31	71	24	43
R230	41	40	24	71	25	19
R231	41	40	23	71	25	7
R232	41	40	22	71	24	56
R233	41	40	22	71	24	43
R235	41	40	14	71	25	19
R237	41	40	13	71	24	56
R238	41	40	12	71	24	44
R241	41	40	4	71	24	56
R242	41	40	3	71	24	44
R312	41	40	46	71	24	38
R313	41	40	46	71	24	27
R314	41	40	46	71	24	17
R315	41	40	46	71	24	5
R316	41	40	46	71	23	54
R317	41	40	46	71	23	43
R318	41	40	37	71	24	39
R319	41	40	37	71	24	28
R320	41	40	37	71	24	17
R321	41	40	37	71	24	6
R322	41	40	37	71	23	55
R323	41	40	37	71	23	43
R324	41	40	28	71	24	39
R325	41	40	28	71	24	28
R326	41	40	28	71	24	17
R326	41	40	14	71	25	7
R327	41	40	28	71	24	5
R328	41	40	28	71	23	54
R329	41	40	28	71	23	43
R330	41	40	18	71	24	38
R331	41	40	18	71	24	28
R332	41	40	19	71	24	16
R333	41	40	19	71	24	5
R334	41	40	19	71	23	53
R335	41	40	19	71	23	42
R336	41	40	10	71	24	40
R337	41	40	10	71	24	29
R338	41	40	10	71	24	17

Table 29 (continued)
Station Locations for Stickney and Stringer 1952 Data (continued)

Station	Latitude Degrees	Latitude Minutes	Latitude Seconds	Longitude Degrees	Longitude Minutes	Longitude Seconds
R339	41	40	10	71	24	7
R340	41	40	0	71	24	40
R341	41	40	1	71	24	28
R342	41	40	1	71	24	17
T102	41	41	19	71	26	42
T103	41	41	10	71	26	54
T104	41	41	10	71	26	42
T105	41	41	10	71	26	31
T110	41	41	2	71	26	42
T111	41	41	1	71	26	31
T112	41	41	1	71	26	20
T113	41	41	1	71	26	10
T114	41	41	1	71	25	58
T116	41	41	44	71	26	43
T117	41	41	44	71	26	31
T118	41	41	44	71	26	20
T119	41	40	52	71	26	10
T120	41	40	52	71	25	58
T122	41	41	44	71	26	31
T123	41	41	44	71	26	20
T124	41	41	44	71	26	10
T125	41	41	44	71	25	58
T128	41	41	44	71	26	20
T129	41	41	44	71	26	9
T130	41	41	44	71	25	58
T131	41	41	44	71	26	20
T132	41	41	44	71	26	9
T133	41	41	44	71	25	58
T134	41	40	15	71	26	40
T136	41	40	17	71	26	19
T137	41	40	16	71	26	9
T138	41	40	16	71	25	58
T139	41	40	6	71	26	39
T140	41	40	6	71	26	29
T141	41	40	7	71	26	19
T142	41	40	7	71	26	8
T313	41	40	43	71	24	35
T314	41	40	43	71	24	25
T315	41	40	43	71	24	14
T316	41	40	44	71	24	4
T317	41	40	44	71	23	53
T318	41	40	44	71	23	42
T319	41	40	34	71	24	35
T320	41	40	34	71	24	25
T321	41	40	34	71	24	14
T322	41	40	34	71	24	4
T323	41	40	35	71	23	53
T324	41	40	35	71	23	42

Table 29 (continued)
Station Locations for Stickney and Stringer 1952 Data (continued)

Station	Latitude Degrees	Latitude Minutes	Latitude Seconds	Longitude Degrees	Longitude Minutes	Longitude Seconds
T325	41	40	25	71	24	35
T326	41	40	25	71	24	25
T327	41	40	25	71	24	14
T328	41	40	26	71	24	4
T329	41	40	26	71	23	53
T330	41	40	26	71	23	42
T331	41	40	16	71	24	37
T332	41	40	16	71	24	26
T333	41	40	15	71	24	14
T334	41	40	15	71	24	4
T335	41	40	14	71	23	52
T336	41	40	7	71	24	37
T337	41	40	7	71	24	26
T338	41	40	6	71	24	14
T339	41	40	6	71	24	4
T340	41	39	57	71	24	37
T341	41	39	57	71	24	26

