2000 harbor benthic monitoring report

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2000 HARBOR BENTHIC MONITORING REPORT

submitted to

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EXECUTIVE SUMMARY

MWRA began its studies of the infaunal communities and benthic habitats in Boston Harbor in 1989 and initiated the ongoing studies of infaunal communities in 1991, just prior to the cessation of sludge dumping into the Harbor. The principal aim of the Harbor studies is documentation of continuing recovery of benthic communities in areas of Boston Harbor as improvements are made to the quality of wastewater discharges. Briefly, these can be listed as the

- cessation of sludge discharge into the Harbor—December 1991,
- operation of a new primary treatment facility at Deer Island—1995,
- initiation of secondary treatment (first battery)—1997,
- continuation of secondary treatment implementation (second battery)—1998,
- cessation of effluent discharge from Nut Island—July 1998,
- transfer of effluent offshore—September 2000, and
- completion of the implementation of secondary treatment—Winter 2001.

Recent reports have indicated that some observed infaunal community changes are consistent with those expected with habitat improvements that have resulted from the changes in discharges into the Harbor. Among the changes reported in these studies, the increase in abundance and geographic distribution of the tube-dwelling amphipod *Ampelisca* has been the most dramatic.

A major change to discharges into the Harbor that occurred in September 2000, the diversion of effluent to the new ocean outfall, is expected to result in further improvements in the Harbor's benthic habitats.

The Boston Harbor benthic monitoring program includes three components. Sediment profile images (SPI) are collected during the late summer to monitor the general condition of the soft-bottom benthic habitats in the Harbor. Sediment geochemistry studies, conducted via the collection of sediment grab samples from Traditional stations in April and August, consist of grain-size analysis and total organic carbon (TOC) content determination. The presence of a sewage tracer, *Clostridium perfringens*, also is quantified during these studies. The 2000 studies included 16 grain-size, TOC, and *Clostridium* samples. Infaunal communities in Boston harbor are monitored via the collection of samples from eight Traditional stations. All stations were visited in 2000, although one infaunal sample (station T03, sampled in August) was lost. Summaries of the 2000 results from these studies and overall programmatic trends follow.

Sediment Profile Images

Typically, the distribution of sediment textures in the Harbor primarily results from a combination of sources, morphology, and hydrodynamics. In 2000, as in 1999, biogenic mixing dominated the surface sediments and was able to obliterate physical features such as bedforms. The broad range of sedimentary habitats within the Harbor was also reflected in the range of average station prism penetration, which ranged from 1.0 cm at Station R08 on Deer Island Flats to 21.6 cm at T04 in inner Dorchester Bay. In physically dominated habitats with coarse sediments surface relief was due to sediment grain (gravel, pebble, or cobble) and in silty sediments to irregularities in the surface. In biologically dominated habitats surface relief was typically biogenic structures produced by benthic organisms. *Ampelisca* spp. tube mats were the primary relief surface creating biogenic features, followed by what appeared to be feeding pits or mounds.

It appears that the *Ampelisca* spp. population in the harbor continued to decline in 2000 with a third of stations having a modal classification of tube mat. This is down from a high of about 60% from 1995 to 1997 and about 40% in 1998 and 1999. Over the last three years the number of stations with tube mats declined and the number of stations with poor quality tubes increased. In 1998, *Ampelisca* spp. tube mats were composed of long (>1 cm) tubes and appeared "fresher". In 1999, about a quarter of the tube mats appeared to be in senescence with the average size of the tubes on the order of 0.5 cm and many of the mats appeared to be deteriorating. In 2000, only a tenth of the mats appeared senescent, Stations R50 and T02, but the number of stations with mats declined for the third year in a row. The size of *Ampelisca* spp. tubes at stations, where only one or two of the three replicate images had amphipods at mats densities was 0.4 cm. At stations with mat in all three replicate images, the tubes were 1.1 cm long.

The apparent modal successional stage indicated that the infaunal communities in the harbor area were about evenly split between pioneering (19 stations Stages I) and intermediate (18 stations Stage II), serial Stages. The high degree of biogenic sediment reworking observed in many images was consistent with Stage II with indications of the equilibrium serial stage (Stage III) observed at six stations. Station T04, inner Dorchester Bay, with the poorest community structure of all stations, had a Stage I designation. Evidence of Stage I communities occurred at 60% of stations, the same as in 1999, with evidence of Stage II communities at 68% of stations, about the same as 1999.

The range of the Organism Sediment Index (OSI) at harbor stations was indicative of the wide range of conditions effecting infaunal community development. OSI ranged from 0.7 to 10.0 with the lowest values occurring at fine sediments stations with little evidence of infaunal activity, for example T04. Highest OSI values were also at fine sediments stations that had high levels of infaunal activity. The majority, 70%, of harbor stations had OSI values <6, which indicated communities were under some form of moderate stress. This could be related to organic loading or physical disturbance of the benthic habitat.

Overall, general benthic habitat quality within the study area was similar from August 1992 to 2000 with minor variation from year to year. Using the OSI as a surrogate for habitat quality, none of the stations exhibited monotonic long-term trends, either improving or declining. However, there were six stations that consistently had OSI values ≥6 (R11, R12, R24, R28, R29, R45), the break point for stressed/not stressed habitat conditions, and six stations with consistently <6 OSI values (R10, R33, R43, R49, T01, T04). Station T04 located in inner Dorchester Bay consistently had low OSI values with three years of negative values, indicative of a highly stressed habitat. Stations R11, R12, R45, and T03 along the western side of Long Island had consistently good habitat quality, and had the highest overall averages.

From 1992 to 2000, key indicators of benthic habitat quality oscillated about the long-term mean with no year being more than 14% and 32% from the grand mean, for OSI and RPD respectively. Current benthic communities appeared to have developed in response to major events in 1991, the October severe storm, and December 1991 sewage discharge abatement.

Sediment Geochemistry

Spatial and temporal distribution in sediment grain size composition and total organic carbon concentrations in 2000 were not substantially different from previous years (1991–1999). With few exceptions, grain size and TOC were strongly correlated across all sampling years.

Seasonal peaks in TOC were not clearly evident when TOC from the Benthic Nutrient Flux and Traditional Harbor programs were compared. This could be related to station locations and the lower number of stations sampled in the Benthic Nutrient Flux program.

Variability in *Clostridium perfringens* concentrations appeared to settle down over time and the system seemed to be more stable between 1998 and 2000. In addition, the overall abundance of *Clostridium perfringens* spores appeared to decrease since 1998, suggesting that *Clostridium perfringens* has shown a response to facility improvements implemented to clean-up Boston Harbor (*e.g.*, secondary treatment and the cessation of Nut Island discharges), demonstrating that *Clostridium perfringens* has served as a good tracer.

Clostridium perfringens results for April surveys generally correlated well with bulk sediment properties in recent years, indicating that grain size and TOC are likely controlling factors in the spring. Interestingly, the correlation between *Clostridium perfringens* and bulk sediment properties for August surveys degraded after 1998, suggesting that independent processes (*e.g*., bioturbation) are emerging possibly as a result of low input of TOC to the system following secondary treatment coming on-line in August 1997 and cessation of Nut Island discharges in July 1998.

Further, the correspondence between *Clostridium perfringens* and bulk sediment properties was generally weaker in August compared to April, which may be attributed to either bioturbation and mixing of sediment, TOC burn-off, or poor preservation of *Clostridium* spores during the warmer months.

Infaunal Communities

In general, infaunal abundances among Harbor stations sampled in 2000 were similar to those encountered in 1999 and continued to be lower than they have been in recent years. There were no significant changes in abundance between 1999 and 2000 at any of the stations.

Most of the 2000 samples showed no major differences from those collected in previous years in the numbers of species per station. Species numbers at most stations were within the general range found for the past 6–7 years. However, at station T04 more species (13) were found in April 2000 than occurred there in April or August 1999. By August 2000, that number had decreased to 5 species. At station T05A, the number of species (22) found in August was much lower than found there since 1996 and represented a loss of 15 species since April 2000. However, it is still apparent that species numbers at many stations are now much higher than they were in 1991.

With two exceptions, species diversity, as measured by log-series alpha, in 2000 was essentially the same as it was in 1999 and within the general range of values reported previously for each station. Station T01 had high diversity (10.4) in April 2000, but the value decreased to 7.1 in August, a more typical value for the station. At station T05A, log-series alpha in April (10.2) was higher than previously found there, but decreased to 4.6 in August. The latter value was lower than any reported at the station since about 1995.

Although the samples collected during the MWRA Harbor monitoring represent many habitats and have shown strong geographic character, there are Harbor-wide patterns of change in the various ecological metrics that have become noticeable. Despite the large variability inherent in collecting samples from different locations within the Harbor, and at different times of the year, it is useful to combine the Harbor data to look for general patterns that might be related to changes in the Harbor's ecosystem resulting from the intense clean-up activities occurring since the early 1990s. Summer total infaunal abundance in the Harbor was low in September 1991, increased sharply through Summer 1993, and remained high through 1998 (with the exception of 1996). Summer abundance decreased noticeably in 1999 and then again in

2000. The Summer 1997 value represented a seven-fold overall increase in abundance in the Harbor since 1991. The rapid decline since 1997 represented about a three-fold decrease in abundance in four years. The pattern for Spring samples is not the same. Although there was a gradual increase from Spring 1992 through 1996 and a gradual decrease since, abundances were relatively consistent from 1992 through 2000. From 1992 through 1998 (again with the exception of 1996), Summer infaunal abundances differed considerably from abundances measured the previous Spring. The disparity decreased markedly in 1999 and was further reduced in 2000 such that there is relatively little difference between Spring and Summer abundance values.

One of the most noticeable features of the change in species numbers in the Harbor during the monitoring program was the very dramatic increase between September 1991 and Summer 1992 when the number of species per sample almost doubled (from 17 to 32). Since 1992, the changes in species numbers per sample in Summer have been more modest. The number of species per sample found in Spring has increased gradually since 1992 (from 22 to 31). The net effect of these patterns is that from 1992 to 1995 there were considerable differences in the species numbers per sample between Spring and Summer with Summer values being higher. Since then, with the exception of 1998, these differences have been much less distinct, with values in Spring 1996 and 2000 exceeding those found in Summer.

Infaunal communities patterns from 1991 to 2000, as determined by multivariate analyses, were primarily related to strong within-station similarity, with temporal trends being of secondary importance. At the eight-group level, three stations formed exclusive or nearly exclusive groups: Station T04 in inner Dorchester Bay, T08 in Hingham Bay, and T05A in President Roads. There was one exclusive seasonal grouping, which contained four summer collections at T05A. Despite this, Spring and Summer infaunal composition at T05A, and also T08, was similar over the ten-year period with little differentiation between these season.

Over the ten-year period, Stations T01, T02, T03, T04, T06, T07, and T08 maintained a high degree of within station similarity with at least 75% (15 of 19) of the sampling periods within the same cluster group. Any disturbance of infaunal communities by the major events that occurred near the initiation of the T-station monitoring in 1991, the October severe storm and December sewage discharge abatement at the inner harbor outfall, was not obvious.

Conclusions

The observed changes in the Harbor's infaunal communities, coupled with data from SPI studies, provide good evidence for improvement in benthic habitat conditions in the Harbor since the cessation of sludge discharge in 1991. The most substantial changes in the Harbor's benthos probably occurred within the first two to three years after sludge discharge ended. Among these were the sudden increase in abundance and geographic spread of the amphipod *Ampelisca* spp, and the general increase in infaunal abundance and species numbers that occurred after 1991. Recently, some data indicate that the infaunal communities are in transition from those that appeared in the early 1990s to those more likely to be found in a less-polluted Harbor that is still prone to periodic natural disturbance. There also appears to be a reduction in the apparent seasonal differences in the descriptive infaunal metrics that had consistently been found in the Harbor before the late 1990s.

1.0 INTRODUCTION

1.1 Program Background

MWRA began its studies of benthic habitats in Boston Harbor in 1989, and initiated the ongoing studies of infaunal communities in 1991, just prior to the cessation of sludge dumping into the Harbor. The principal aim of the Harbor studies is documentation of continuing recovery of benthic communities in areas of Boston Harbor as improvements are made to the quality of wastewater discharges. Blake *et al.* (1998) and Werme and Hunt (2000) have summarized past and future changes in discharges into Boston Harbor. Briefly, these can be listed as the

- cessation of sludge discharge into the Harbor—December 1991,
- operation of a new primary treatment facility at Deer Island—1995,
- initiation of secondary treatment (first battery)—1997,
- continuation of secondary treatment implementation (second battery)—1998,
- cessation of effluent discharge from Nut Island—July 1998, and
- completion of the implementation of secondary treatment—September 2000.

Recent reports have indicated that some observed infaunal community changes are consistent with those expected with habitat improvements that have resulted from the changes in discharges into the Harbor (Kropp and Diaz 1995, Hilbig *et al.* 1996, Blake *et al.* 1998, Kropp *et al.* 2000). Among the changes reported in these studies, the increase in abundance and geographic distribution of the tube-dwelling amphipod *Ampelisca* has been the most dramatic.

Results from the 2000 harbor benthic surveys, presented in this report, represent the final data from the harbor before the complete diversion of effluent to the new ocean outfall on September 6, 2000.

1.2 Overview of this Report

The Boston Harbor benthic monitoring program includes three components. Sediment profile images (SPI) are collected during the late summer to monitor the general condition of the soft-bottom benthic habitats in the Harbor. In this report, the analyses of the SPI that were collected from 60 Harbor Traditional and Reconnaissance stations are presented in Section 3. Sediment geochemistry studies, conducted via the collection of sediment grab samples from Traditional stations in April and August, consist of grain-size analysis and total organic carbon (TOC) content determination. The presence of a sewage tracer, *Clostridium perfringens*, also is quantified during these studies. 2000 studies included 16 grain-size, TOC, and *Clostridium* samples. These studies are presented in Section 4. Infaunal communities in Boston harbor are monitored via the collection of samples from eight Traditional stations. All stations were visited in 2000. Analyses of the infaunal communities are described in Section 5. Each section also includes a programmatic evaluation.

The raw data generated for all of these studies are available from MWRA.

2.0 FIELD OPERATIONS

by Jeanine D. Boyle

2.1 Sampling Design

The Harbor Benthic Surveys provide the benthic samples and other data required to document long-term improvement of sediment quality and resulting recovery of the benthic communities in Boston Harbor following the cessation of sludge and effluent discharge into the Harbor. Data from an extensive reconnaissance survey using sediment profile images (SPI) supplements and extends traditional infaunal data to provide a large-scale picture of benthic conditions in the Harbor. This expanded coverage is particularly important because conditions are expected to improve over a broader expanse of the Harbor as secondary treatment is implemented and effluent discharge is diverted to the outfall.

2.1.1 Traditional

During the Harbor traditional surveys, conducted late April and late August 2000, soft-sediment grab samples were collected from eight sampling locations. These "traditional" stations were selected after consideration of historic sampling sites and Harbor circulation patterns (Kelly and Kropp 1992). Samples from these traditional stations were collected for analysis of selected physical sediment parameters and sewage tracers, and for benthic infaunal community parameters. The actual locations of all Boston Harbor grab samples collected in 2000 are listed in Appendix A-1.

2.1.2 Reconnaissance

To provide for greater geographic coverage of benthic community recovery, a Harbor reconnaissance survey was conducted during August 2000. Sediment profile images (SPI) were obtained at the 52 "reconnaissance" stations, the 8 'traditional" stations. The actual locations of all Boston Harbor sediment profile images collected in 2000 are listed in Appendix A-2.

2.2 Surveys/Samples Collected

The dates of the Boston Harbor Traditional and Reconnaissance surveys and the numbers of samples collected on them are listed in Table 2-1.

Table 2-1. Survey dates and numbers of samples collected on Boston Harbor benthic surveys in 2000.

Survey	ID	Date(s)	Samples Collected				
			Inf	TOC	Gs	Cp	SPI
April Harbor Benthic	HT001	25 April 2000	24	8	8	8	–
August Harbor Benthic	HT002	23-25 August 2000	24	8	8	8	–
SPI	HR001	21-24 August 2000	–	–	–	–	375

Key:

Inf, Infauna
TOC, total organic carbon
Gs, grain size
Cp, *Clostridium perfringens*
SPI, sediment profile images (slides)

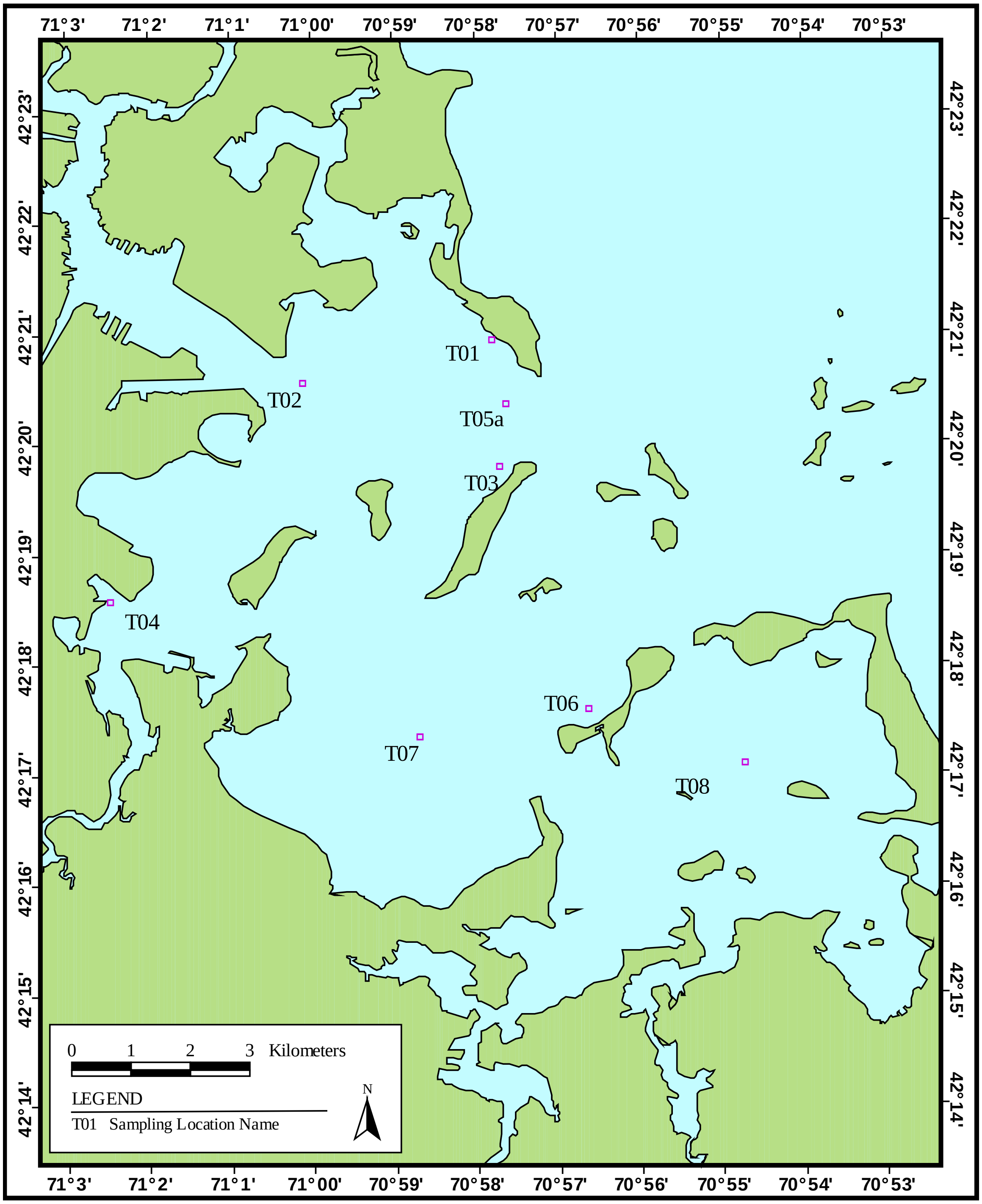


Figure 2-1. Target locations of the eight Boston Harbor Traditional stations.