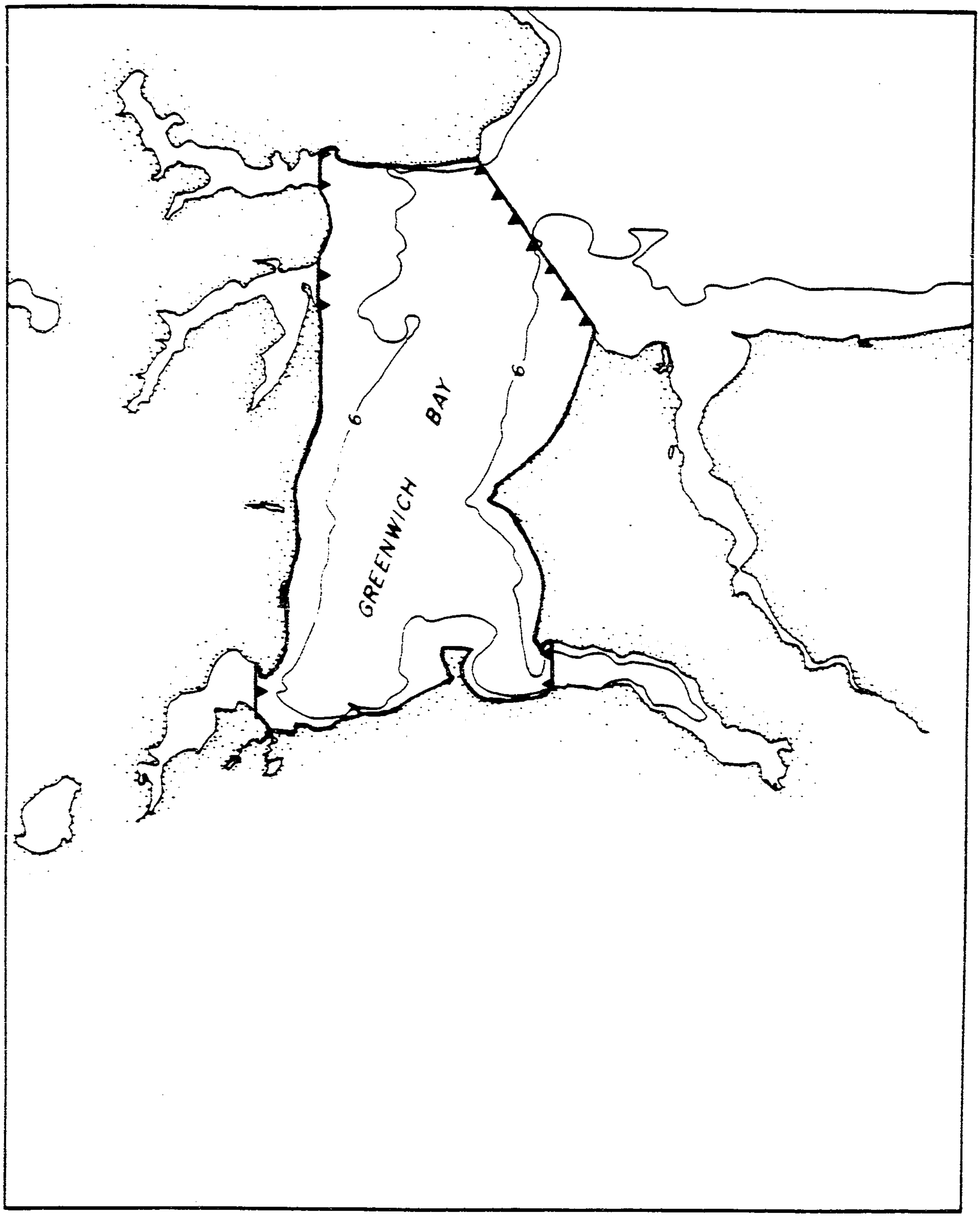


Figure 19 - Stickney and Stringer Unpublished - Area of Study

Table 30
Terceiro 1985

Kind of data: Epibenthic invertebrate and demersal fish abundance

Data set description: Number of sample stations: 2
Sample period: 1970 - 1983
Sample frequency: Weekly
Sample type: Otter trawl
Number of replicates: 1
Area of individual samples:
Lowest mesh size used: 5.1 cm

Sampling locations: West Passage 41 34 N 71 24 W
Rhode Island Sound 41 25 N 71 25 30 W

Principal Investigator(-): Dr. Mark Terceiro
Dr. H. Perry Jeffries
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882-1197

Study used in benthic characterization project: Yes.

Investigator(s) contacted for characterization project: No.

Funding institution: Unknown.

Citation for published data: Terceiro, M. 1985. Changes in epibenthic macro-invertebrate and demersal fish assemblages in Narragansett Bay and rhode Island Sound. Ph.D. Dissertation, University of Rhode Island, Kingston, RI, 122p.

Location of original raw data: Unknown.

Person to contact for original raw data:
Dr. H. Perry Jeffries
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882-1197
401-792-6281

Computer status of original data set: Unknown. Data in publication were not entered into computer data sets as part of project.

Addition comments: Although data were collected weekly, only monthly means were given in publication.