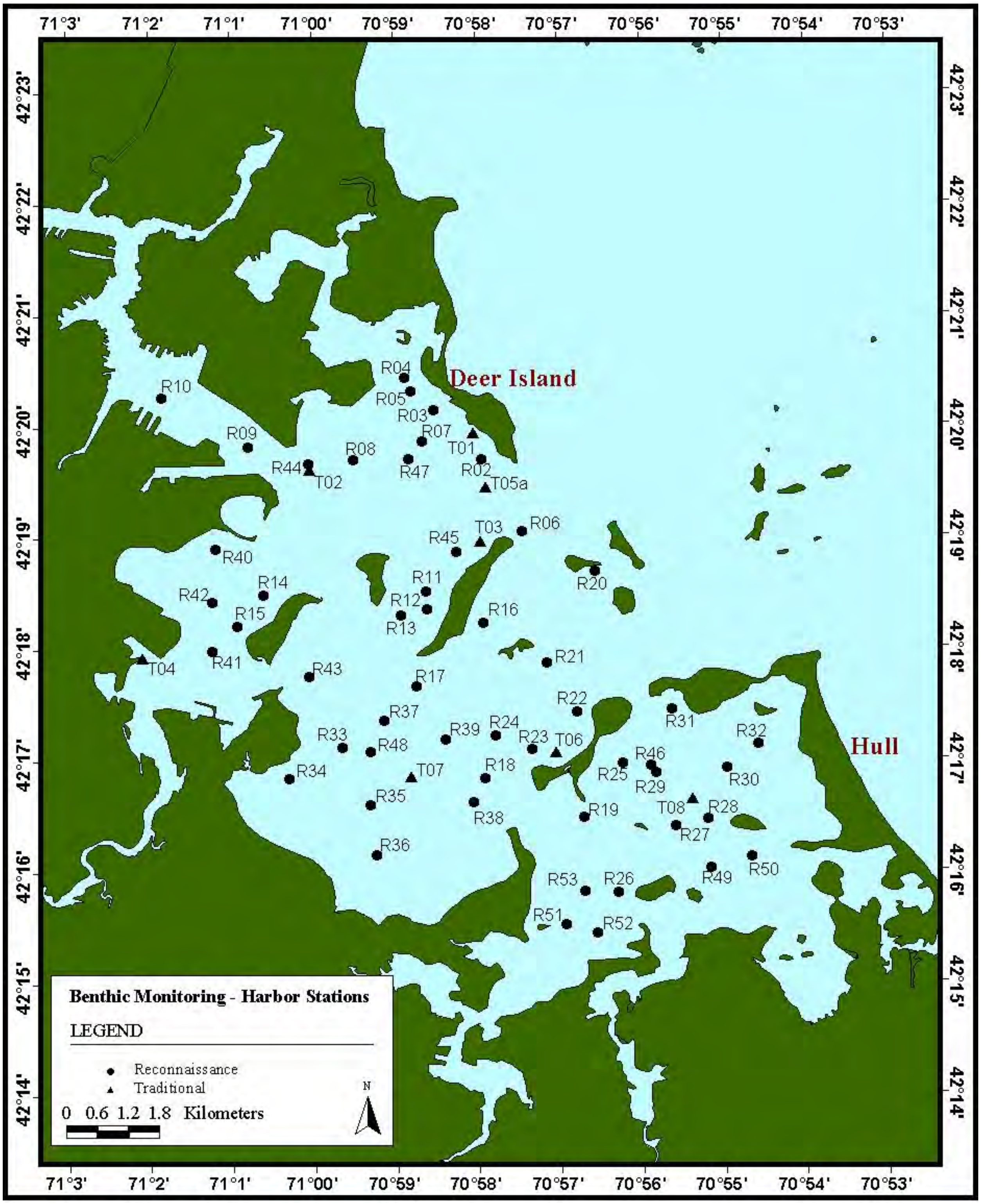


Figure 2-2. Target Locations of Boston Harbor Reconnaissance stations.

2.3 Field Methods Overview

The following is a brief overview of the methods and protocols used on the benthic surveys. More detailed descriptions of the methods are contained in the CW/QAPP (Kropp and Boyle 1998).

2.3.1 Vessel/Navigation

Vessel positioning during benthic sample operations was accomplished with the BOSS Navigation system. This system consists of a Northstar differential global positioning system (DGPS) interfaced to the on-board BOSS computer. Data were recorded and reduced using NAVSAM data acquisition software. The GPS receiver has six dedicated channels and is capable of locking into six satellites at one time. The system was calibrated with coordinates obtained from USGS navigation charts at the beginning and end of each survey day.

At each sampling station, the vessel was positioned as close to target coordinates as possible. The NAVSAM navigation and sampling software collected and stored navigation data, time, and station depth every 2 seconds throughout the sampling event, and assigned a unique ID to each sample when the sampling instrument hit bottom. The display on the BOSS computer screen was set to show a radius of 30 m around the target station coordinates (6, 5-m rings) for all Boston Harbor benthic surveys. A station radius of up to 30 m is considered acceptable for sediment sampling in Boston Harbor.

2.3.2 Grab Sampling

At all eight Traditional stations, a 0.04-m^2 Ted Young-modified van Veen grab sampler was used to collect three replicate samples for infaunal analysis. One additional sample was collected for *Clostridium perfringens*, sediment grain size, and total organic carbon (TOC) analyses. Infaunal samples were sieved onboard over a 300-μm-mesh sieve and fixed in buffered formalin. The “chemistry” grab sample was skimmed off the top 2 cm of the grab using a Kynar-coated scoop, and was homogenized in a clean glass bowl before being distributed to appropriate storage containers. The TOC samples were frozen, whereas the *C. perfringens* and grain size samples were placed on ice in coolers.

2.3.3 SPI

At each Reconnaissance and Traditional station, a Hulcher Model Minnie sediment profile camera fitted with a digital video camera was deployed three times. The profile camera was set to take two pictures, using Fujichrome 100P slide film, on each deployment at 2 and 12 seconds after bottom contact. In the event that sediments were soft the two-picture sequence ensured that the sediment-water interface would be photographed before the prism window became over penetrated. The combination of video and film cameras ensured accurate and reliable collection of sediment profile images. Any replicates that appeared to be disturbed during deployment were retaken. Due to malfunction, the videotape was not recording during the harbor sampling. Mr. Cutter and Dr. Robert Diaz, the SPI senior scientist, agreed that SPI evaluation of the harbor stations could be accomplished with the slides alone. Mr. Cutter recorded the station, time, approximate prism penetration depth and a brief description of the substrate in the survey log. In addition, Mr. Cutter estimated the Oxidation-Reduction Potential Discontinuity at each nearfield station. Each touch down of the camera was marked as an event on the NAVSAM©.

3.0 2000 SEDIMENT PROFILE CAMERA RECONNAISSANCE OF HARBOR BENTHIC HABITATS

by Robert J. Diaz

3.1 Materials and Methods

3.1.1 Field Methods

On 21, 23, and 24 August 2000 the sediment profile survey of Boston Harbor stations was conducted. Sediment Profile Images (SPI) data were successfully collected at 60 long-term R and T stations (Figure 3-1). At each station a Hulcher Model Minnie sediment profile camera was deployed three times. The profile camera was set to take two pictures, using Fujichrome 100P slide film, on each deployment at 2 and 12 seconds after bottom contact. Any replicates that appeared to be disturbed during the camera deployment were retaken.

3.1.2 Image Analysis

The sediment profile images were first analyzed visually by projecting the images onto a screen and recording all features seen into a formatted, standardized spreadsheet file. The images were then digitized using a Nikon 2000 scanner and analyzed using the Adobe PhotoShop and NTIS Image programs. Data from each image were sequentially saved to a spreadsheet file for later analysis. Details of how these data were obtained can be found in Diaz and Schaffner (1988), Rhoads and Germano (1986), and Kropp *et al*. (2000).

3.2 Results and Discussion

3.2.1 2000 Harbor Image Data

One replicate image from each station is contained in the CD-ROM Appendix. Images were selected to show the range of physical and biological processes active in the Harbor area.

3.2.1.1 Physical Processes and Sediments

The predominant sediment type throughout the study area was silty mud (modal Phi 8 to 5) and occurred at about half (33 of 60) of the stations (Table 3-1, Figure 3-1). Silty fine sands and fine sandy silts occurred at about a third of the stations and were also broadly distributed within the harbor. The remaining six stations ranged from sands (R08, R23, T08) to coarser gravel and pebbles (R06, R08, R19, T05A). Three stations (R14, R40, R42) appeared to have layered sediments with about 1 cm of fine-sand over silty-fine-sand sediments. Beds of clamshells occurred at R16 east of Long Island and mussel shells occurred at R13 west of Long Island.

Pure sands and coarser sediments, indicative of high kinetic energy bottoms tended to occur toward the Outer Harbor (Figure 3-1). Bedforms, also indicators of higher energy bottoms, were not observed at any of the stations. In 2000, as in 1999, biogenic mixing dominated surface sediments and was able to obliterate physical features such as bedforms. The broad range of sedimentary habitats within the Harbor was also reflected in the range of average station prism penetration, which ranged from 1.0 cm at Station R08 on Deer Island Flats to 21.6 cm at T04 in inner Dorchester Bay.

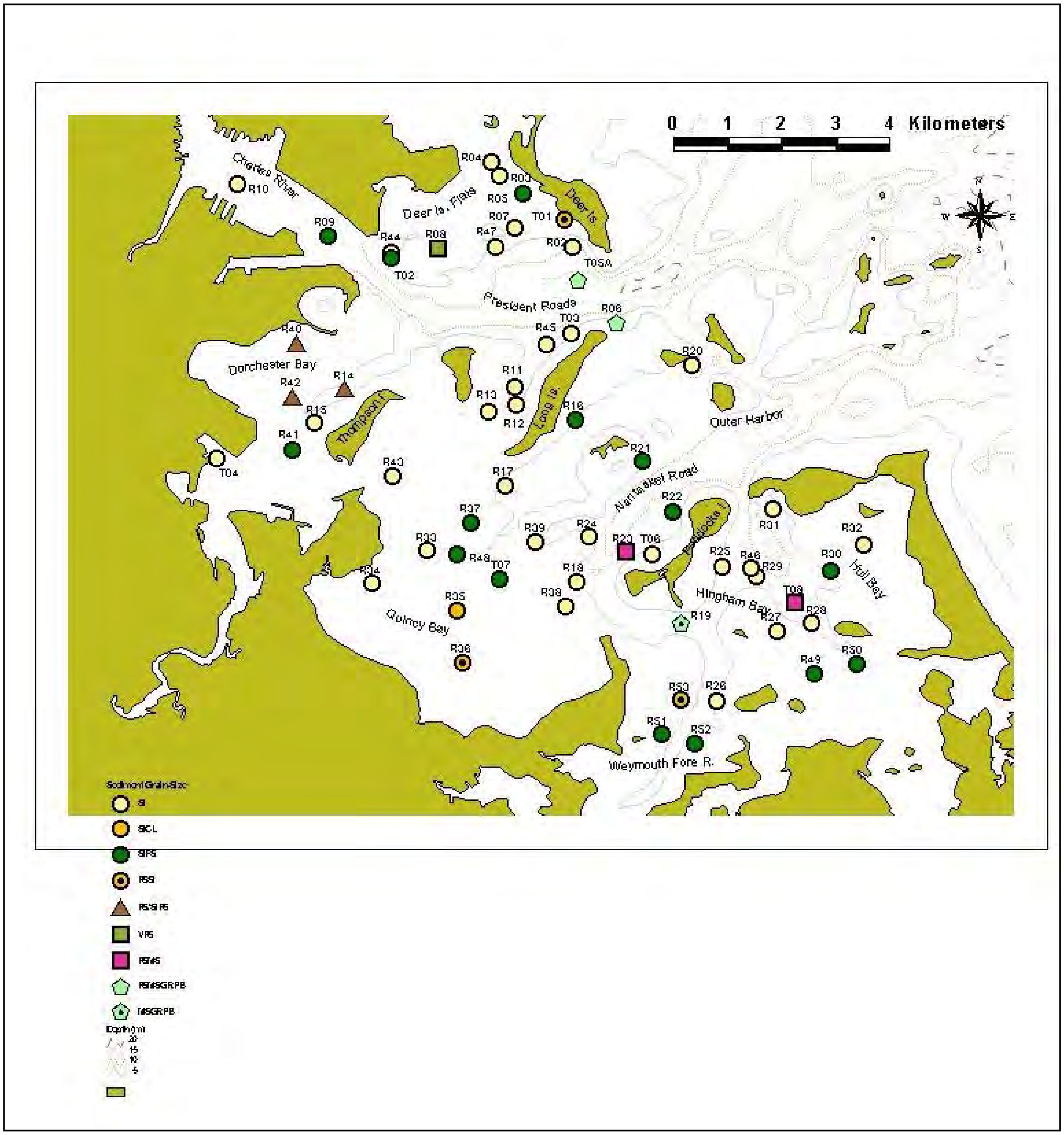


Figure 3-1. Spatial distribution of sediment types determined from sediment profile images, August 2000.

Table 3-1. Summary of sediment profile image data for Boston Harbor, August 2000. Data from all three replicates were averaged for quantitative parameters and summed for the qualitative parameters (for example, the presence of shell in one of the three replicates results in a + for the station).

Station	Mean Prism Penetration (cm)	Mean Surface Relief (cm)	Mean RPD (cm)	Modal Grain-Size	Dominant Process	Shell	Sediment Layering	Modal Amphipod Tubes	Modal Worm Tubes	Mean Infauna (#/image)	Mean Burrows (#/image)	Voids Oxic Mean (#/image)	Voids Anaerobic Mean (#/image)
R02	16.1	1.7	3.0	SI	BIOG	-	-	MAT	NONE	1.7	3.0	1.3	3.3
R03	12.6	0.6	1.4	SIFS	BIO&PHY	-	-	SOME	SOME	2.0	7.3	1.3	1.7
R04	15.6	1.3	0.8	SI	BIOG	-	-	NONE	SOME	1.0	6.7	0.0	2.3
R05	14.9	1.0	1.0	SI	BIOG	-	-	FEW	MANY	1.7	10.3	1.7	1.3
R06	2.2	1.7	1.3	FSMSGRPB	PHYS	-	-	NONE	MANY	0.0	0.0	0.0	0.0
R07	15.5	1.0	4.7	SI	BIOG	-	-	SOME	SOME	3.3	9.0	2.7	2.0
R08	1.0	0.9	>1.0	VFS	PHYS	+	-	NONE	NONE	0.0	0.0	0.0	0.0
R09	7.4	0.7	0.9	SIFS	BIOG	-	-	FEW	SOME	0.0	5.0	0.7	0.7
R10	19.5	1.3	1.8	SI	PHYS	-	-	NONE	FEW	0.7	3.0	0.3	3.7
R11	18.2	1.2	5.7	SI	BIOG	-	-	MAT	NONE	2.7	2.0	1.0	0.0
R12	19.8	1.5	6.1	SI	BIOG	-	-	MAT	NONE	3.7	2.3	1.7	2.7
R13	9.6	1.7	0.7	SI	BIO&PHY	Bed	-	NONE	SOME	0.0	0.0	0.3	0.0
R14	5.8	0.8	0.9	FSSI	BIO&PHY	+	-	NONE	SOME	0.7	6.7	0.7	0.0
R15	19.3	0.7	0.5	SI	PHYS	+	-	NONE	SOME	2.0	4.7	1.0	1.7
R16	5.9	2.9	2.2	SIFS	BIOG	Bed	+	SOME	SOME	0.0	0.0	0.0	0.0
R17	19.5	1.3	2.2	SI	BIOG	-	-	MAT	NONE	2.3	5.7	0.0	1.0
R18	17.5	1.2	1.8	SI	BIOG	-	-	MANY	FEW	1.3	4.7	2.0	1.3
R19	1.2	0.8	>1.2	FSMSGR	BIO&PHY	-	-	NONE	MANY	0.0	0.3	0.0	0.0
R20	14.5	1.6	3.2	SI	BIOG	-	-	MAT	FEW	1.7	7.3	0.7	1.3
R21	10.9	1.9	2.6	SIFS	BIOG	-	-	MAT	NONE	3.7	5.7	1.0	0.0
R22	12.7	1.9	1.6	SIFS	BIOG	-	-	MAT	SOME	1.0	3.7	0.7	0.0
R23	4.6	0.9	2.3	FSMS	BIO&PHY	-	-	MAT	SOME	1.0	2.3	0.3	0.0
R24	15.3	1.9	3.1	SI	BIOG	-	-	MAT	NONE	4.3	6.7	0.7	0.7
R25	20.4	0.5	0.9	SI	BIO&PHY	-	-	NONE	SOME	0.0	2.3	0.7	1.3

Table 3-1. Summary of sediment profile image data for Boston Harbor, August 2000. (con't)

Station	Voids Gas AVE (#/image)	Modal Successional Stage	Range Successional Stage	OSI	Comments
R02	1.0	II	II	7.0	
R03	0.0	I/II	I/II	4.0	
R04	0.0	I	I	2.7	
R05	0.0	I/II	I/II	3.7	
R06	0.0	I	I	3.3	
R07	0.0	II/III	II/III	9.3	
R08	0.0	I	I	>2.7	
R09	0.0	I/II	I - I/II	3.7	
R10	2.7	I	I - I/II	3.7	
R11	0.0	II	II - II/III	8.3	
R12	0.0	II	II - II/III	9.3	
R13	0.0	I	I	2.3	Mussel shell
R14	0.0	I/II	I - I/II	3.3	
R15	0.0	I/II	I/II	3.0	
R16	0.0	I/II	I/II	5.3	Clam shell over silty
R17	0.0	II	II	6.3	
R18	0.3	II	II	5.3	
R19	0.0	I	I	>3.0	
R20	0.0	II	II	7.7	
R21	0.0	II/III	II - III	8.0	
R22	0.0	II	II - II/III	6.0	
R23	0.0	I/II	I - II	5.3	
R24	0.0	II/III	II - II/III	8.0	
R25	0.0	I	I - I/II	3.3	

Table 3-1. Summary of sediment profile image data for Boston Harbor, August 2000. (con't)

Station	Mean Prism Penetration (cm)	Mean Surface Relief (cm)	Mean RPD (cm)	Modal Grain-Size	Dominant Process	Shell	Sediment Layering	Modal Amphipod Tubes	Modal Worm Tubes	Mean Infauna (#/image)	Mean Burrows (#/image)	Voids Oxic Mean (#/image)	Voids Anaerobic Mean (#/image)
R26	14.7	3.7	1.1	SI	BIO&PHY	-	-	NONE	SOME	0.3	1.7	0.0	0.7
R27	16.9	1.3	2.6	SI	BIOG	-	-	MAT	NONE	3.3	4.7	1.7	0.0
R28	16.2	1.4	2.6	SI	BIOG	-	-	MAT	NONE	5.0	4.3	1.3	0.0
R29	17.8	0.8	2.9	SI	BIOG	-	-	MAT	NONE	3.3	3.7	2.3	0.3
R30	10.4	1.3	1.6	SIFS	BIOG	-	-	MAT	NONE	2.0	3.3	0.7	0.0
R31	12.3	2.3	2.4	SI	BIOG	-	-	MAT	NONE	2.7	5.0	0.7	0.0
R32	14.8	0.7	0.7	SI	BIO&PHY	-	-	NONE	MANY	0.7	5.7	2.3	0.0
R33	15.4	1.3	0.6	SI	PHYS	-	-	NONE	FEW	0.3	4.0	0.7	1.0
R34	15.8	2.1	0.6	SI	BIO&PHY	-	-	NONE	FEW	0.0	8.0	0.0	1.0
R35	14.2	1.0	0.8	SICL	BIO&PHY	-	-	NONE	SOME	0.3	7.0	1.7	0.0
R36	2.8	1.0	2.0	FSSI	PHYS	+	-	NONE	NONE	0.0	0.3	0.0	0.0
R37	11.8	1.0	0.9	SIFS	BIOG	+	-	NONE	MANY	0.0	7.0	1.7	0.7
R38	18.1	0.8	1.7	SI	BIOG	-	-	MANY	SOME	2.3	6.0	0.3	0.7
R39	17.2	0.7	2.0	SI	BIOG	-	-	SOME	MANY	1.7	8.7	0.7	0.7
R40	10.2	0.9	1.5	VFS/SIFS	BIO&PHY	-	+	NONE	SOME	2.7	5.0	2.3	0.7
R41	10.8	0.8	1.0	SIFS	BIO&PHY	+	-	FEW	MANY	1.7	4.0	1.0	0.0
R42	9.8	1.5	2.0	VFS/SIFS	PHYS	+	+	NONE	SOME	0.3	2.3	0.3	0.0
R43	19.8	0.5	0.4	SI	PHYS	-	-	NONE	FEW	0.7	1.0	0.0	2.0
R44	16.2	1.2	1.3	SI	PHYS	-	-	NONE	SOME	0.7	1.7	0.0	3.3
R45	17.4	1.9	3.9	SI	BIOG	-	-	MAT	NONE	2.0	4.3	0.7	1.0
R46	19.3	1.0	2.6	SI	BIOG	-	-	MAT	NONE	1.0	3.7	2.0	0.3
R47	14.3	1.7	4.6	SI	BIOG	-	-	MAT	NONE	3.7	6.0	3.3	1.0
R48	12.4	2.1	1.1	SIFS	BIO&PHY	+	+	NONE	MANY	1.0	4.0	1.3	0.3
R49	12.7	2.1	0.4	SIFS	BIO&PHY	+	-	NONE	MANY	0.3	2.3	1.7	0.7
R50	11.7	1.2	1.4	SIFS	BIO&PHY	-	-	MAT	MANY	2.7	9.3	1.0	0.0
R51	10.7	0.8	0.7	SIFS	PHYS	-	-	NONE	MANY	0.3	4.7	0.3	0.0

Table 3-1. Summary of sediment profile image data for Boston Harbor, August 2000. (con't)

Station	Voids Gas AVE (#/image)	Modal Successional Stage	Range Successional Stage	OSI	Comments
R26	0.0	I	I - II	3.3	
R27	0.0	II	II	6.7	
R28	0.0	II/III	II - II/III	7.3	
R29	0.0	II	II	7.3	
R30	0.0	II	II	5.7	
R31	0.0	II	II	6.7	
R32	0.0	II	I/II - II	4.0	
R33	0.0	I	I - I/II	3.0	
R34	0.0	I	I	2.3	
R35	0.0	I/II	I - I/II	3.0	
R36	0.0	I/II	I - I/II	4.3	
R37	0.0	I/II	I - I/II	3.7	
R38	0.0	I/II	I/II	4.7	
R39	0.0	I/II	I/II - II	5.3	
R40	0.0	II	I/II - II	4.7	Sand over silty sand
R41	0.0	I/II	I - I/II	3.3	
R42	0.0	II	I - II	5.0	Sand over silty sand
R43	0.0	I	I	2.0	
R44	0.0	I	I	3.0	
R45	0.0	II	II	8.3	
R46	0.0	II/III	II - II/III	7.7	
R47	0.0	II/III	II/III	10.0	
R48	0.0	I/II	I/II	4.0	Shelly laryer over silty
R49	0.0	I	I - I/II	2.3	
R50	0.0	II	I/II - II	5.0	
R51	0.0	I	I - I/II	2.3	

Table 3-1. Summary of sediment profile image data for Boston Harbor, August 2000. (con't)

Station	Mean Prism Penetration (cm)	Mean Surface Relief (cm)	Mean RPD (cm)	Modal Grain-Size	Dominant Process	Shell	Sediment Layering	Modal Amphipod Tubes	Modal Worm Tubes	Mean Infauna (#/image)	Mean Burrows (#/image)	Voids Oxic AVE (#/image)	Voids Anaerobic AVE (#/image)
R52	8.7	1.8	0.9	SIFS	PHYS	+	-	NONE	SOME	0.3	5.7	0.7	0.3
R53	8.4	0.9	0.9	FSSI	BIO&PHY	+	-	MANY	MANY	0.0	2.7	0.0	0.0
T01	4.9	0.8	1.3	FSSI	PHYS	+	-	NONE	MANY	0.0	2.3	0.3	0.0
T02	9.4	1.2	1.0	SIFS	BIOG	+	-	MANY	SOME	0.3	9.0	0.3	1.7
T03	19.3	1.4	4.9	SI	BIOG	-	-	MAT	NONE	4.0	5.7	0.7	0.7
T04	21.6	0.5	0.6	SI	PHYS	-	-	NONE	NONE	0.0	0.7	0.0	0.7
T05A	2.9	1.6	1.4	FSMSGRPB	PHYS	-	-	NONE	SOME	0.0	0.0	0.0	0.0
T06	12.0	1.6	2.1	SI	BIOG	-	-	MAT	NONE	2.7	3.7	0.3	0.0
T07	17.2	1.1	1.2	SIFS	BIO&PHY	+	+	NONE	MANY	0.3	3.7	0.3	3.0
T08	4.4	0.6	2.5	FSMS	BIO&PHY	+	-	NONE	MANY	0.0	0.0	0.0	0.0

Station	Voids Gas AVE (#/image)	Modal Successional Stage	Range Successional Stage	OSI	Comments
R52	0.0	I	I - I/II	3.0	
R53	0.0	I/II	I/II	0.7	
T01	0.0	I	I - I/II	3.7	
T02	1.0	I/II	I - II	3.0	
T03	0.0	II	II	9.0	
T04	0.3	I	I	1.3	
T05A	0.0	I	I	3.0	
T06	0.0	II	II	6.3	
T07	0.0	I/II	I - I/II	3.7	Shelly layer over silty
T08	0.0	I	I	4.7	

Table 3-1. Summary of sediment profile image data for Boston Harbor, August 2000. (con't)

Legend Key:

Grain-Size:

/ = Layering	PB = Pebble
FS = Fine-sand	SICL = Silty-clay
GR = Gravel	SIFS = Silty-fine-sand
FSSI = Fine-sandy-silt	SI = Silt
MS = Medium-sand	VFS = Very-fine-sand

Shell, Sediment Layering:

- = Not present
+ = Some Shell present
BED = Shell Bed

Dominant Process:

BIOLG = Biological processes dominate surface sedimentary features
BIO/PHY = Both biological and physical processes shape surface features
PHYS = Physical processes dominate surface sedimentary features

Ampelisca, Infauna:

NONE = 0
FEW = 1-6
SOME = 7-18
MANY = >18
MAT = Density high enough to completely cover the surface

Successional Stage

I = Pioneering sere
II = Intermediate sere
III = Equilibrium sere

OSI = Organism Sediment Index of Rhoads and Germano (1986)

Overall, prism penetration was lowest (2.7±0.6 cm) in coarser sediments that were sand, gravel, or pebble and highest (14.0±0.6 cm) (mean±SE) in silty sediments. The bed roughness or surface relief in areas that appeared to be dominated by physical or biological processes were about the same magnitude (Table 3-1), with a range of 0.4 to 4.6 cm. Surface relief averaged 1.1±0.1 cm at physically-dominated stations and 1.4±0.1 cm at biologically-dominated stations. In physically-dominated habitats with coarse sediments, surface relief was due to sediment grain size (gravel, pebble, or cobble) and, in silty sediments, was related to irregularities in the surface. In biologically-dominated habitats, surface relief was typically biogenic structures produced by benthic organisms. *Ampelisca* spp. tube mats were the primary relief-creating biogenic features, followed by what appeared to be feeding pits or mounds.

3.2.1.2 Apparent Color RPD Layer Depth

The grand average depth of the apparent color redox potential discontinuity (RPD) layer for 2000 was 1.8±1.3 (±SD), with a range from 0.4 to 6.1 cm (Table 3-1, Figure 3-2). Stations with shallower RPD layer depths tended to be closest to the shore along the mainland and furthest from the mouth of the Harbor. For the most part, the shallowest RPD values (<0.8 cm) were associated with what appeared to be organically-enriched dark-gray silty sediments without much indication of bioturbation, for example Stations R15 and T04 in Dorchester Bay. Surface sediments at these shallower RPD layer stations were dominated by physical processes or a combination of physical and biological processes. Benthic community structure at Station T04 consistently showed the signs of being the most stressed of all harbor stations (see Section 5). Organic content of sediment at T04 was also highest of all stations (see Section 4). The organic loading and periodic low dissolved oxygen that likely eliminated deep bioturbating fauna contributed to the shallow RPD layer depth at T04. Stations with deeper RPD values (>3.0 cm) also consisted of silty sediments but tended to be close to the mouth of the Harbor and away from the mainland. Surface sediments at these deeper RPD layer stations were dominated by biological processes and characterized by a high degree of bioturbation. For example, Stations R11 and R12 west of Long Island, with dense *Ampelisca* spp. tube mats and a well-developed infaunal community, had the deepest RPD layer depths.

The deepest RPD layer depths were associated with biogenic activity of the infauna. *Ampelisca* spp. were the primary bioturbating species. Their tube mats in silty fine sand and silty sediments occurred in at least one replicate image at 25 stations (42%) and at two or more replicates at 20 stations (30%) across a broad band from the outer harbor to the western ends of Deer Island Flats, Long Island, Peddocks Island and Hull Bay (Figure 3-3). Where *Ampelisca* spp. tube mats occurred, mean RPD depths were deeper (3.1±0.3 cm) (mean±SE) than at stations without mats (1.2±0.1cm). This indicates the importance of this amphipod in the irrigation of surface sediments and advancing community succession. For the same fine sediment types where mats were not present, RPD layer depths were about 1.0±0.1 cm (Table 3-1).

Biogenic activity in the form of infaunal burrows convoluted and extended the depth of the RPD layer at most stations, with *Ampelisca* spp. mats extending well below the depth of the average RPD layer. The maximum extent of oxic sediments exceeded 6 cm at 17 stations. The deepest penetration of apparent oxic sediments was 11.6 cm at Station R11 west of Long Island. These deep oxic sediments were evidence of a large, deep-burrowing infaunal assemblage and were present at 28% of the stations. For example, four or five large (>1 cm diameter) terribellid-like worms were present in replicate 1 of Station R24.

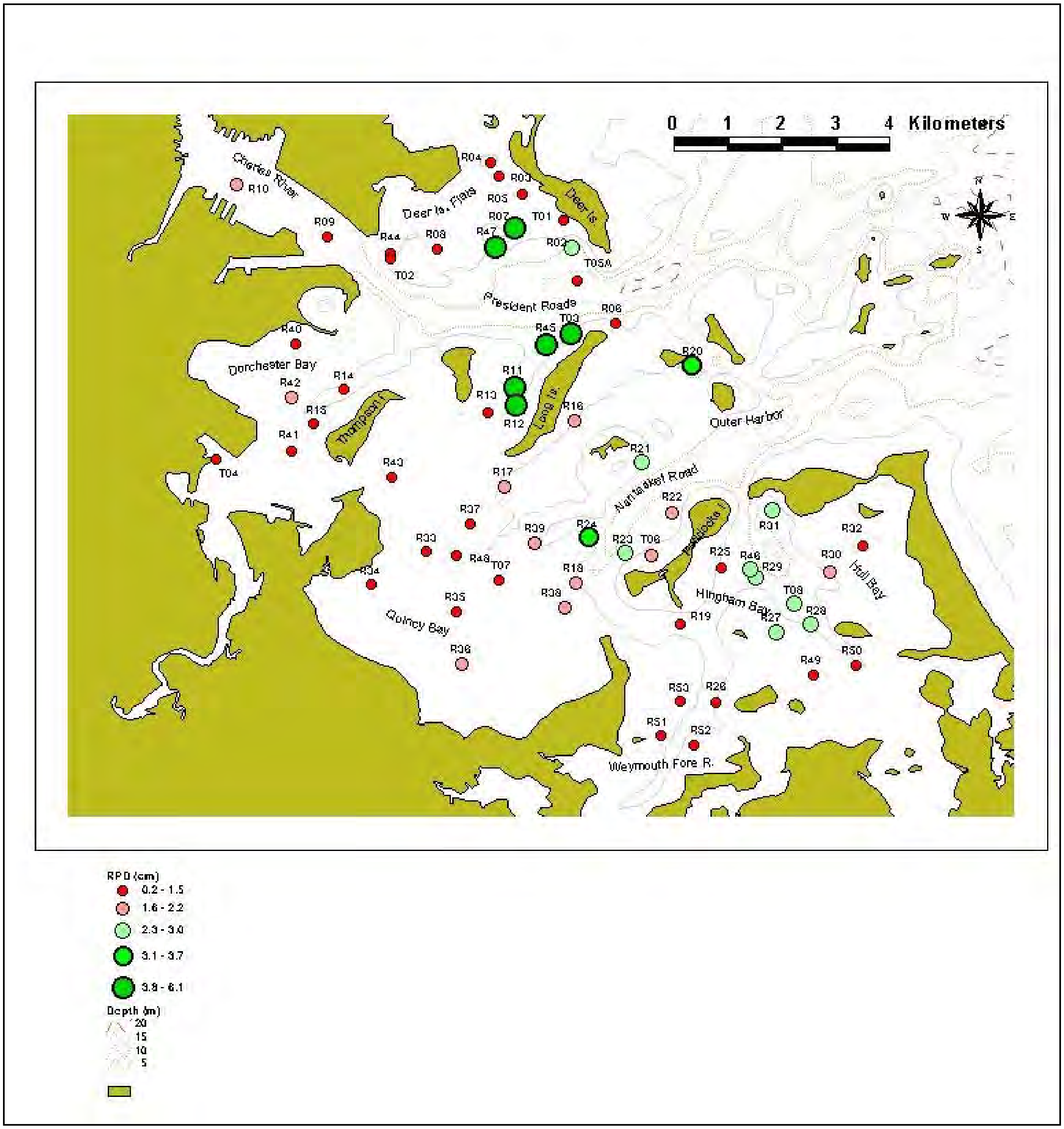


Figure 3-2. Spatial distribution of the apparent color RPD layer depth (cm) determined from sediment profile images, August 2000.

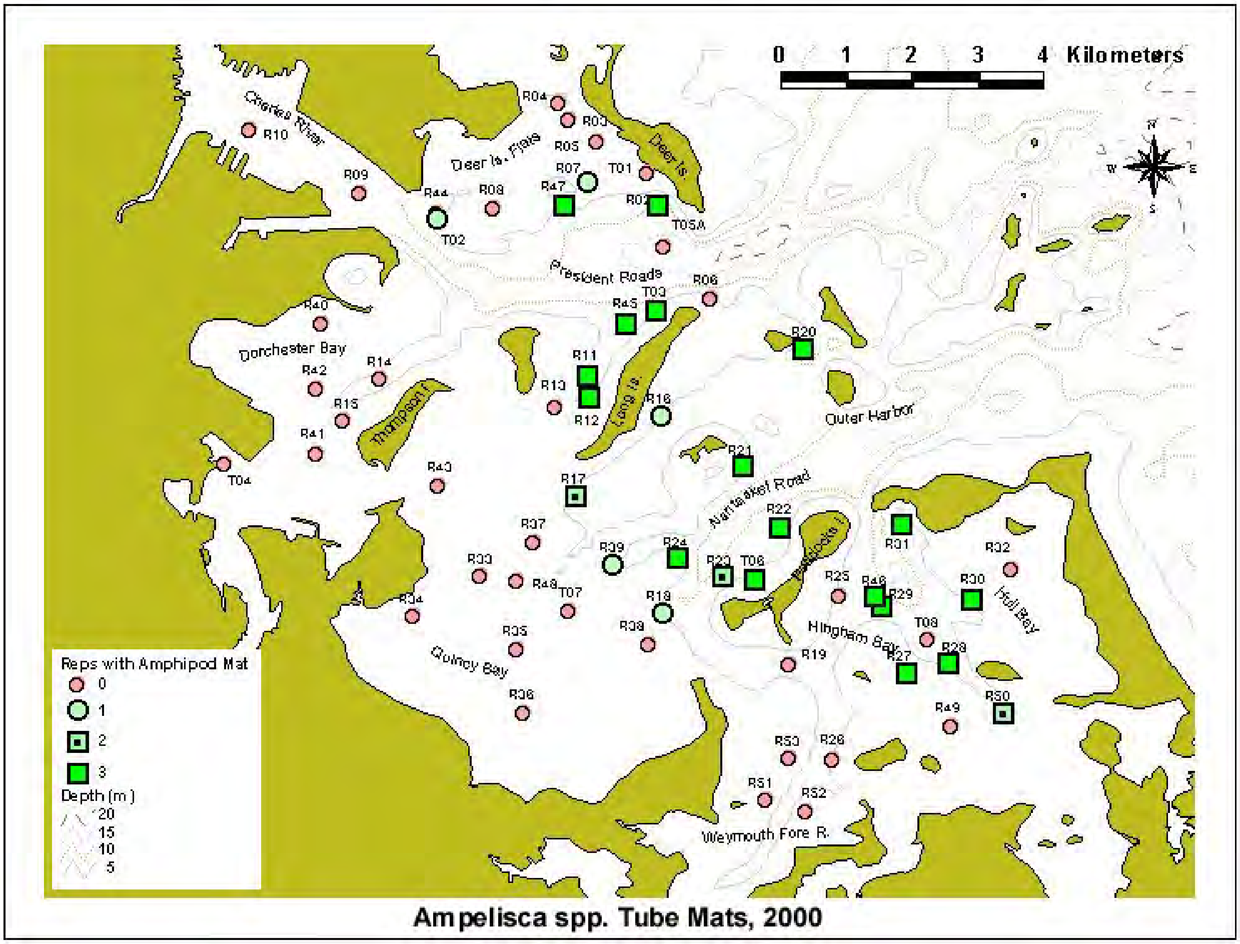


Figure 3-3. Spatial distribution of *Ampelisca* spp. mats determined from sediment profile images, August 2000.