Figure 19 - Terceiro 1985 - Station Locations

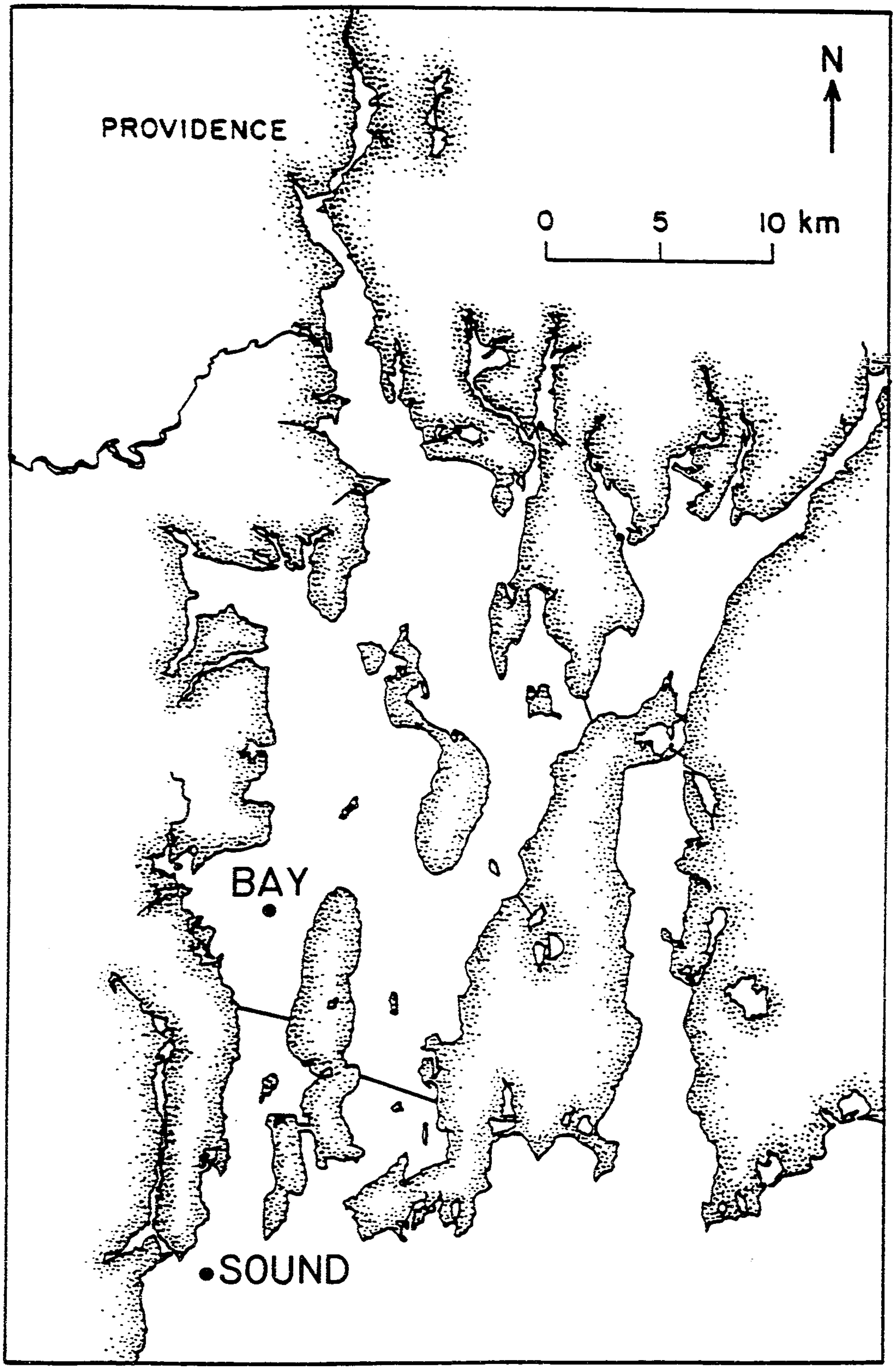


Table 31
U.S. Army Corps of Engineers 1981

Kind of data: Environmental Impact Report

Data set description: See below.

Sampling locations: Bristol Harbor

Principal Investigator(s): U.S. Army Corps of Engineers

Study used in benthic characterization project: No.

Investigator(s) contacted for characterization project: No.

Funding institution: U.S. Army Corps of Engineers

Citation for published data: U.S. Army Corps of Engineers. 1981. Bristol Harbor, Rhode Island navigation Improvements: Phase I AED General Design Memorandum Plan Formulation. Department of the Army, New England Division, Corps of Engineers, Waltham, MA.

Location of original raw data: Unknown.

Person to contact for original raw data: Unknown.

Computer status of original data set: Unknown.

Addition comments: Completed for an environmental impact assessment of navigational improvements in Bristol Harbor. Incidental descriptions only, no data given.

Shellfish Studies

Barnes, E.W. 1905. A preliminary list of the marine mollusca of Rhode Island. Rhode Island Commissioners of Inland Fisheries Annual Report 36:30-37.

Bockstael, G.E. 1972. Survey of Sheffield Cove. Rhode Island Division of Fish and Wildlife, Leaflet No. 38, September, 1972.

Campbell, R. (No date). An inventory of the quahaug population of the Providence River and Mount Hope Bay. Rhode Island Division of Fish and Game, Un-numbered leaflet.

Campbell, R. (No date). Quahaug investigations, Nausauket - Buttonwoods, 1955 1958 - 1959. Division of Fish and Game, Department of Agriculture and Conservation, Pamphlet No. 1, 8p.

Campbell, R. (No dat3). Quahaug investigations, Potowomut River, 1959. Leaflet No. 2. Division of Fish and Game, Department of Agriculture and Conservation, 2p.

Campbell, R. (No date). Quahaug investigations, Kickamuit River, 1959. Leaflet No. 3. Division of Fish and Game, Department of Agriculture and Conservation, 2p.

Campbell, R. (No date). The 1961 starfish census of Narragansett Bay. Leaflet No. 10. Division of Fish and Game, Department of Agricutlrue and Conservation, 20p.

Campbell, R. and P. Dalpe. (No date). A report on the 1960 starfish census of Narragansett Bay. Leaflet No. 8. Division of Fish and Game, Department of Agriculture and Conservation, 10p.

Canario, M. 1964. Intertidal soft clam survey. Leaflet No. 14. Division of Fish and Game, Department of Agriculture and Conservation, 2p.

Canario, M. 1963. Shellfish survey of the Kickamuit River. Leaflet No. 12. Division of Fish and Game, Department of Agriculture and Conservation, 14p.

Canario, M.T. 1963. Shellfish survey of Duck Cove, North Kingstown. Rhode Island Division of Fish and Game Leaflet No. 15.

Canario, M. and K. Kovach. 1966. Shellfish survey of the Warren River. Leaflet No. 22. Rhode Island Division of Conservation, Department of Natural Resources, 8p.

Canario, M.T., K.A.M. Kovach and R.A. Green. 1965. Shellfish survey of Bluff Hill Cove, Narragansett, RI. Rhode Island Division of Fish and Game Leaflet No. 18.

Canario, M.T. and K.A.M. Kovach. 1965. Shellfish survey of the Providence River. Rhode Island Division of Conservation Leaflet No. 17.

Canario, M.T. and K.A. Kovach. 1965. Shellfish survey of East Passage Channel. Rhode Island Division of Fish and Game Leaflet No. 16.

Cooper, R.A., S.B. Chenoweth and M. Nelson. 1964. Condition of the quahog "Mercenaria mercenaria" from polluted and unpolluted waters. Chesapeake Science 5: 135-140.

Cullen, J.D. 1984. A biogeochemical survey: Copper and nickel in Mercenaria mercenaria relative to concentrations in the water column in a New England Estuary. MS Thesis, University of Rhode Island, Kingston, RI, 141p.

Farrington, J.W. and J.G. Quinn. 1973. Petroleum hydrocarbons in Narragansett Bay. I. Survey of hydrocarbons in sediments and clams (Mercenaria mercenaria).
Estuarine and coastal Marine Science 1:71-70.

Ganz, A. and R. Sisson. 1977. Inventory of the fisheries resources of the Quonset-Davisville Area, North Kingstown, Rhode Island. Leaflet No. 48, Rhode Island Department of Natural Resources, Division of Fish and Wildlife, Marine Fisheries Section, 20p.

Gray, G.W. 1969. Sheilfish survey of the west passage of Narragansett Bay. Rhode Island Division of Fish and Game Leaflet No. 26.

Jeffries. H.P. 1972. A stress syndrome in the hard clam. Mercenaria mercenaria. J. Invertebrate Pathology 20:242-251.

Kern, F.G. 1986. Quahog histopathology studies. Draft final report for Narragansett Bay Project. National Oceanic and Atmospheric Admistration, National Marine Fisheries Service, Northeast Fisheries Center, Oxford Biological Laboratory, 25p.

Kovach, K.A.M. and M.T. Canario. 1968. Shellfish survey of Quicksand Pond, Little Compton, RI. Leaflet No. 23. Rhode Island Division of Conservation, Department of Natural Resources, 18p.

Kovach, K.A.M. and M.T. Canario. 1968. Shellfish survey of Quonset Point Area. Rhode Island Division of Conservation Leaflet No. 25.

Kovach, K.A.M., M.T. Canario and G. Gray. 1968. Sheilfish survey of the west passage of Narragansett Bay, RI. Leaflet No. 26. Rhode Island Division of Conservation, Department of Natural Resources, 13p.

Landers, W.S. 1954. Seasonal abundance of clam larvae in Rhode Island waters, 1950-1952. U.S. Fish and Wildlife Service Special scientific report - Fisheries No. 117.

Pratt, D.M. 1953. Abundance and growth of Venus mercenaria and Callocardia morrhuana in relation to the character of bottom sediments. Journal of Marine Research 12:60-74.

Pratt, D.M. and D.A. Campbell. 1956. Environmental factors affecting growth in Venus mercenaria. Limnology and Oceanography 1:2-17. NBREF.

Pratt, S.D. 1987. Status of the hard clam fishery in Narragansett Bay. Manuscript prepared for the Narragansett Bay Project, Draft dated October 20, 1987.

Pratt, S.D., B.K. Martin and S.B. Saila. 1987. Status of the hard clam (Mercenaria mercenaria) in the Providence River and Mount Hope Bay. Report to the U.S. Environmental Protection Agency, Region 1, Water Management Division. Draft dated February 1987.

Rhode Island Division of Conservation. 1968. Management plan and shellfish survey of the west passage and Sakonnet River of Narragansett Bay, RI. Rhode Island Division of Conservation, Department of Natural Resources, 14p.