It appeared that the *Ampelisca* spp. population in the harbor continued to decline in 2000, with a third of stations having a modal classification of tube mat (Table 3-1). This is lower than the high of about 60% recorded from 1995 to 1997 and about 40% in 1998 and 1999 (Figure 3-3). Over the last three years the number of stations with tube mats declined and the number of stations with poor quality tubes increased. In 1998, *Ampelisca* spp. tube mats were composed of long (>1 cm) tubes and appeared “fresher”. In 1999, about a quarter of the tube mats appeared to be in senescence with the average size of the tubes about 0.5 cm. Many of the mats appeared to be deteriorating. In 2000, only a tenth of the mats appeared senescent, Stations R50 and T02, but the number of stations with mats declined for the third consecutive year. The size of *Ampelisca* spp. tubes was 0.4 cm at stations where only one or two of the three replicate images had amphipods at mat densities. The tubes were 1.1 cm long at stations with mat in all three replicate images.

3.2.1.3 Biogenic Activity

The sediment surface at 47% (28 of 60) of the stations was dominated by biological processes as evidenced by the widespread biogenic activity associated with successional Stage II fauna (Table 3-1). Evidence that a combination of biological and physical processes was active in structuring bed roughness occurred at 30% (18) of the stations. Physical processes dominated at 23% (14) of the stations. Two of these were the coarse sediment stations (R06 and T05A), but the rest were finer sediment stations with little indication of biological activity.

The distribution of subsurface biogenic features (burrow structures, infaunal organisms, water- and gas-filled voids) was sediment related and tended to mirror patterns seen for surface biogenic features. Burrows were seen at 90% of all stations with a grand average of 4.1±2.7 burrows/image (±SD). Infauna occurred at about 75% of all stations (1.4±1.4 infaunal/image) and were more abundant in finer sediments than in coarser sediments. Gas-filled voids, indicative of high rates of organic loading to the sediments, occurred at five stations (T02, T04, R02, R10, R18). Water-filled voids, oxic (75% of stations) and anaerobic (57%), occurred at about 87% of all stations with a pattern similar to burrows and infauna (Table 3-1). Water-filled voids and burrows are biogenic structures indicative of infaunal activity. Water -filled voids were about equally divided between oxic voids (52%; apparently filled with oxidized sediment indicating current or recent infaunal activity) and anaerobic voids (48%; apparently relic voids from previous infaunal activity or created by some physical processes such as sediment cracking during profiling of the sediment).

Subsurface biogenic structures and activities were highest at stations where biological processes dominated surface features. For example, the number of infaunal organisms per image (2.7±0.3 infauna/image, mean±SE) was highest at stations with *Ampelisca* spp. tube mats verses non-mat stations (0.7±0.1 infaunal/image). The highest number of infauna was seen at Station R28 in Hingham Bay where the average was 5 infauna/image. Similar patterns of higher mean and median values at biologically-dominated stations were observed for number of burrows, oxic voids and anaerobic voids per image, and also the Organism Sediment Index.

3.2.1.4 Successional Stage and Organism Sediment Index

The apparent modal successional stage indicated that the infaunal communities in the harbor area were about evenly divided between pioneering (19 stations, Stage I) and intermediate (18 stations, Stage II) serial Stages (Table 3-1). The high degree of biogenic sediment reworking observed in many images was consistent with Stage II communities, with indications of the equilibrium seral stage (Stage III) observed at six stations. Station T04, inner Dorchester Bay, with the poorest community structure of all stations, had a Stage I designation. Evidence of Stage I communities occurred at 60% of the stations, the same as in 1999, with evidence of Stage II communities occurring at 68% of the stations, about the same as 1999.

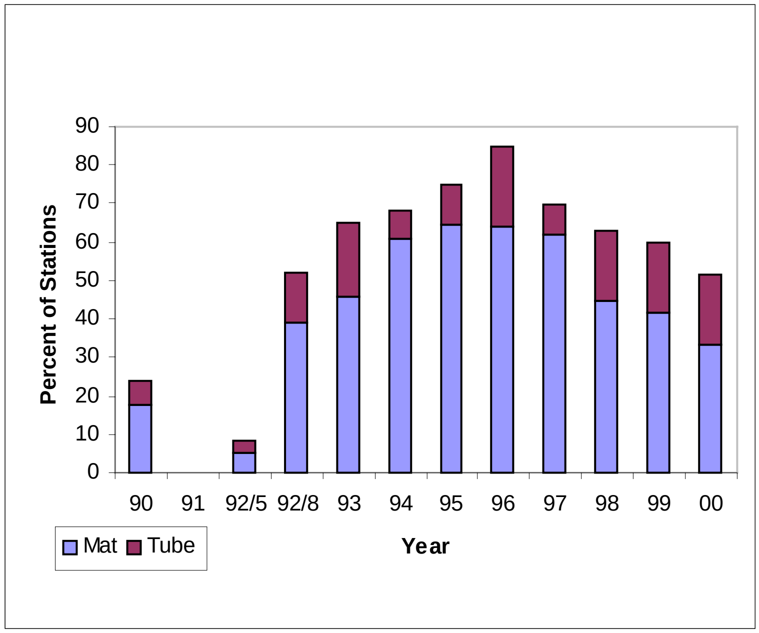


Figure 3-4. Percentage of benthic monitoring stations within Boston Harbor with *Ampelisca* spp. tubes (open bars) and mats (solid bars) from 1990 to 2000. Based in part on Blake *et al*. (1998) and Kropp *et al*. (2000).

The range of the Organism Sediment Index (OSI) values at harbor stations indicated the wide range of conditions effecting infaunal community development. OSI ranged from 0.7 to 10.0, with the lowest values occurring at fine-sediment stations that had little evidence of infaunal activity, for example T04 (Table 3-1). The highest OSI values were also at fine-sediment stations, but at those that had high levels of infaunal activity. Most harbor stations (70%) had OSI values <6, which indicated communities that were under some form of moderate stress, possibly related to organic loading or physical disturbance of the benthic habitat (Rhoads and Germano 1986). Most of these lower OSI stations were located in the inner bays and away from the harbor mouth. Higher OSI stations occurred in a broad band that arced through the mid harbor running from Deer Island to Hull Bay, basically following the distribution of *Ampelisca* spp. tube mats (Figure 3-3). The source of stress to the benthos at both types of harbor stations, Traditional (T) and Reconnaissance (R), is most likely a combination of physical processes such as hydrodynamics and sediment transport at coarse sediment stations (for example R06) and high rates of sediment accumulation and organic enrichment at muddy stations (for example T04).

3.2.2 2000 Harbor Summary

Overall, the harbor SPI data for 2000 continued the 1999 observation of the predominance of biological processes in structuring surface sediments. Physical features such as bedforms were absent, while macrobenthic tubes and other biogenic structures occurred at almost all stations. For example, Stations R04, R06, R08, R36, and T04 lacked surface biogenic structures. While the distribution of sediment textures in the Harbor was related primarily to a combination of sources (geomorphology and hydrodynamics), surface features continued to be dominated by biogenic activity. *Ampelisca* spp. tube mats, feeding pits and mounds, and worm tubes were the dominant surface biogenic structures. The sediment surface at 47% of the stations appeared to be dominated by biogenic structures such as tubes, feeding pits, and mounds. Physical processes, as indicated by coarse-grained sediment or soft, deep-penetration sediments, appeared to structure the sediment surface at 23% of the stations. The remaining 30% of the stations were intermediate, showing signs of physical and biological processes.

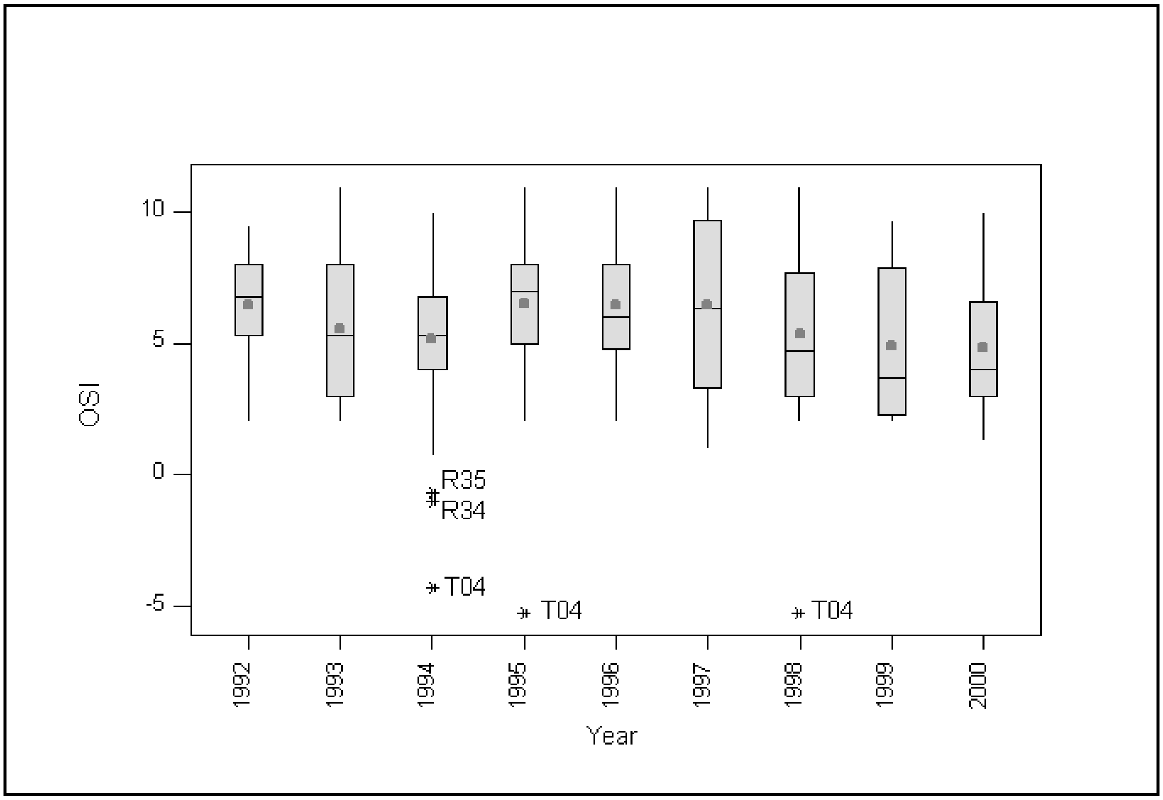
The aereal distribution of *Ampelisca* tube mats at the 60 long-term stations continued to decline. From 1999 to 2000, seven stations lost tube mats and two stations gained mats. At 18 stations mats were present both years. The size of the *Ampelisca* tubes at stations with only one or two image replicates having tube mats in 2000 was about the same as in 1999. However, at stations where all three replicates had mats, the tubes were about twice as long and about equal to the average tube size for 1998. This may indicate that the solid patches of tubes seen in previous years are disintegrating.

The predominance of biological activity at most stations, particularly those near the mouth of the Harbor and in a broad arcing band running along the mid-Harbor from Deer Island to Hull Bay, indicated a well-developed fauna generally characterized as intermediate in succesional stage. The occurrence of epifaunal organisms, also indicative of good benthic habitat conditions, was about the same in 1999 as in 2000, but the prevalence of larger infauna appeared to be greater in 2000 than in 1999. The organism sediment index reflected this pattern, with values >6 occurring toward the Harbor mouth and values <6 in the inner areas of the Harbor. *Ampelisca* spp. tube mats continued to be wide spread and indicated macrobenthic community successional transition (Stage II) from the pioneering-dominated (Stage I) inner harbor area to the equilibrium-dominated (Stage III) Nearfield area, but their aereal distribution has contracted from the high values observed from 1995 to 1997 (Figure 3-4). This might indicate the general senescence and decline in *Ampelisca* spp. populations, an event consistent with the advancing succession of benthic communities (Don Rhoads, personal communication). However, the overall indication of Stage III fauna declined from 1998 to 1999 and 1999 to 2000. For example, the stick building amphipod *Dyopedos* spp. was not seen in 2000, completing the declining trend from a high occurrence in 1998.

Station T04 continued to have poor benthic habitat quality, but appeared to be oxic with a few gas-filled voids and an apparent color RPD layer of about 0.6 cm. On average the OSI at T04 was about the same from 1999 to 2000, 2.0 to 1.3 respectively. Overall, the grand average OSI between 1999 and 2000 for all station was the same, about 4.8 and 4.9 respectively.

3.2.3 Long-term Benthic Habitat Conditions: 1992 to 2000

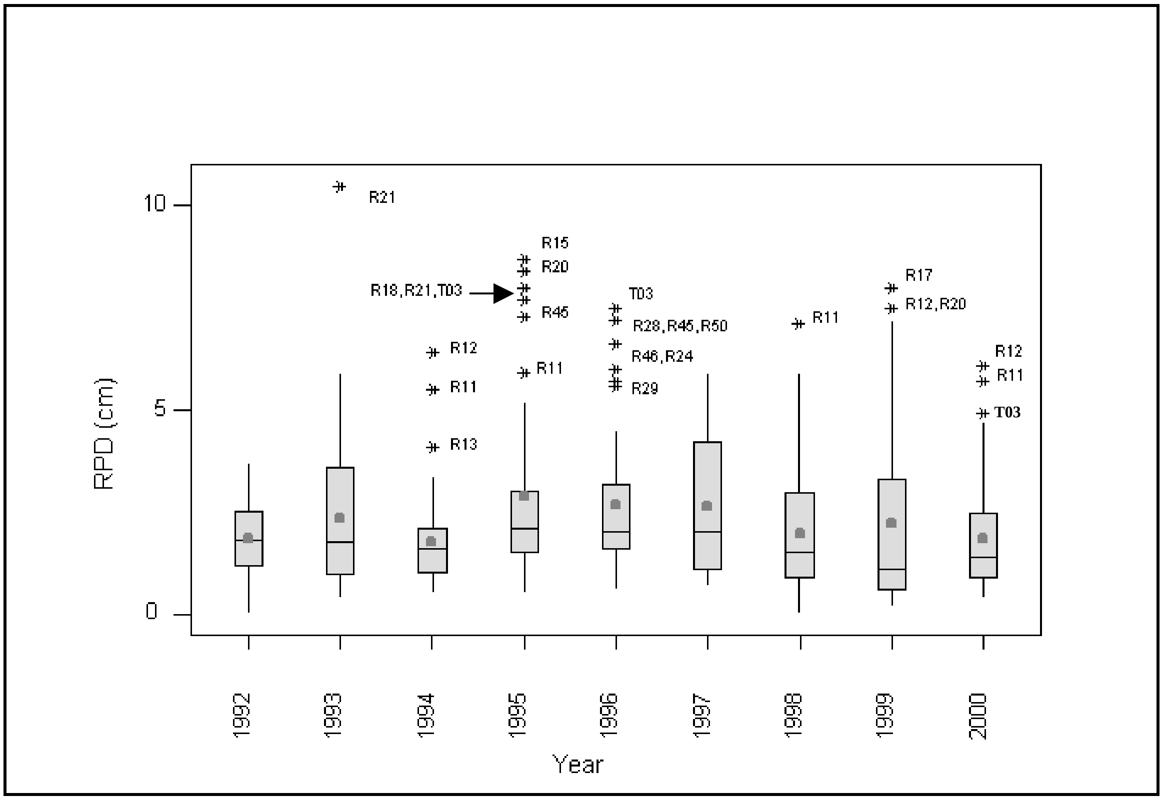
Some sediment profile image (SPI) data on benthic habitat conditions were collected in 1990–1992 (SAIC 1992, Blake *et al*. 1993), prior to the establishment of the current monitoring strategy in 1993, (Summer sampling at R and T stations, Figure 3-1). SPI images provide an *in-situ* cross-section of surface sediments that can be evaluated for the physical and biological processes that are structuring benthic habitats. The two basic measures of benthic habitat quality, the Organism Sediment Index (OSI) of Rhoads and Germano (1986) and the depth of the apparent color RPD layer, showed slight oscillations around their grand means from 1990/92 to 2000 (Figures 3-5 and 3-6). The OSI averaged 5.7±2.7 for all years, which was slightly below the threshold of 6.0 that is indicative of some form of stress acting upon the benthos (Rhoads and Germano 1986). OSI values ranged from –5.3 to 11.0. The former reflecting very poor habitat quality associated with Station T04 that appeared to be in an area of high sedimentation and organic loading at times effected by low dissolved oxygen, and the latter indicating very good habitat quality associated with many stations that had well-developed infaunal communities. For a given year, the mean or median OSI for summer sampling was as high as about 7 and as low as about 4. In 1997, about a third of the stations were sampled in the autumn, because of technical problems during the summer, which indicated that there was substantial seasonal variation in both the OSI and RPD. Autumn averages were 4.3±0.3 and 1.6±0.1 cm (mean±SE, n=19) for OSI and RPD respectively. A similar pattern was observed for the depth of the apparent color RPD layer, which averaged 2.2±0.1 for all years. The range in RPD depth values went from 0.0 to 10.5 cm. The former indicating that hypoxic or anoxic conditions had recently affected the bottom (Stations R10 in 1992 and T04 in 1998), the latter reflecting very good habitat quality associated with *Ampelisca* spp. tube mats (Station R21 in 1993). For a given year, the mean or median RPD layer depth oscillated from about 1 to 3 cm.