Russell, H.J. 1969. Report of the 1969 hard clam commercial dredge season in the West Passage, Narragansett Bay, Rhode Island. Rhode Island Division of Fish and Wildlife Leaflet No. 31.

Russell, J.J. 1973. The ecology of round Swamp, Jamestown, RI. Rhode Island Division Fish and Wildlife. Leaflet No. 39.

Saila, S.B., J.M. Flowers and M.T. Cannario. 1967. Factors affecting the relative abundance of Mercenaria mercenaria in the Providence River, Rhode Island. Proceedings of the National Shellfisheries Association 57: 83-89. 2/87.

Sisson, R.T. (No date). Occurrence of bay scallop seed in Rhode Island 1970. Project 3-113-R. Leaflet No. 32. Rhode Island Division of Conservation, Department of Natural Resources, 4p.

Stringer, L.D. 1959. The population abundance and effect of sediment on the hard clam. In, Hurrican damage control, Narragansett Bay and vicinity, Rhode Island and Massachusetts. A detailed report on Fishery Resources. U.S. Fish and Wildlife service, Appendix E.

U.S. EPA. 1974. State of Rhode Island Shellfish Atlas. U.S. Envrionmental Protection Agency and Rhode Island Department of Natural Resources, Division of Fish and Wildlife.

Zinn, D.J. 1974. Quahog: Queen of the mudflats. Maritimes 17:4-7.

Additional Studies

Table 32
Frithsen Unpublished B

Kink of Data: Benthic macrofaunal abundance

Data set description:
Number of sample stations: 14
Sample period: 81086 - 81094
Sample frequency: Twice
Sample type: Smith McIntyre grabs and hand cores
Number of replicates: 1
Area of individual sample: 1174 cm^2 and 35.3 cm^2
Lowest sieve size used: 1000 um
Number of species or species groups identified: 19

Sample locations: Seekonk River. Specific locations given below.

Principal investigator(s):
Dr. Jeffrey B. Frithsen
Dr. Michael E.Q. Pilson
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882-1197

Study used in benthic characterization project: Yes.

Investigator(s) contacted for characterization project: No.

Funding Institution: Philip A. Hunt Chemical Corporation

Citation for published data: Unpublished.

Location of original raw data:
Marine Ecosystem Research Laboratory
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882-1197

Person to contact for original raw data: Dr. Jeffrey B. Frithsen

Computer status of original data set: Fully enetered into labeled SAS data sets residing on the GSO Computer Center's Micro-VAX II.

Figure 20 - Frithsen, Unpublished B - Station Locations

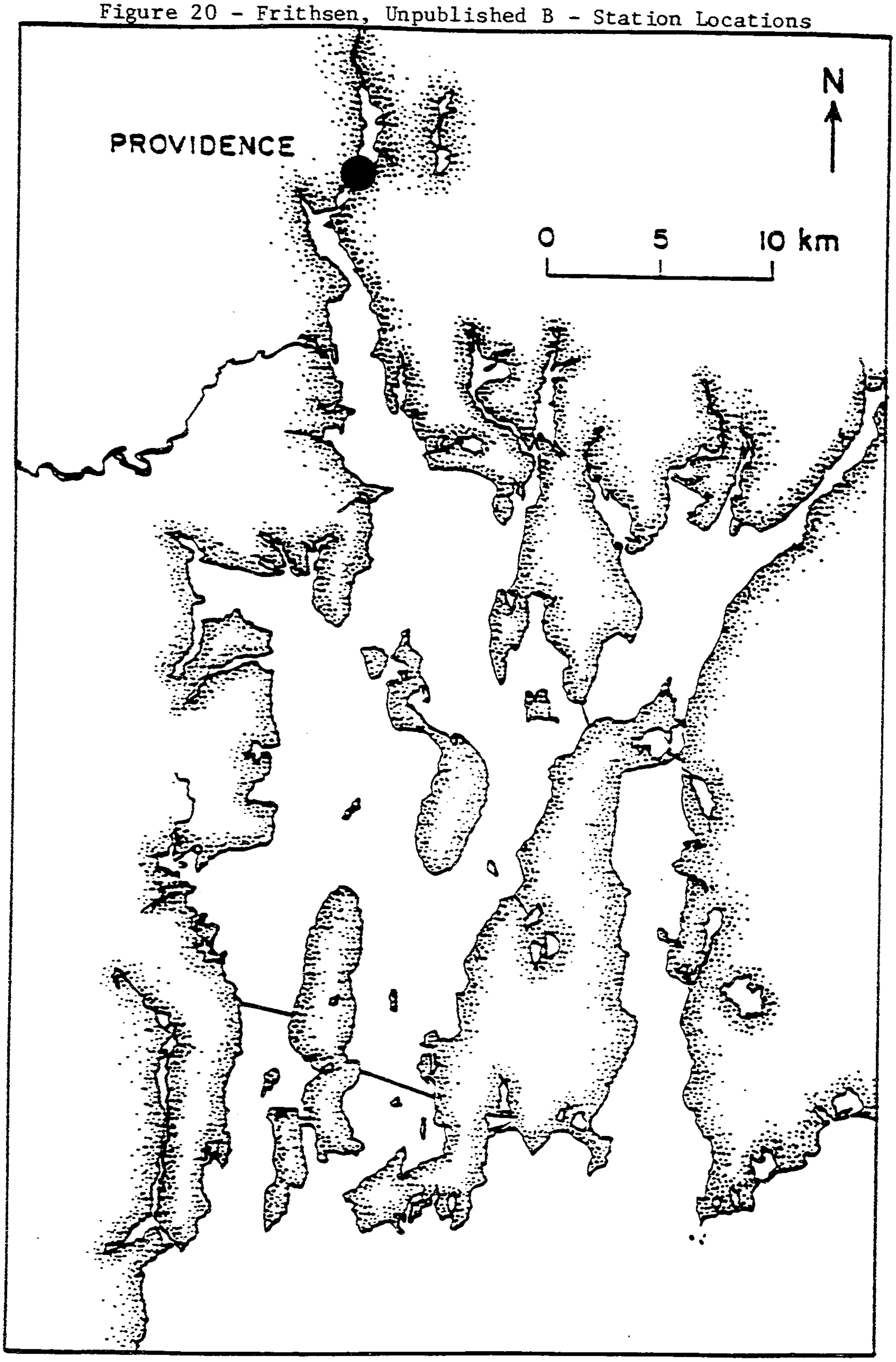


Table 33
Hyland 1981

Kind of data: Benthic macrofaunal abundance

Data set description: Number of sample stations: 2
Sample period: 77213 - 78213
Sample frequency: Irregular (5 times)
Sample type: Diver cores
Number of replicates: 10
Area of individual samples: 41.85 cm^2
Lowest sieve size used: 300 um

Sample locations: Mid Narragansett Bay - 41 34 54 N 71 22 48 W
Pettaquamscutt River - 41 28 48 N 71 26 48 W

Principal investigator(s): Dr. Jeffrey L. Hyland

Study used in benthic characterization project: Yes

Investigator(s) contacter for characterization project: No

Funding institution: U.S. Environmental Protection Agency

Citation for published data: Hyland, J.L. 1981. Comparative structure and response to (petroleum) disturbance in two nearshore infaunal communities. Ph.D. Dissertation, University of Rhode Island, Kinston, RI, 141p.

Location of original raw data: Publication.

Person to contact for original raw data: Dr. Jeffrey L. Hyland

Computer status of original data set: Fully entered into labeled SAS data sets residing on the GSO Computer Center's Micro-VAX II.

Additional Comments: Data from the Pettaquamscutt River was not entered into SAS data sets.