Organism Sediment Index

	90/2	93	94	95	96	97	98	99	00
Median	6.8	5.3	5.3	7.0	6.0	6.3	4.7	3.7	4.0
Mean	6.4	5.6	5.2	6.5	6.4	6.4	5.3	4.9	4.9
SE	0.2	0.4	0.4	0.4	0.3	0.4	0.4	0.3	0.3
N	61	46	46	59	56	45	60	61	60

Figure 3-5. Boxplots of long-term trends in the Organism Sediment Index, an index of benthic habitat quality, for harbor stations. Box is interquartile range (IR), bar is median, dot is mean, vertical lines are range, asterisks are outliers (>2IR).



RPD Layer Depth (cm)

	90/2	93	94	95	96	97	98	99	00
Median	1.8	1.7	1.6	2.1	2.0	2.0	1.5	1.1	1.4
Mean	1.8	2.4	1.8	2.9	2.7	2.7	2.0	2.2	1.8
SE	0.1	0.3	0.2	0.3	0.2	0.2	0.2	0.3	0.2
N	66	46	49	59	58	45	61	61	60

Figure 3-6. Boxplots of long-term trends in the apparent color RPD layer depth (cm), a measure of the thickness of oxidized sediments, for harbor stations. Box is interquartile range (IR), bar is median, dot is mean, vertical lines are range, asterisks are outliers (>2IR).

Variation in the yearly average OSI and RPD was associated with the apparent successional stage of the infauna, with much of the benthic habitat quality determined by the spatial distribution of Stage I and Stage II seres (Blake *et al* 1998). The long-term predominance of pioneering successional Stage I seres at most inner harbor stations tended to reduce yearly averages in OSI and RPD, whereas the predominance of intermediate Stage II to equilibrium Stage III seres at most outer harbor stations tended to increase these parameters. As one successional stage or the other increases, the overall estimate of benthic habitat quality varies.

The tube-building amphipods in the genus *Ampelisca* were key to following temporal change in benthic habitat quality. The presence of *Ampelisca* spp. is associated with the intermediate successional stage (Stage II) and key to improving benthic habitat quality. Data from grab samples indicated that *Ampelisca* spp. tube mats were not broadly distributed in Boston Harbor prior to 1993. In 1992 there was about a doubling of stations with *Ampelisca* spp. tube mats from <20% to about 40% (Figure 3-4). From 1993 to 1995 the spatial distribution of tube mats increased to >60% of stations. Populations of *Ampelisca* spp. appeared stable until 1998 when the distribution of tube mats started to contract. In 2000, tube mats occurred at only 33% of stations. This decline in the intermediate successional stage seres may represent a decline of the *Ampelisca* spp. populations that had increased in response to abatement of sewage sludge discharge on Long Island in late 1991.

Overall, general benthic habitat quality within the study area was similar from August 1992 to 2000 with minor variation from year to year (Blake *et al*. 1998, Kropp *et al*. 2000, 2001, and this report). Using the OSI as a surrogate for habitat quality, none of the stations exhibited monotonic long-term trends, either improving or declining (Table 3-2). However, there were six stations that consistently had OSI values ≥6, the break point for stressed/not stressed habitat conditions (Rhoads and Germano 1986), and six stations with consistently <6 OSI values (Figure 3-7). Station T04 located in inner Dorchester Bay consistently had low OSI values with three years of negative values, indicative of a highly stressed habitat. Stations R11, R12, R45, and T03 along the western side of Long Island had consistently good habitat quality, and had the highest overall averages. Station T03 was located <1.4 km from the Deer Island treatment plant combined sludge and effluent discharge and had the fourth highest long-term average OSI index of all monitoring stations (Table 3-2).

Table 3-2. Long-term data for the organism sediment index from 1992 to 2000.

	1992	1993	1994	1995	1996	1997	1998	1999	2000	Mean
R12		6.7	10.0	10.3	8.0	10.0	11.0	9.0	9.3	9.3
R11		8.7	9.0	11.0	8.3	9.7	9.7	9.0	8.3	9.2
R45	9.0			9.7	9.7	9.7	7.7	7.7	8.3	8.8
T03	8.3	11.0	5.5	9.7	9.7	10.3	5.7	8.3	9.0	8.6
R47	4.7			8.7	7.0	10.3	9.3	9.0	10.0	8.4
R21		9.0	8.0	9.0	7.3	10.0	9.3	5.7	8.0	8.3
R28	9.0	6.3	10.0	6.7	9.7	7.3	9.7	8.3	7.3	8.3
R24	8.0	9.0	5.0	9.0	9.7		7.3	9.7	8.0	8.2
R18		9.0	5.7	8.3	7.7	9.7	10.7	9.0	5.3	8.2
R46				8.0	10.3	7.7	9.0	6.3	7.7	8.2
R29	7.3	8.0	8.7	8.0	10.3	6.7	10.0	7.0	7.3	8.1
R31	5.3	10.3	8.0	7.3	8.7	9.0	9.0	8.7	6.7	8.1
R20		9.3	5.5	11.0	7.3	10.3	4.0	9.0	7.7	8.0
R07		2.7	6.0	7.3	8.3	10.7	6.7	9.3	9.3	7.5
R27	9.0	4.3	7.0	6.3	8.0	6.0	10.3	6.3	6.7	7.1
R25	7.3	7.7	4.3	5.3	9.0	8.7	10.0	8.0	3.3	7.1
R38	7.7	5.3	4.7	8.7	6.3	9.7	6.7	9.0	4.7	7.0
T06	6.7	9.3	5.0	6.3	5.7	7.7	7.7	7.7	6.3	6.9
R22		9.0	5.7	7.3	4.3	10.3	7.7	4.5	6.0	6.9
R39	8.3	6.7	8.7	7.0	6.3	6.3	9.0	3.7	5.3	6.8
R50	8.0			7.3	11.0	5.7	7.7	2.7	5.0	6.8

Table 3-2. Long-term data for the organism sediment index from 1992 to 2000. (con't)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	Mean
R30	8.0	5.7	7.3	6.3	6.7	5.7	8.3	6.3	5.7	6.7
R23		9.0	6.7	6.0	8.0		3.0		5.3	6.3
R16		8.0	2.5	6.3	9.0	8.0	4.0	5.7	5.3	6.1
R03		3.7	6.7	7.7	8.0	8.3	6.7	3.3	4.0	6.1
R17	6.0	4.3	5.3	8.0	3.0	4.7	4.3	8.7	6.3	5.6
R02	6.7	3.0	5.7	2.0	4.7	9.3	5.7	5.7	7.0	5.5
R14	5.7	5.3	4.7	7.0	5.0	11.0	5.3	2.3	3.3	5.5
R09		5.3	5.0	2.7	7.3	6.3	4.7	8.0	3.7	5.4
R40	6.0	3.5	4.0	10.7	8.0		2.7	3.3	4.7	5.4
T08	7.0	7.0	4.5	8.0			3.7	2.7	4.7	5.4
R05	7.7	4.0	6.0	7.0	5.7		5.7	3.0	3.7	5.3
R26	7.7	5.0	9.3	4.3	5.7		3.0	3.3	3.3	5.2
R41	6.3	2.3	5.3	11.0	6.0	5.0	4.7	2.3	3.3	5.1
R13	6.8	5.3	10.0	6.7	5.0		2.7	2.0	2.3	5.1
R15	8.7	3.0	2.3	11.0	5.0		3.0	2.0	3.0	4.8
R08					8.0	4.5	3.5	3.7	2.7	4.5
R32	6.0	4.0	6.3	5.0	5.3	2.7	3.7	3.0	4.0	4.4
T05A				6.7	4.3	5.5	4.3	2.3	3.0	4.4
R19	7.0	5.7	4.0	4.0	6.0		3.0	2.0	3.0	4.3
T02	3.0		5.7	6.7	5.0	4.3	3.7	3.0	3.0	4.3
R42	5.0	4.7		6.0	3.0		3.7	2.3	5.0	4.2
R44				7.0	3.3	2.7	5.7	3.3	3.0	4.2
R48				5.0	5.7		3.0	2.3	4.0	4.0
R37	5.7	2.7	4.3	7.0	3.0	3.3	4.0	2.3	3.7	4.0
R04		2.7	4.3	7.0	5.0	3.0	4.7	2.3	2.7	4.0
T01	3.0	5.3	4.0	5.0	4.3	4.0	3.7	2.3	3.7	3.9
R52	8.0			2.0	4.0		3.5	3.0	3.0	3.9
R51	7.0			2.7	4.7		3.0	3.3	2.3	3.8
R10		2.0	3.0	3.3	4.0	5.0	5.3	4.3	3.7	3.8
R06		6.0	4.0	3.3				2.3	3.3	3.8
R53	6.0			3.0	5.3		2.5	2.0	3.7	3.7
T07	2.0	2.7	3.7	7.5	4.3	3.0	2.7	4.0	3.7	3.7
R34	7.0	3.0	-1.0	6.7	5.7	3.3	2.3	2.7	2.3	3.6
R35	7.4	2.7	-0.7	5.0	5.0	2.7	2.7	3.7	3.0	3.5
R33	5.3	2.7	0.7	7.0	4.0	2.7	2.3	3.0	3.0	3.4
R49	3.5			3.0	7.7	1.0	3.0	3.3	2.3	3.4
R36				3.7		2.3	3.0	2.0	4.3	3.1
R43	3.3	2.3	2.5	4.7	2.0	2.7	2.0	2.0	2.0	2.6
T04	2.6	2.0	-4.3	-5.3		2.0	-5.3	2.0	1.3	-0.6

	Very Good	Good	Stressed	Very Stressed
OSI =	≥8	<8 - ≥6	<6 - ≥3	<3

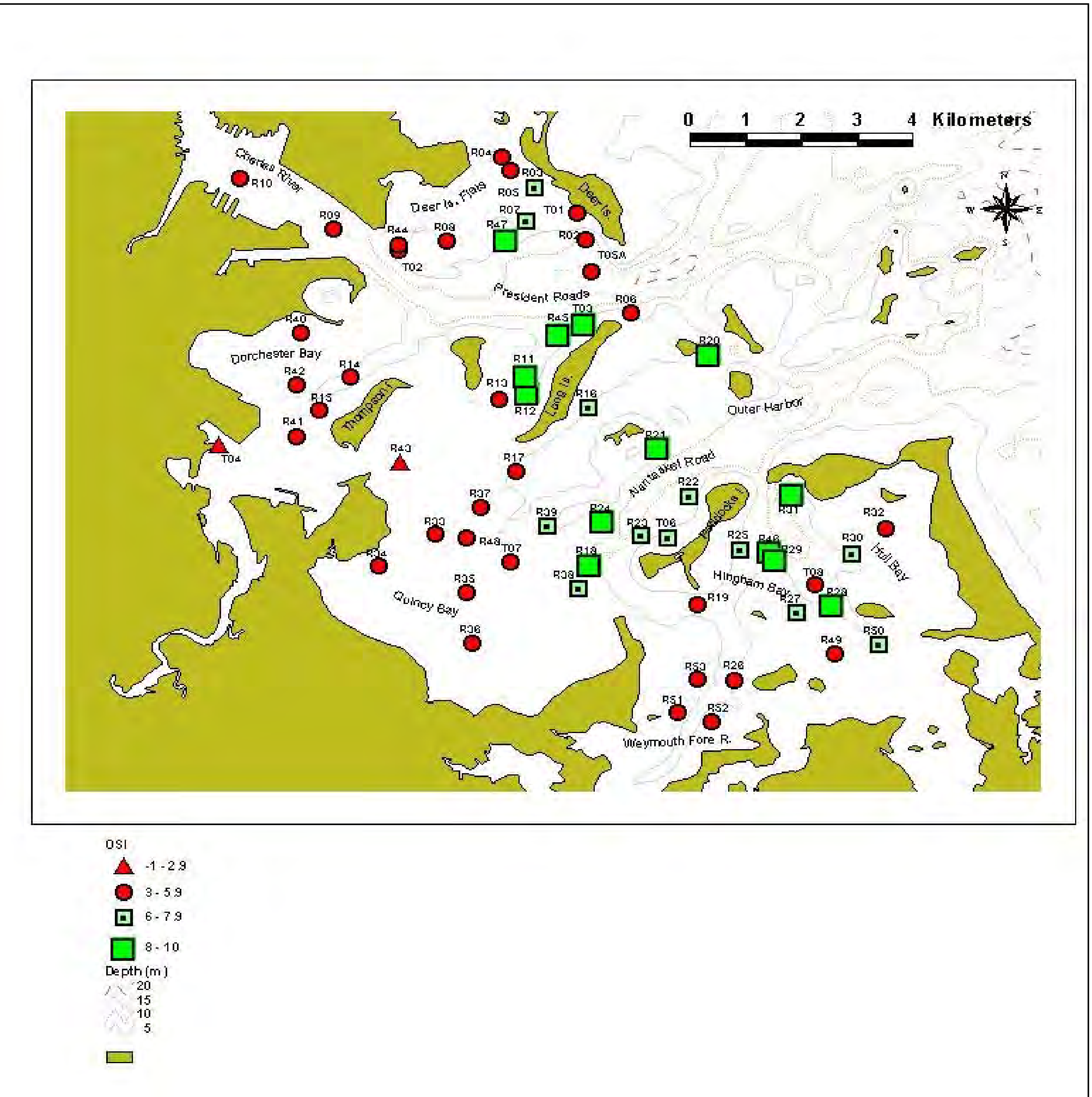


Figure 3-7. Long-term average for the Organism Sediment Index at harbor stations from 1992 to 2000.

From 1992 to 2000, key indicators of benthic habitat quality oscillated about the long-term mean with no year being more than 14% and 32% from the grand mean, for OSI and RPD respectively. Current benthic communities appeared to have developed in response to major disturbance events in 1991, the October severe storm and December sewage sludge discharge abatement (Blake *et al*. 1998). Interestingly, stations with poorest habitat quality in 1989/90 (Blake *et al*. 1993) continued to have poor quality habitat in 2000. Stations T04 and R43, both in Dorchester Bay, had long-term average OSI values ≤ 3.

4.0 ANALYTICAL CHEMISTRY

by Deirdre T. Dahlen and Carlton D. Hunt

4.1 Methods

4.1.1 Laboratory Analyses for Ancillary Measurements

Laboratory procedures followed those outlined in the Benthic Monitoring CW/QAPP (Kropp and Boyle 1998; Kropp and Boyle, 2001). Summaries of the procedures are provided below.

Grain Size — Samples were analyzed for grain size by a sequence of wet sieving and dry sieving. Methodologies followed Folk (1974). The sand/gravel fraction was separated from the mud fraction. This sand/gravel fraction was transferred to a 200-mL beaker, decanted, and dried overnight at 95 ºC. The dried sand/gravel fraction was mixed by hand to disaggregate the material, and then dry-sieved on stacked !1-, 0-, 1-, 2-, 3-, and 4-phi sieves. Each size class was weighed to the nearest 0.1 mg on a top-loading balance. Particles smaller than 4 phi were analyzed using the pipette method. Data were presented in weight percent by size class. In addition, the gravel:sand:silt:clay ratio and a numerical approximation of mean size and sorting (standard deviation) were calculated. Grain size determinations were made by GeoPlan Associates.

Total Organic Carbon — A portion of the sample to be analyzed for TOC content was dried at 70 ºC for 24–36 hours and ground to a fine powder. The sample was treated with 10 % HCl to remove inorganic carbon and dried at 70 ºC for 24 hours. Between 10 and 500 mg of dry, finely ground, and homogenized sample were weighed to the nearest 0.1 mg and placed in a crucible that had been precombusted for 4 hours at 500 ºC. A Coulometric Carbon Analyzer was used to determine the TOC content of the samples. TOC determinations were performed by Applied Marine Sciences, Inc. according to SOP AMS-TOC94.

***Clostridium perfringens* —** Sediment extraction methods for determination of *Clostridium perfringens* spores followed those developed by Emerson and Cabelli (1982), as modified by Saad (1992). The filters for enumeration of *Clostridium perfringens* spores were incubated anaerobically at 44.5 ºC for 24 hours. Following incubation, the filter was exposed to ammonium hydroxide for 15–30 seconds. Yellowish colonies that turn red to dark pink upon exposure were counted as *Clostridium perfringens*. Data are reported as colony–forming units (cfu) per gram dry weight of sediment. This analysis was performed by MTH Environmental Associates.

4.1.2 Statistical Analyses and Data Treatments

Statistical Analysis — Microsoft Excel® and JMP® were used to perform correlation analysis on sediment grain size, TOC, and *Clostridium perfringens* data to examine the correlation between these parameters. Probability values were taken from Rohlf and Sokal (1969).

Data Treatments — In the discussion of bulk sediment data, the following terms are used.

- Percent Fines—sum of percent silt and clay.
- Numerical approximate mean phi (hereafter referred to as mean phi)—calculated by weighting each class fraction measured and summing the weighted fractions as described in Kropp *et al* (2000).

Mean parameter (*e.g.,* sand) values were determined for two categories:

- Station Mean—average of all station replicates. Single grab samples were generally collected at all Traditional stations during most sampling years and seasons, but replicate grabs were also collected during some sampling years (*e.g.,* August 1994 and 1997). Station means were determined for each parameter within a given sampling year and season (*i.e.,* April, August) to assess the spatial and temporal distribution in bulk sediment properties and *Clostridium perfringens* from 1991 to 2000.
- Grand Station Mean—average of all years, by station and season. Grand station means were determined for each parameter over all sampling years and season to assess variability in the spatial and temporal distribution in bulk sediment properties and *Clostridium perfringens* from 1991 to 2000.

The spatial and temporal distributions of sediment grain size were evaluated by using ternary plots to visually display the distribution of gravel plus sand, silt and clay in sediment collected from Traditional stations from 1991 to 2000.

Results from TOC and *Clostridium perfringens* analyses were compared from all Traditional stations by using line charts to evaluate if the spatial and temporal distributions in 2000 were substantially different from those for previous years.

Seasonal TOC data collected from the Flux program from 1993 to 2000 were evaluated with the Harbor TOC data to explore if there was a characteristic seasonal "peak" in Harbor TOC levels that more or less corresponded to the faunal sampling events. Flux results from February were excluded from the analysis since these data were only available from a single sampling event in 1993.

4.2 Results and Discussion

Bulk sediment results for all Traditional samples collected in April and August surveys were evaluated separately to examine spatial and temporal characteristics. April and August 2000 results are presented in Table 4-1. Grand station means and associated standard deviation and coefficient of variation values, by station and parameter, for April (1993–2000) and August (September 1991 and August 1992–2000) surveys are presented in Table 4-2. Ternary plots showing grain size composition and line charts showing TOC and *Clostridium perfringens* results for April (1993–2000) and August (September 1991 and August 1992–2000) surveys, by station and season, are presented in Appendix C-1. April and August mean values for grain size, TOC, and *Clostridium perfringens*, by station across all sampling years, are reported in Appendices C-2 and C-3, respectively. All sediment results are discussed in terms of dry weight using station mean values.

4.2.1 Grain Size 1991–2000

April—Patterns in sediment composition at all Traditional stations in 2000 were within the ranges observed for previous years. Patterns in sediment composition were consistent at some stations and more variable at others (representative stations, T01 and T04, are shown in Figure 4-1; ternary plots for all stations are provided in Appendix C-1). Patterns in sediment composition at station T01 displayed very consistent grain size composition over time and 2000 results were consistent with previous years (Figure 4-1, Appendix C-1). Sediments collected at stations T02, T03, T06, and T07 displayed variable grain size composition over time and 2000 results were within ranges observed in previous years (Appendix C-2). Patterns in sediment composition at station T04 were consistent across all years except 1999. Sediment collected in 1999 at T04 contained considerably higher sand and less silt content relative

Table 4-1. Grain size, TOC, and *Clostridium perfringens* data from sediments collected at Traditional stations in April and August 2000.

Parameter	Units	T01	T02	T03	T04	T05A	T06	T07	T08
April Survey, 2000									
Gravel	pct	10.7	2.9	0.2	4.1	0	0	9.2	0.3
Sand	pct	65.3	39.5	14.2	7.2	66.6	31.2	29.3	96.6
Silt	pct	15.3	35.2	41	51	21	34.1	35.3	1.2
Clay	pct	8.7	22.3	44.6	37.8	12.4	34.7	26.2	1.9
Fines	pct	24	57.5	85.6	88.8	33.4	68.8	61.5	3.1
Mean phi	pct	3.34	5.27	6.93	6.53	4.42	6.15	4.98	2.51
TOC	pct	1.61	1.87	3.45	4.44	1.2	2.36	2.88	0.4
Clostridium perfringens	cfu/g dw	5,910	9,520	12,700	9,880	2,800	6,950	8,980	395
August Survey, 2000									
Gravel	pct	2.5	0.1	1.7	1.5	0.3	0.2	11	0.6
Sand	pct	67.5	54	49.4	29.4	93.5	58.3	30.6	94.7
Silt	pct	23.7	31	36.3	55.5	4.9	26.7	34	2.6
Clay	pct	6.3	14.9	12.7	13.5	1.4	14.8	24.4	2.1
Fines	pct	30	45.9	49	69	6.3	41.5	58.4	4.7
Mean phi	pct	3.83	4.85	4.25	5.05	3.02	4.47	4.74	2.48
TOC	pct	1.8	1.51	3.03	3.9	0.93	2.16	2.53	0.37
Clostridium perfringens	cfu/g dw	3,130	6,820	11,300	1,960	1,700	3,430	6,040	330

Table 4-2. Grand station mean, standard deviation, and coefficient of variation results for sediment parameters from April and August surveys.

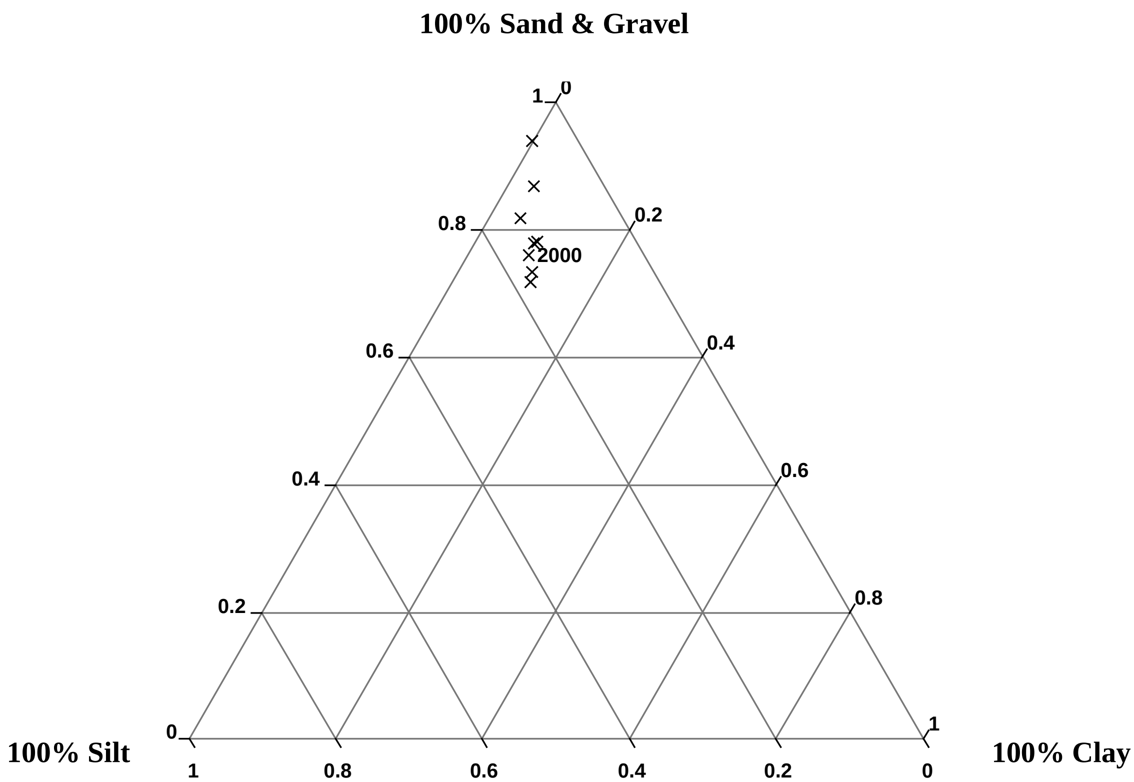
Stn		Gravel (pct)	Sand (pct)	Silt (pct)	Clay (pct)	Fines (pct)	TOC (pct)	*Clostridium* (cfu/g dw)
April Surveys, 1993 - 2000								
T01	**Mean**	6.78	73	13.2	7	20.2	1.18	4,880
	Stdev	5.51	8.1	3.77	3.66	7.3	0.253	2,120
	CV	81.2	11.1	28.6	52.3	36.2	21.5	43.4
T02	**Mean**	1.29	43.6	34	21.1	55.2	1.83	15,000
	Stdev	1.32	15.4	10.6	8.15	15.9	0.39	11,800
	CV	102	35.4	31.1	38.6	28.8	21.3	78.5
T03	**Mean**	2.16	29.1	39.7	29.1	68.8	3.05	24,100
	Stdev	4.4	14.2	6.86	13.3	15.7	0.334	22,600
	CV	203	48.7	17.3	45.6	22.8	10.9	93.8
T04	**Mean**	0.55	13.5	55.2	30.8	86	5.13	16,900
	Stdev	1.44	10.5	10.3	10.9	10.3	1.33	8,620
	CV	262	77.9	18.6	35.5	11.9	26	51
T05	**Mean**	0.251	72.6	18.9	8.28	27.2	0.783	3,320
	Stdev	0.214	10.4	7.94	4.47	10.4	0.376	1,860
	CV	85.5	14.3	42.1	54	38.3	48.1	56
T06	**Mean**	1.31	42.9	32.9	22.9	55.8	2.24	15,200
	Stdev	2.12	15.3	8.41	11.3	16.9	0.646	12,100
	CV	161	35.7	25.6	49.2	30.3	28.8	79.4

Table 4-2. Grand station mean, standard deviation, and coefficient of variation results for sediment parameters from April and August surveys. (con't)

Stn		Gravel (pct)	Sand (pct)	Silt (pct)	Clay (pct)	Fines (pct)	TOC (pct)	*Clostridium* (cfu/g dw)
T07	**Mean**	12	36.6	32.2	19.2	51.4	2.74	14,100
	Stdev	10.4	22.9	17.2	10.1	21.9	0.375	10,100
	CV	86.6	62.5	53.4	52.4	42.6	13.7	71.8
T08	**Mean**	3.09	79.4	9.17	8.32	17.5	0.582	3,920
	Stdev	3.9	21.9	11.3	10.4	21.7	0.372	2,630
	CV	126	27.6	124	126	124	63.9	67
August Surveys, 1991 - 2000								
T01	**Mean**	14.6	59.8	19.4	6.25	25.6	1.97	5,530
	Stdev	19.3	20.5	14.6	2.11	13.5	0.685	3,470
	CV	132	34.2	75.3	33.7	52.8	34.8	62.8
T02	**Mean**	2.73	50.5	30.9	15.9	46.8	1.69	13,600
	Stdev	6.61	10	7.04	6.18	12	0.21	6,340
	CV	242	19.9	22.8	38.8	25.6	12.5	46.5
T03	**Mean**	1	31.4	41	26.6	67.6	3.31	35,500
	Stdev	1.9	19	8.66	13.4	20.1	0.437	61,100
	CV	190	60.7	21.1	50.2	29.8	13.2	172
T04	**Mean**	0.65	13.7	58.1	27.6	85.7	4.32	16,300
	Stdev	1.21	11.4	10.7	11.5	11.2	1.66	19,800
	CV	186	83.9	18.5	41.5	13.1	38.4	121
T05	**Mean**	9.44	76.7	8.97	4.95	13.9	0.998	7,780
	Stdev	29.2	26.2	5.52	3.66	9.05	0.42	11,900
	CV	309	34.2	61.6	73.8	65	42.1	153
T06	**Mean**	0.752	50.4	30.5	18.4	48.8	2.17	15,300
	Stdev	0.894	17.2	10.7	7.75	17.1	0.641	17,300
	CV	119	34.1	35	42.1	35.1	29.5	113
T07	**Mean**	8.58	32.6	38.7	20.1	58.8	2.74	12,200
	Stdev	7.31	11.6	7.75	6.7	10.1	0.319	8830
	CV	85.1	35.6	20	33.3	17.2	11.7	72.5
T08	**Mean**	1.28	84	8.15	6.52	14.7	0.526	2,680
	Stdev	1.19	25.5	15.7	10.4	26	0.279	2,570
	CV	92.7	30.4	192	159	177	53	96

to other years (Figure 4-1). Sediments from station T05A showed moderately consistent patterns of sediment composition over time and 2000 results were not substantially different from previous years (Appendix C-2). Patterns in sediment composition at station T08 in 2000 were consistent with patterns observed from 1993 to 1996 (Appendix C-2), and varied from patterns observed in 1997–1998. Apparent temporal outliers at T04 (1999) and T08 (1997, 1998) may, in part, result from small-scale spatial heterogeneity.

Sediments from station T01 were comprised primarily of coarse-grained sediments and clustered in the upper apex of the ternary plot (Figure 4-1, Appendix C-1). Sediments from station T02 displayed variable sediment composition over time with sediment texture ranging from sandy (70% sand and gravel in 1994) to very silty (84% fines in 1998) (Appendix C-2). Sediments from station T03 also displayed variable sediment composition over time, ranging from sandy (52% sand and gravel in 1994) to very silty (90% fines in 1995) (Appendix C-2). Sediments from station T04 in 1993–1998 and 2000 were comprised primarily of very silty sediments and clustered in the lower left of the ternary plot (Figure 4-1).



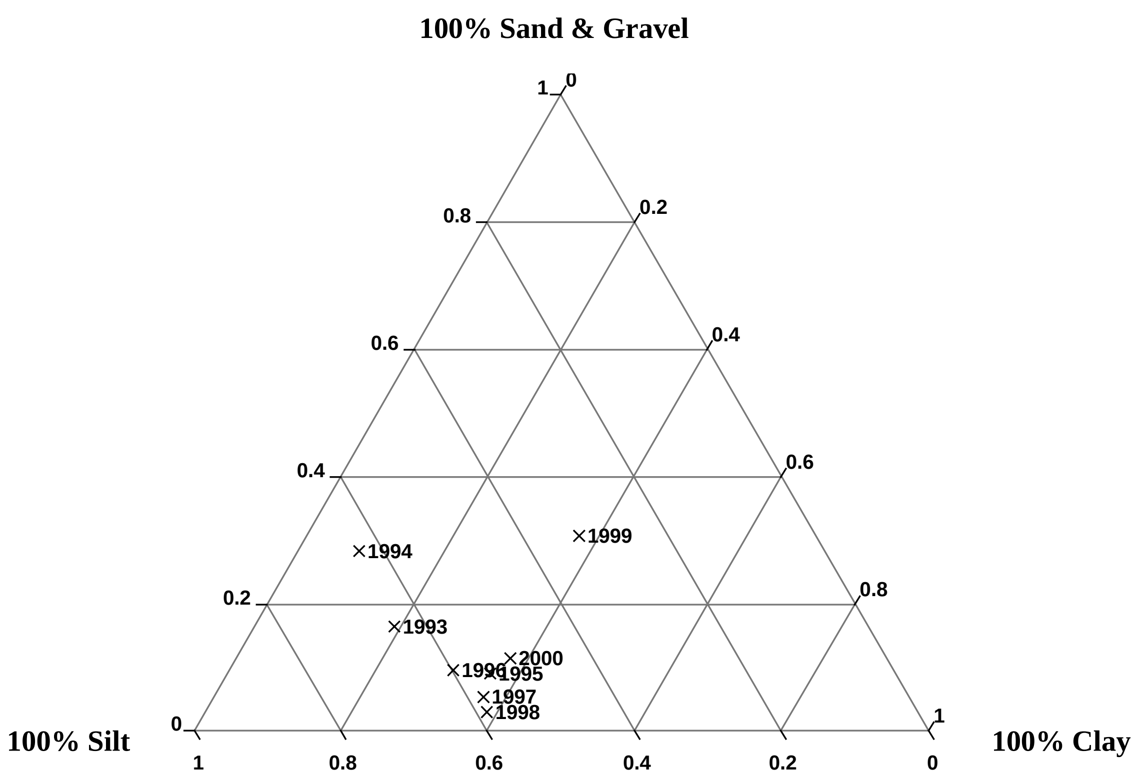


Figure 4-1. Grain size composition from sediments collected at stations T01 (top) and T04 (bottom) in April 1993–2000.

In contrast, sediment from station T04 in 1999 was sandier, with less silt content, and clustered closer to the mid-region of the ternary plot (Figure 4-1). Sediments collected from stations T05A and T08 generally were comprised of coarser-grained sediments (> 60% gravel and sand) and clustered in the upper quadrants of the ternary plot (Appendix C-1). One exception was observed in 1997, when sediments collected at station T08 were siltier (63% fines) in sediment texture relative to all other sampling years. However, grain size results for T07 and T08 in April 1997 are anomalous and suggest that these two samples could have inadvertently been switched. Had the two samples been switched, then the grain size composition for T08 in April 1997 would be consistent (*e.g.*, sandy) with other sampling years. Sediments collected at station T06 displayed variable patterns of sediment composition with sediment texture ranging from sandy in 1994 (69% sand and gravel) to silty in 1996 (77% fines) (Appendix C-2). Similarly, sediments from station T07 also had variable sediment composition over time, ranging from very sandy in 1997 (92% sand and gravel) to very silty in 1993 (80% fines) (Appendix C-2).

August—Patterns in sediment composition in 2000 at all Traditional stations were not substantially different from previous years (1991–1999). Patterns in sediment composition were consistent at some stations and variable at others (representative stations T01 and T04 are shown in Figure 4-2; ternary plots for all stations are provided in Appendix C-1). Sediments from station T01 displayed very consistent patterns in sediment texture during all sampling years except 1995, and were comprised primarily of coarse-grained sediments (Figure 4-2). Sediments collected at station T01 in 1995 were very silty (61% fines) by comparison. Sediments from station T02 displayed moderately consistent patterns in sediment composition over time, with sandy sediment texture in 1991–1994 (> 60% sand and gravel), slightly more silty in 1996 and 2000 (47–46% fines), and again more silty in 1995 and 1997–1999 (56–63% fines) (Appendix C-3). Sediments from station T03 displayed variable sediment composition from 1991 to 2000 and clustered into two groups on the ternary plot (Appendix C-1). Sediments collected from 1995 to 1999 at station T03 were silty and clustered in the lower quadrants of the ternary plot; whereas sediments collected from 1991 to 1994 and 2000 were more sandy with less silt and clay content (Appendix C-1). Sediments from station T04 displayed moderately consistent sediment texture over time and were primarily comprised of silty sediments (68–97% fines), clustering in the lower, middle quadrants of the ternary plot (Figure 4-2). Sediments collected from station T05A displayed the most consistent patterns in sediment composition over time, and were comprised of very sandy sediments clustering in the upper apex of the ternary plot (Appendix C-1). Sediments collected at station T06 displayed variable patterns in sediment composition, clustering into three distinct groups on the ternary plot (Appendix C-1). Sediment collected at T06 in 1996 contained the highest amounts of silt and clay (80% fines) across all sampling years. Sediments collected at T06 in 1995 and 1998–1999 were also silty, ranging from 61 to 66% fines. Sediment collected at T06 in 1991–1994, 1997, and 2000 was sandier relative to other sampling years and clustered in the upper regions of the ternary plot (Appendix C-1). Sediments collected from station T07 had variable sediment texture over time, ranging from sandy (59% sand and gravel) in 1991 to silty (78% fines) in 1998 (Appendix C-3). Sediments from station T08 had very consistent patterns in sediment composition during all sampling years except 1991, and were comprised of very sandy sediments (> 80% sand and gravel) clustering in the upper apex of the ternary plot (Appendix C-1). Sediments collected station T08 in 1991 contained high amounts of silt and clay by comparison (88% fines). Apparent temporal outliers at T08 and other sites may result from small-scale spatial heterogeneity.