Figure 21 - Hyland 1981 - Station Locations

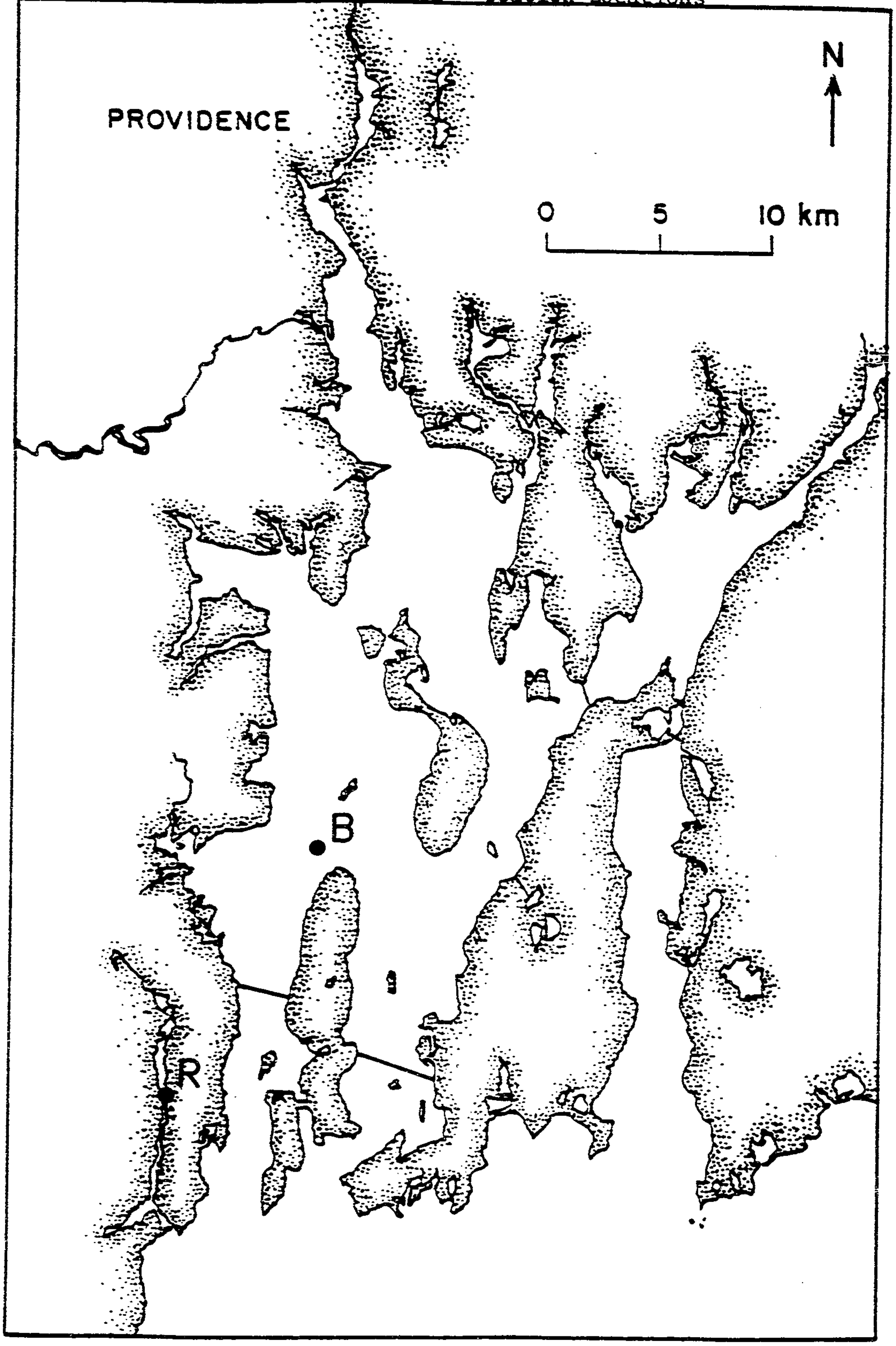


Table 34
Marine Resources, Inc.

Kind of Data: Benthic macrofaunal abundance

Data set description: Number of sample stations: 3 - 5
Sample period: 72121 - present
Sample frequency: Monthly
Sample type: 5/72 - 2/75 Diver cores
3/75 - present Van Veen Grab
Number of replicates: 1 - 3
Area of individual sample: 0.04 m^2
Lowest sieve size used: 500 um

Sample locations: Mt. Hope Bay

Principal investigator(s): Marine Research, Inc.
141 Falmouth Heights Road
Falmouth, MA 02540
617-548-0700

Study used in benthic characterization project: No

Investigator(s) contacted for characterization project: No

Funding Institution: Brayton Point Power Plant

Citation for published data: Unpublished

Location of original raw data: Marine Research, Inc.
Copies of data reports in Pell Library, GSO.

Person to contact for original raw data: Richard C. Toner
Marine Research, Inc.

Computer status of original data set: Unknown

Table 36
Rhode Island Shellfish Landings

Kind of data: Rhode Island shellfish catch statistics

Data set description: Sample period: 1880 - 1986
Sample frequency: Annual summary of monthly statistics

Sample locations: Rhode Island - Not necessarily limited to Narragansett Bay

Data used in benthic characterization project: Yes

Citation for published data: Lyles, C.H. 1969. Historical catch statistics (Shellfish). United States Department of the Interior, U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Washington, DC, July 1969, 116p.

Computer status of data set: Entered into labeled SAS datasets residing on the GSO Computer Center's Micro-VAX II.

Additional Comments:
Annual Rhode Island catch statistics for shellfish for the period 1880 - 1967 were taken from Lyles (1969). More recent statistics were obtained through the Rhode Island Department of Environmental Management with the assistance of Mr. Richard Sisson.

Statistics were compiled for the following species: the hard clam or quahaug (*Mercenaria mercenaria*), the soft shelled clam (*Mya arenaria*), the eastern oyster (*Crassostrea virginica*), the bay scallop (*Aequipecten irradians*), the channel whelk or conch (*Busycon canaliculatum*), the green crab (*Carcinus maenas*), and the rock crab (*Cancer irroratus*), which also included statistics for the Jonah crab (*Cancer borealis*).

Statistics were reported by the above sources as thousands of pounds of meat caught and thousands of dollars of market value (not adjusted for inflation). Total meat weight was computed by multiplying number of bushels (or for *Aequipecten irradians*, gallons of edible meats) by the following conversion factors:

Mercenaria mercenaria	X12
Mya arenaria	X20
Crassostrea virginica	X 7
Aequipecten irradians	X 9
Busycon canaliculatum	X15

Beginning in July 1971, the conversion factor for *Mya* changed from 20 to 13. Beginning in January 1984, the conversion factor for *Busycon* changed from 15 to 9. In 1985 the conversion factor for *Mercenaria* dropped from 12 to 10.

THE BENTHIC COMMUNITIES WITHIN

NARRAGANSETT BAY

An Assessment Completed
for the
Narragansett Bay Project

APPENDIX C

Benthic Data for Narragansett Bay

These are a few representative pages only;
if you require the entire Appendix C, please
contact our office: (401)277,3165.

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Table of Contents

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Introduction

Presented in this appendix are data sets that were entered into computer files as part of this project. Each data set is printed as a separate table and observations within the data set are sorted first by date, second by station, third by core number, and finally by sediment depth horizon. Station numbers are those given in the original data sets. Since some station numbers included letters, the variable "STATION" was created as a character variable. As such, station numbers were sorted as ASCII codes.

Additional information concerning each data set may be found in Appendix B and in the text of the report.