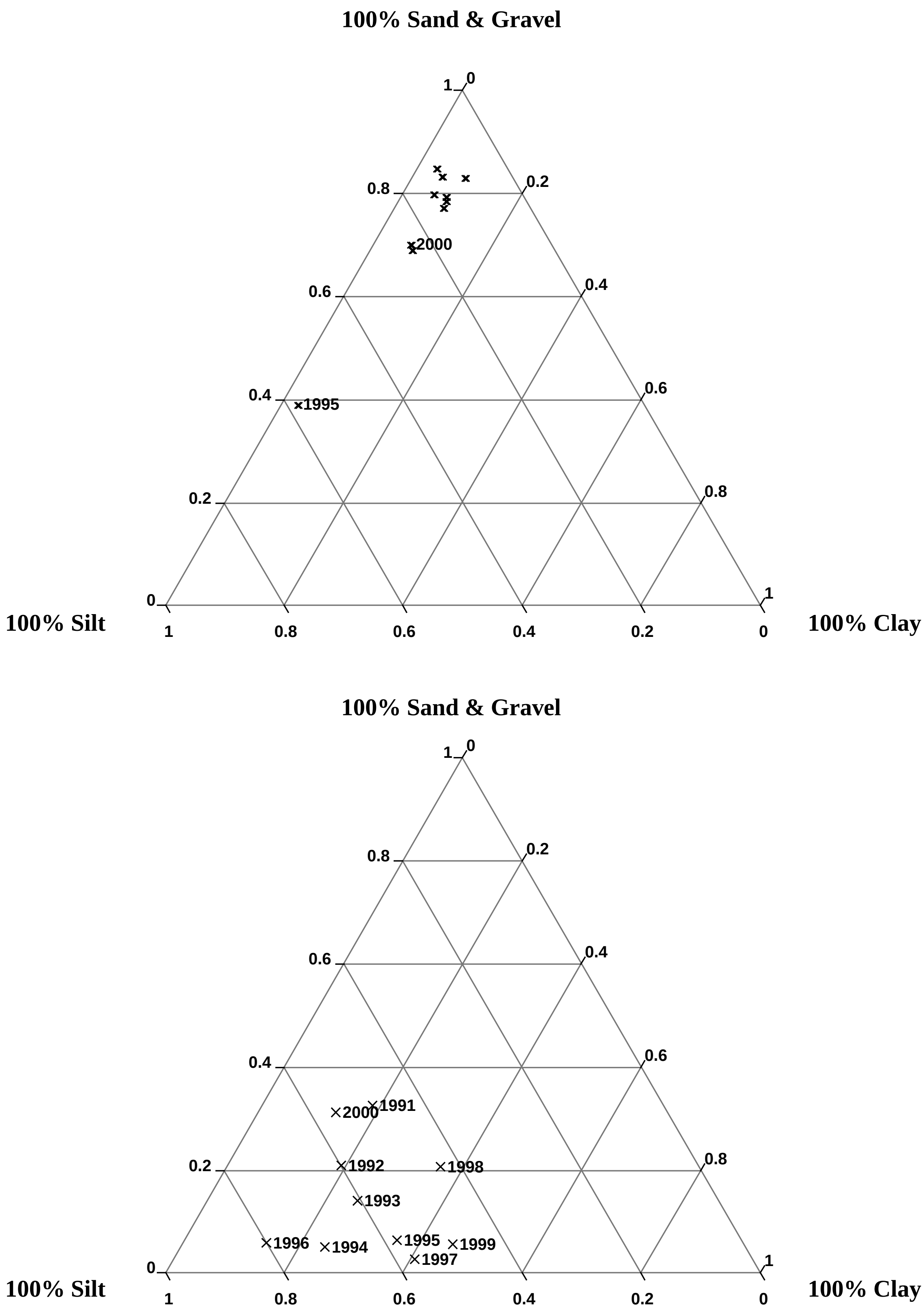


Figure 4-2. Grain size composition from sediments collected at stations T01 (top) and T04 (bottom) in September 1991 and August 1992–2000.

Comparison of April and August Surveys —Patterns in sediment composition between April and August surveys were similar across all common sampling years (1993–2000). For example, stations that were primarily comprised of coarse-grained sediments in April (*i.e.*, T01, T05A, and T08) were also comprised of coarse-grained sediments during August surveys. However, variability in sediment composition over time was higher at some stations (*i.e.*, T07, T08) in April relative to August surveys. In contrast, patterns in sediment composition at station T01 in April were less variable over time relative to August surveys. Stations T03, T04, T05A, and T06 generally showed equally variable patterns in sediment composition over time during April and August surveys.

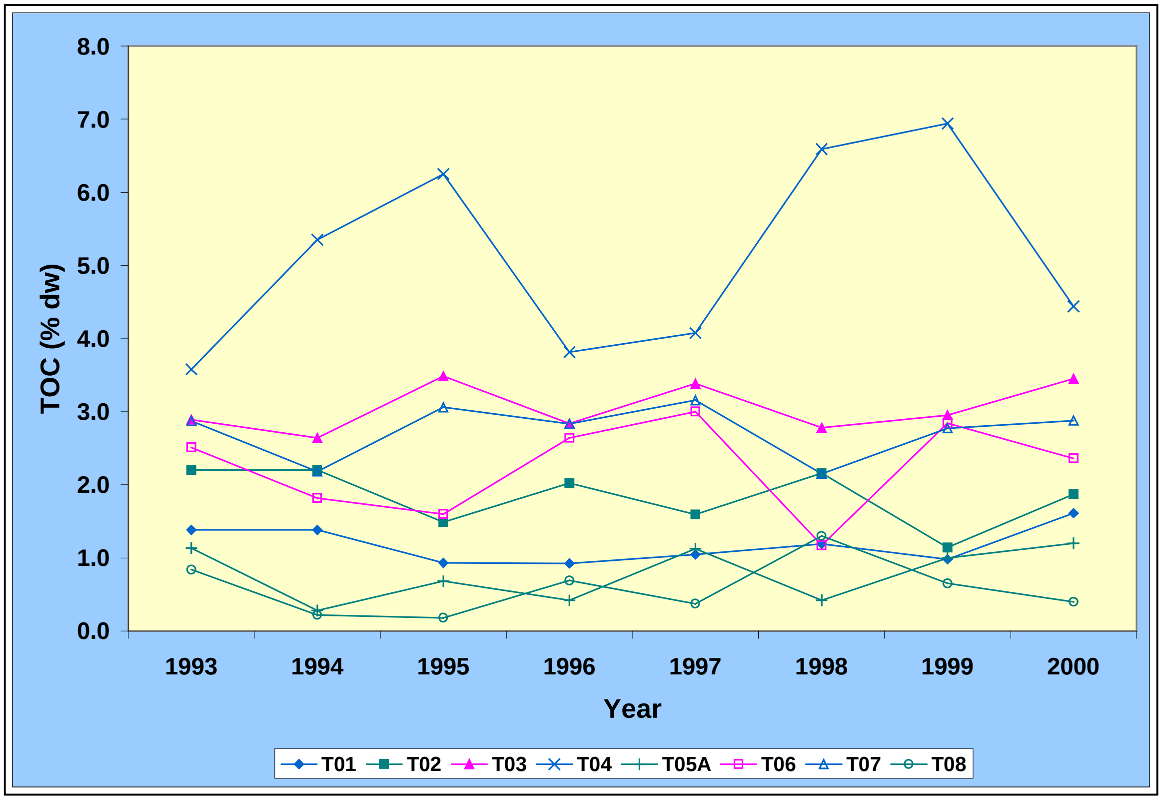


Figure 4-3. Total organic carbon content in sediments collected at Traditional stations in April 1993–2000.

4.2.2 Total Organic Carbon 1991–2000

April—Concentrations of TOC at all Traditional stations were not substantially different in 2000 from earlier years because of the high variability in the historical dataset (Figure 4-3, Appendices C-1 and C-2). Patterns in TOC content were consistent over time at some stations, but were more variable at others (Figure 4-3, Table 4-2). Stations T03 and T07 showed the most consistent (<14% coefficient of variation, CV) patterns in TOC content over time (Figure 4-3, Table 4-2). Stations T01, T02, T04, and T06 had moderately variable (21–29% CV) concentrations of TOC over time, while stations T05A and T08 were the most variable (>48% CV) over time (Figure 4-3, Table 4-2). Sediments from station T04 consistently had the highest levels of TOC over time, whereas the lowest levels were found at stations T05A and T08 (Figure 4-3, Table 4-2).

August—Concentrations of TOC at all Traditional stations were not substantially different in 2000 from earlier years, again because of the high variability in the historical dataset (Figure 4-4, Appendices C-1 and C-3). Patterns in TOC content were consistent over time at some stations, but were more variable at others (Figure 4-4, Table 4-2). Stations T02, T03, and T07 showed the most consistent (<14% CV) patterns in TOC content over time (Figure 4-4, Table 4-2). Station T06 had moderately variable concentrations of TOC over time (30% CV), while stations T01, T04, T05A, and T08 were the most variable (>34% CV) over time (Figure 4-4, Table 4-2). Sediments from station T04 had the highest levels of TOC over time, peaking in 1998 with the highest measured value (8.86% TOC) among all sampling years. The unusually high TOC content observed at T04 in 1998 (Figure 4-4) is likely a result of localized inputs from a major storm event that occurred in June 1998 (Lefkovitz *et al*. 1999). Concentrations of TOC at station T04 decreased in 1999 indicating that the system has returned to previous conditions (Figure 4-4). The return to previous conditions in 1999 may also be further explained by the rapid sedimentation rate (approximately 4 cm/year) observed at the site by Gallagher *et al* (1992) and Wallace *et al* (1991). Stations T05A and T08 consistently contained the lowest levels of TOC (generally ≤1%) over time (Figure 4-4).

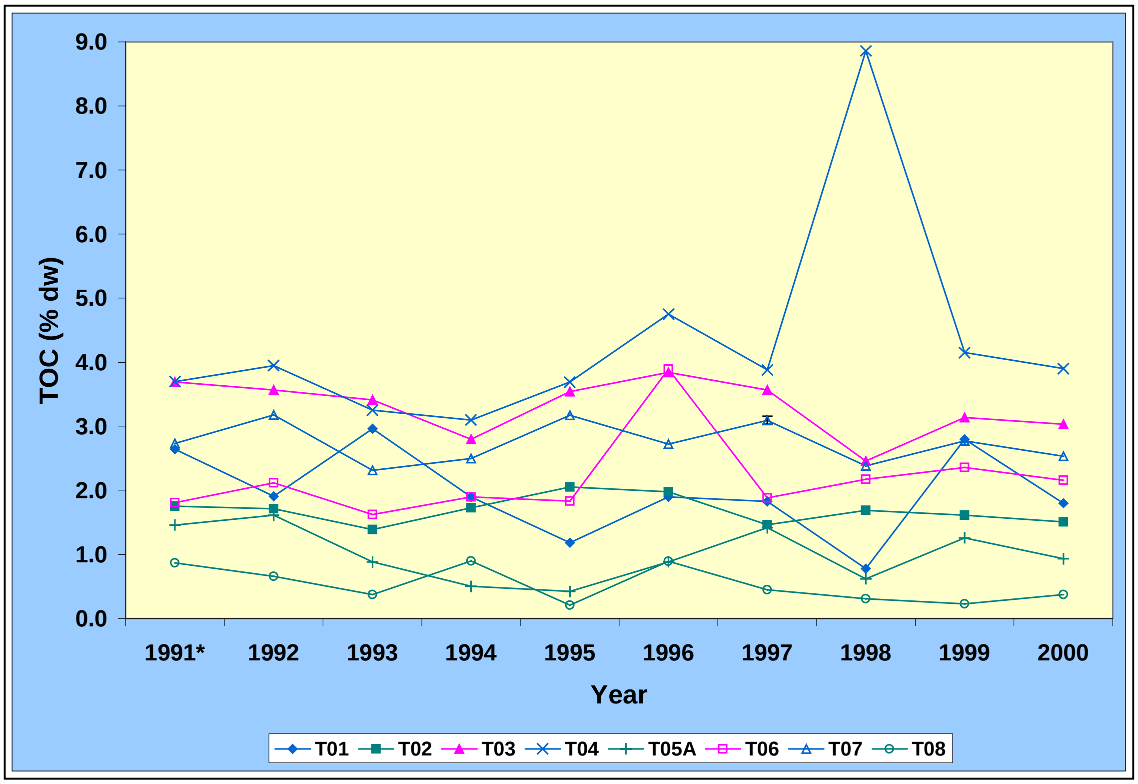


Figure 4-4. Total organic carbon content in sediments collected at Traditional stations in September 1991 and August 1992–2000.

Comparison of April and August Surveys—The TOC content measured during April surveys represents the effects of several factors and processes, for example, contributions such as the spring plankton bloom, inputs resulting from spring run-off, and anthropogenic loadings (Blake *et al*. 1998). Thus, at low temperatures organic carbon is expected to build up in the sediment. Recent studies (Blake *et al*. 1998) suggested that the TOC content measured during August surveys represents the net inventory of organic matter following respiration of the spring input of carbon substrates. It also includes recent inputs from production and other run-off sources. Thus, TOC is generally expected to be higher in April than in August (Blake *et al*. 1998). Close examination of the data suggests that TOC concentrations at approximately 70% of the stations, across all sampling years, had similar or higher concentrations of TOC in August relative to April values, suggesting that this data set does not support the mechanisms described by Blake *et al*. (1998).

To evaluate this, the individual station data by year were compared to the one-to-one correlation expected if no processes were operating to modify the TOC between April and August (Figure 4-5). TOC data from station T04 in 1998 was excluded from the correlation analysis because of the suspected localized influence from a June 1998 storm event. The correlation analysis of the data yielded a slope of less than one. Sediments with low TOC (sandy) tend to have less respiration while muddier, high TOC stations appear to have lower relative TOC due to respiration. Additionally, the data do not consistently support seasonal differences. Rather, only 35% of the April TOC values were higher than the corresponding August values and 13% of the April and August stations had similar TOC values (within 10% R%D). Further, 52% of the August TOC values were higher than the corresponding April values. For example, TOC content at stations T01 and T03 were higher in August for all sampling years except 1998 (T01 and T03) and 2000 (T03 only) relative to April values.

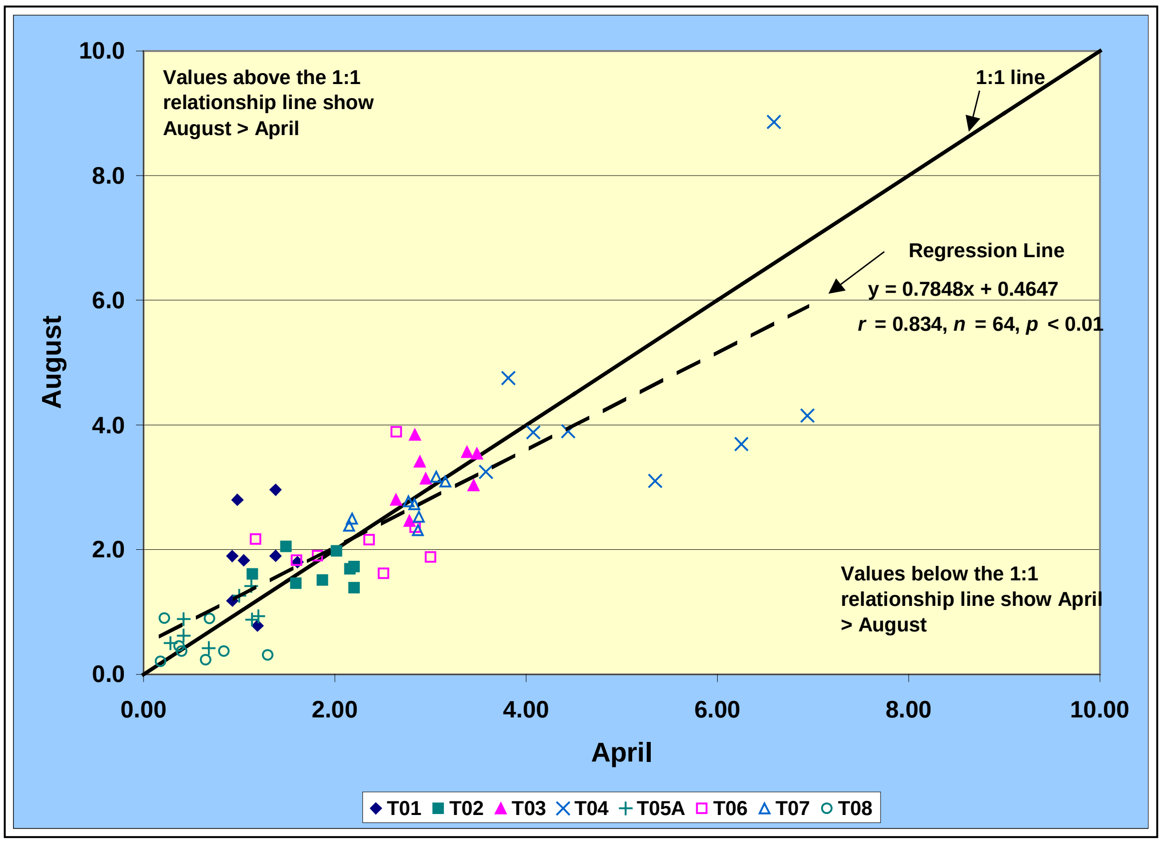


Figure 4-5. A seasonal comparison of April and August total organic carbon (%) content in sediments collected from Traditional stations from 1993 to 2000.

Comparison of April and August Surveys to the Flux Program—Seasonal TOC data collected from the Benthic Nutrient Flux program (Tucker *et al.* 1999) from 1993 to 2000 were also evaluated with the Harbor TOC data to explore if there was a characteristic seasonal "peak" in Harbor TOC levels that corresponded to the faunal sampling events. These samples have been collected in May, July, August, and October at four locations in the harbor since 1995 and at one to four locations in 1993 and 1994. Flux TOC data (harbor) available from March 1993 to 1997 was also included in the analysis. Flux results from February were excluded from the analysis since these data were only available from a single sampling event in 1993.

TOC results were evaluated at two levels. First, the distribution of Flux TOC and Traditional Harbor TOC results for all years within a given sampling month was evaluated (Figure 4-6a). Next, mean TOC results within a given sampling year and month were evaluated (Figure 4-6b). Both analyses showed that on a harbor wide basis there were no characteristic peaks in TOC values within a factor of two variability observed from 1993 to 2000 (Figures 4-6a and b). Interestingly, mean Flux TOC results from May and July were unusually high in 1996 relative to other sampling months and years (Figure 4-6b). In addition, with the exception of 1998 and 1999, Flux TOC values measured in August were consistently higher compared to levels measured during the Traditional Harbor August survey. However, this may be a reflection of the different geographic location of the Flux program and Traditional Harbor stations, as well as the number of stations sampled (four for Flux sampling vs. eight for Traditional Harbor sampling). The proximity of Flux vs. Traditional Harbor station locations to sources of TOC may be another factor influencing the TOC concentrations. For example, stations with a high depositional environment (*e.g.*, Traditional Harbor station T04) will likely contain high TOC concentrations. The analysis (Figure 4-6b) was repeated excluding one such station, Traditional Harbor station T04. Interestingly, there were no significant differences by excluding this station (T04) from the analysis, as the mean TOC results for the April and August Traditional Harbor events still overlapped across all years with Flux program TOC mean values.

One additional observation of note is that mean Flux TOC results determined under HOM2 (1995 to 1997) appear to be slightly higher compared to mean Flux TOC results determined under HOM1 and HOM3 (Figure 4-6b), suggesting that an evaluation of methods used across years is warranted to determine if the difference is method related.

4.2.3 *Clostridium perfringens* 1991–2000

April—The variability in *Clostridium perfringens* concentrations appeared to "settle down" over time and between 1998 and 2000 the system seemed to be much less variable (Figure 4-7), possibly a result of major facility improvements implemented to clean-up Boston Harbor (*e.g.*, secondary treatment coming on-line in August 1997 and cessation of Nut Island discharges in July 1998). With the exception of station T04 and T08, *Clostridium perfringens* concentrations increased slightly in 2000 across all stations compared to 1999 values (Figure 4-7, Appendix C-2). Even so, *Clostridium perfringens* in 2000 still showed an overall decrease in abundance across all stations compared to 1993–1998 values (Figure 4-7, Appendix C-2).