Figure 1 - Chowder and Marching 1967 - Station Locations

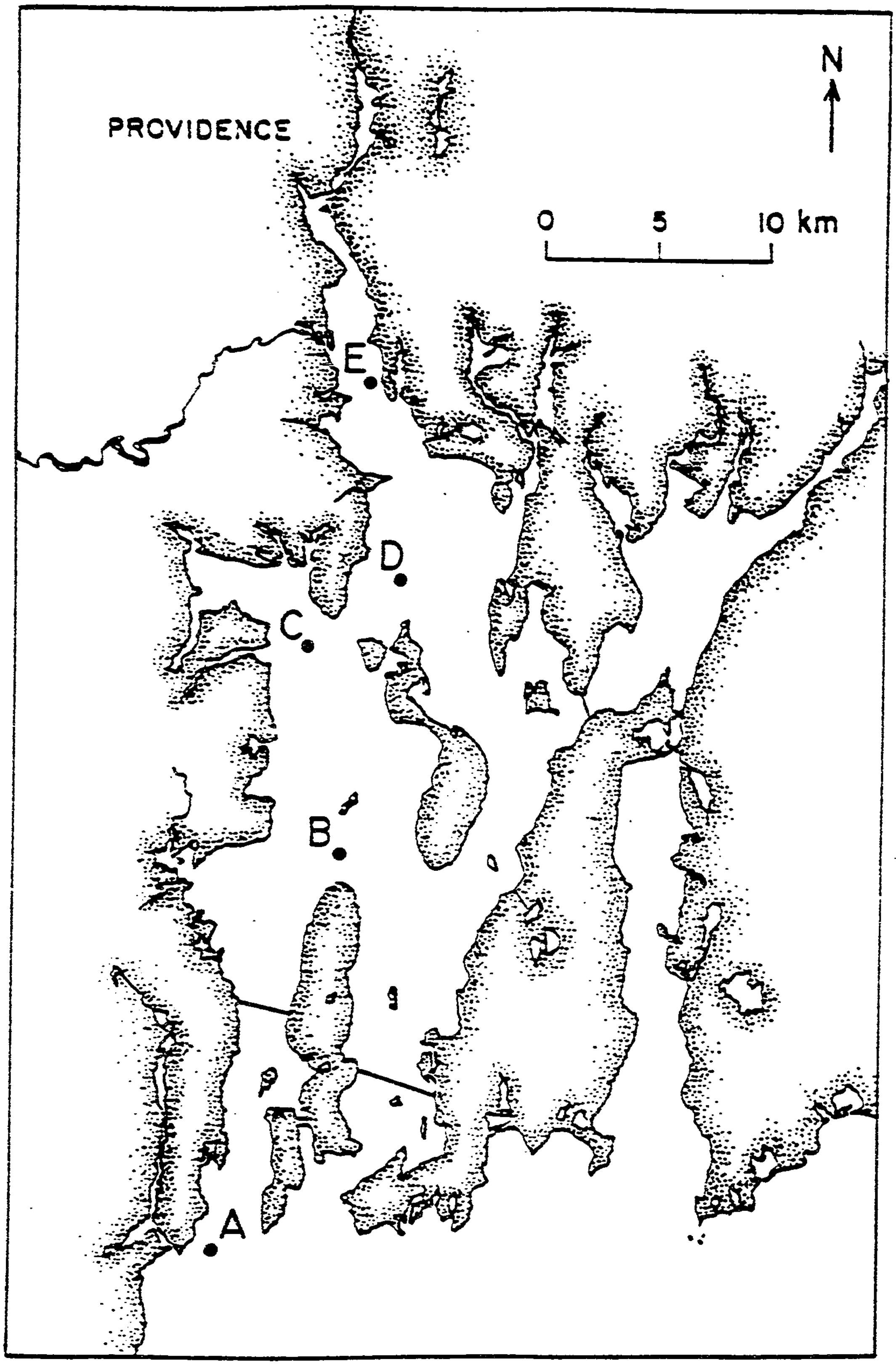

Table 1
Chowder and Marching 1967

Date=16AUG1967 Station=A Core=1 Core Area=1000 cm^2
Sample Method=Smith-McIntyre Grab Lowest Sieve Size Used=2 mm
Sediment Depth Sampled=Unknown Abundance as individuals/m^2

Polychaetes	
Arabella iricolor	100
Clymenella torquata	30
Glycera americana	10
Nephtys incisa	20
Ninoe nigripes	420
Pherusa affinis	30
Scoloplos robustus	140
Spio filicornis	90
Unknown Ampharetidae	20
Oligochaetes	
Bivalves	
Callocardia morrhuana	30
Mercenaria mercenaria	10
Mulinia lateralis	10
Nucula proxima	40
Pandora gouldiana	10
Yoldia limatula	30
Gastropods	
Nassarius trivittatus	20
Amphipods	
Ampelisca vadorum	30
Ampelisca verrilli	380
Leptocheirus pinguis	70
Unciola irrorata	160
Other Crustaceans	
Edotea montosa	190
Diastylis polita	190
Miscellaneous Species	
Ceriantheopsis americanus	10
Cerebratulus lacteus	20
Total Abundance	2060