Stations T01, T05A and T08 generally had the lowest *Clostridium perfringens* concentrations (< 8,500 cfu/g dw) relative to other Traditional stations (Figure 4-7, Appendix C-2). In contrast, stations sampled in 1995 generally had the highest *Clostridium perfringens* concentrations relative to all other sampling years (Figure 4-7, Appendices C-1 and C-2). *Clostridium perfringens* concentrations in April 1996 generally appear unusually low at all stations except T08 (Figure 4-7, Appendices C-1 and C-2).

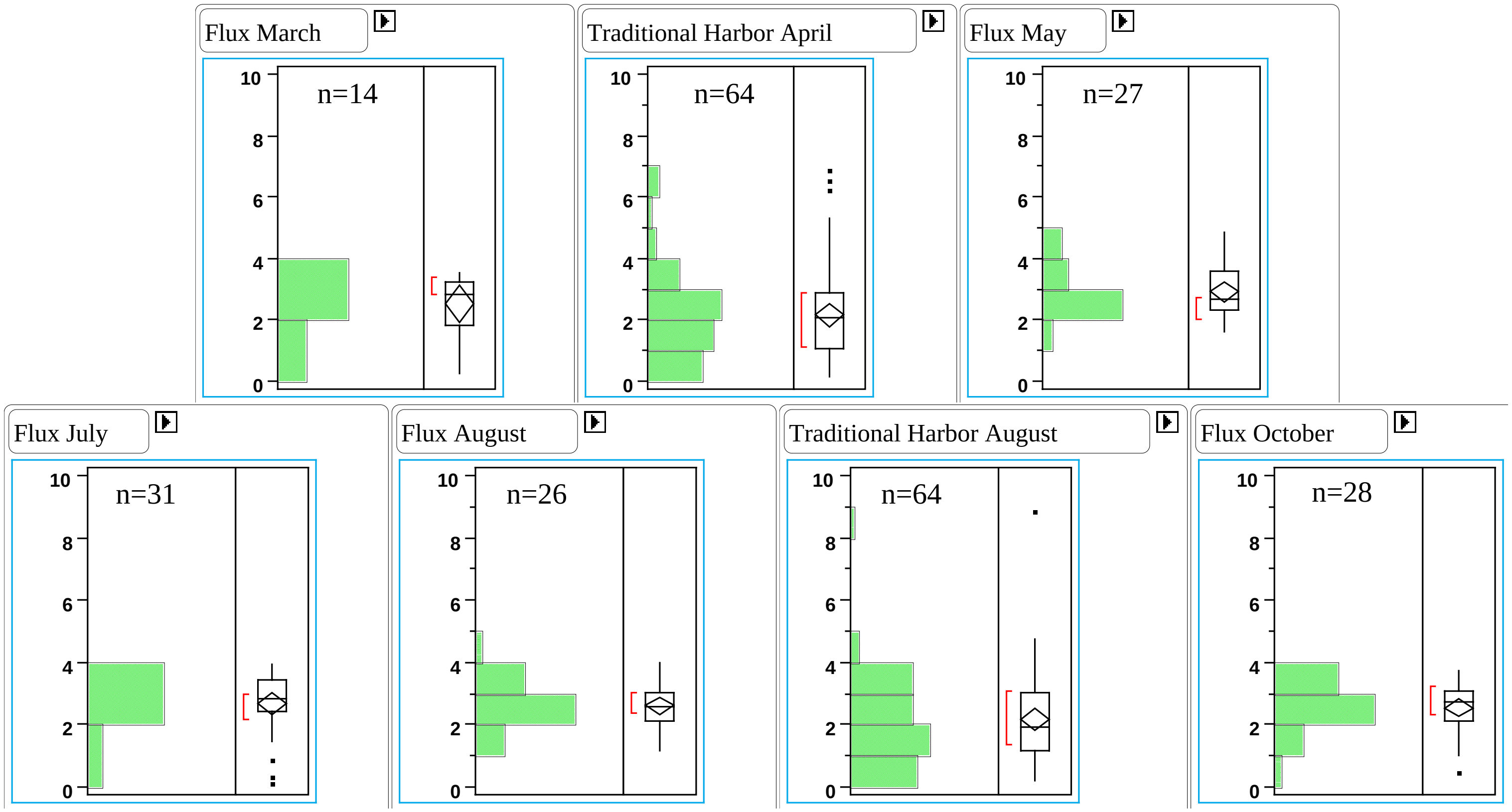


Figure 4-6a. Comparison of TOC results from the Flux program to Traditional Harbor April and August events from 1993 to 2000. Percent TOC (dry) is presented on the y-axis and the frequency of occurrence is presented on the x-axis. The quantile box plot shows selected quantities on the response axis. The box shows the median as a line across the middle and the quartiles (25th and 75th percentiles) as its ends. The means diamond identifies the mean of the sample and the 95% confidence interval about the mean. The Traditional Harbor August data outlier is station T04 from 1998.

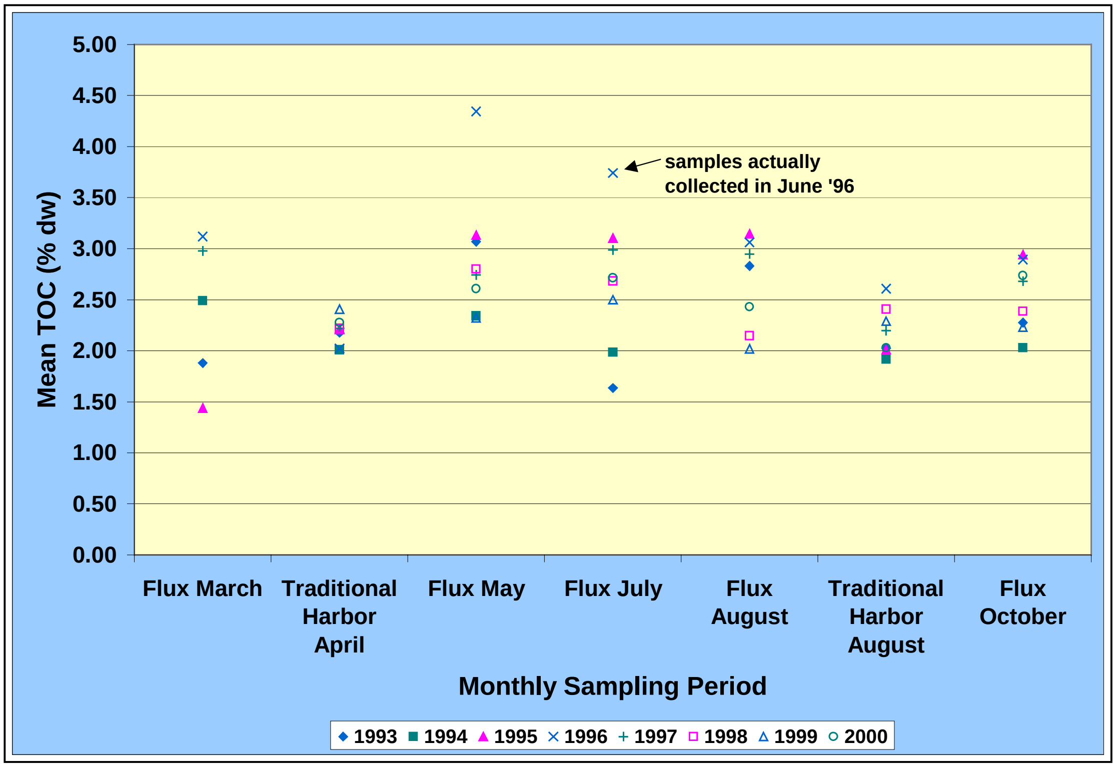


Figure 4-6b. Comparison of mean TOC results (% dry weight) from the Flux program to Traditional Harbor April and August events, by sampling month and year, from 1993 to 2000.

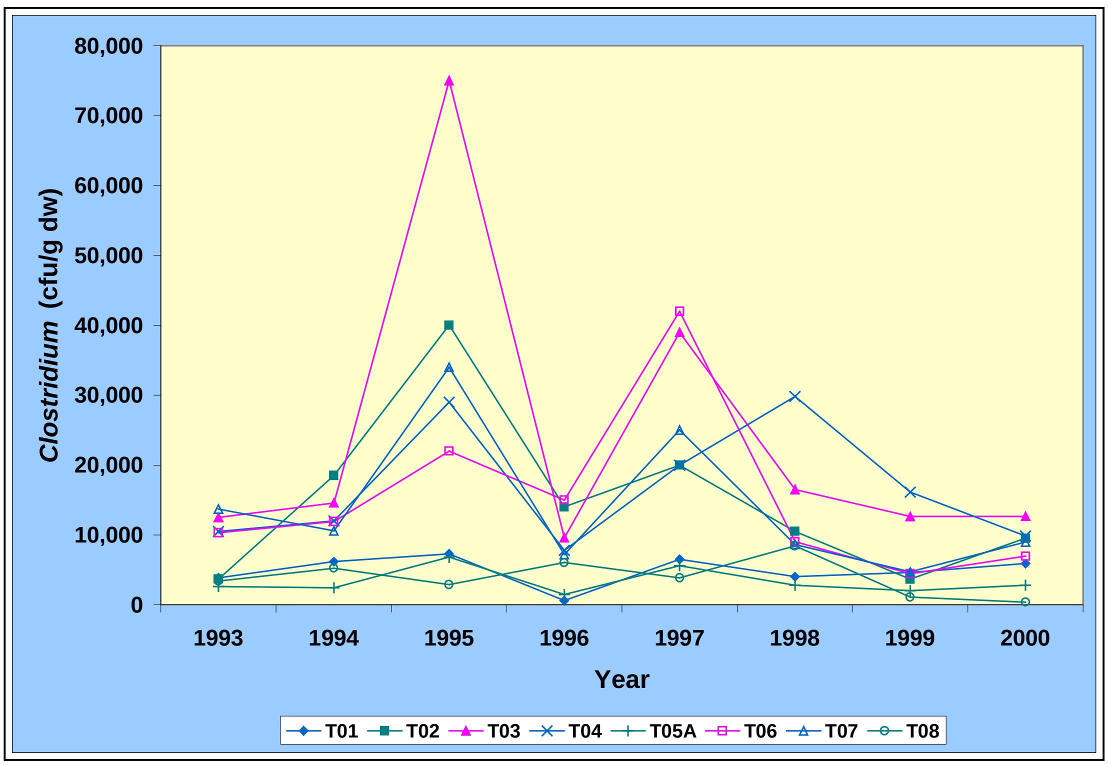


Figure 4-7. *Clostridium perfringens* concentrations in sediments collected at Traditional stations in April 1993–2000.

August—Consistent with April findings, the variability in *Clostridium perfringens* concentrations appeared to "settle down" between 1998 and 2000 and the system was more stable (Figure 4-8), possibly a result of major facility improvements implemented to clean-up Boston Harbor. With the exception of T02 and T07, variability in the August data was generally higher at all stations relative to April values (Table 4-2). *Clostridium perfringens* concentrations increased slightly in 2000 at all stations, except T07 and T08, relative to 1999 values (Figure 4-8, Appendix C-1). Even so, *Clostridium perfringens* in 2000 still showed an overall decrease in abundance across all stations compared to 1991–1998 values (Figure 4-8, Appendices C-1 and C-2).

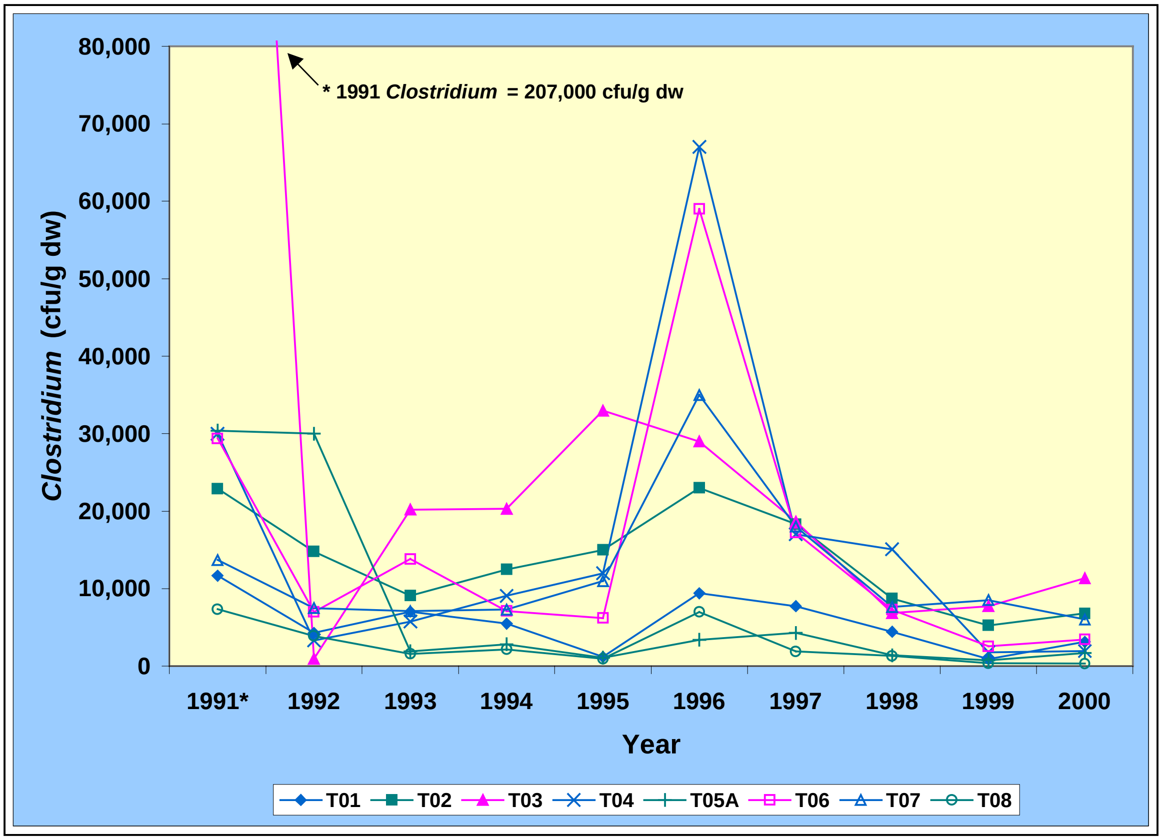


Figure 4-8. *Clostridium perfringens* concentrations in sediments collected at Traditional stations in September 1991 and August 1992–2000.

With few exceptions (*i.e.*, T01 in 1991; T05A in 1991 and 1992), stations T01, T05A and T08 generally had lower *Clostridium perfringens* concentrations (< 10,000 cfu) across all years relative to other Traditional stations (Figure 4-8). In contrast, stations sampled in 1991 and 1996 generally had the highest *Clostridium perfringens* concentrations relative to all other sampling years (Figure 4-8). *Clostridium perfringens* concentrations were high at station T03 in 1991, decreased to less than 1,000 cfu in 1992, increased again in 1993 and remained somewhat consistent until 1997 (20,000 to 30,000 cfu), and decreased in 1998 and 1999 from previous years values (Figure 4-8). While *Clostridium perfringens* concentrations at T03 in 1991 were high relative to other Traditional stations, the concentrations are not unusually high considering that sludge discharges were still ongoing.

Comparison of April and August Surveys—April and August station mean values (raw and normalized to percent fines and TOC) were determined for each sampling year and season. A scatter plot depicting April (x-axis) and August (y-axis) *Clostridium perfringens* concentrations was prepared to evaluate seasonal trends for common sampling years from 1993 to 2000 (Figure 4-9). With the exception of some stations in 1993 (*i.e.*, T01, T02, T03, T06) and all stations in 1996, *Clostridium perfringens* concentrations were consistently higher at most Traditional stations sampled in April relative to August values (Figure 4-9). *Clostridium perfringens* concentrations in April 1996 appear unusually low.

To attempt to remove variability associated with changes in grain size and TOC, *Clostridium perfringens* concentrations were normalized to percent fines and TOC. Normalization did not improve the correspondence; in fact it degraded it, suggesting that *Clostridium perfringens* concentrations are independent of grain size and TOC factors (compare Figures 4-10 and 4-11 to 4-9).

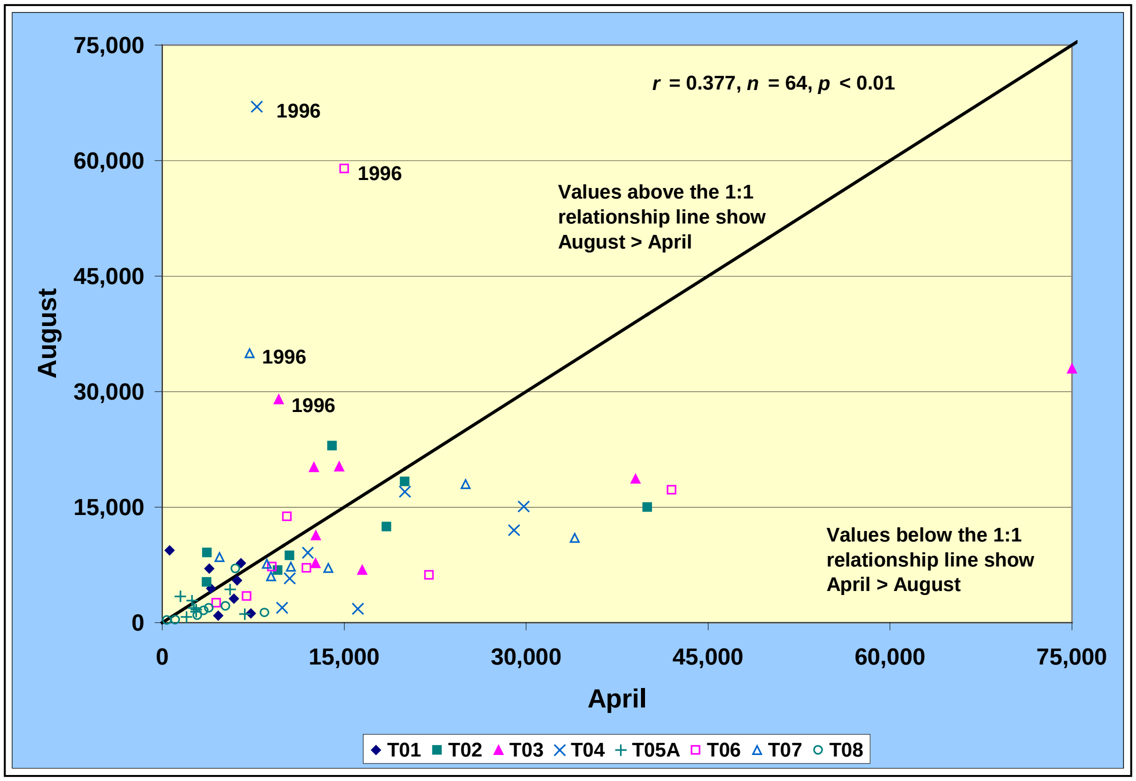


Figure 4-9. Comparison of April and August station mean values for *Clostridium perfringens* (cfu/g dw) from 1993 to 2000.

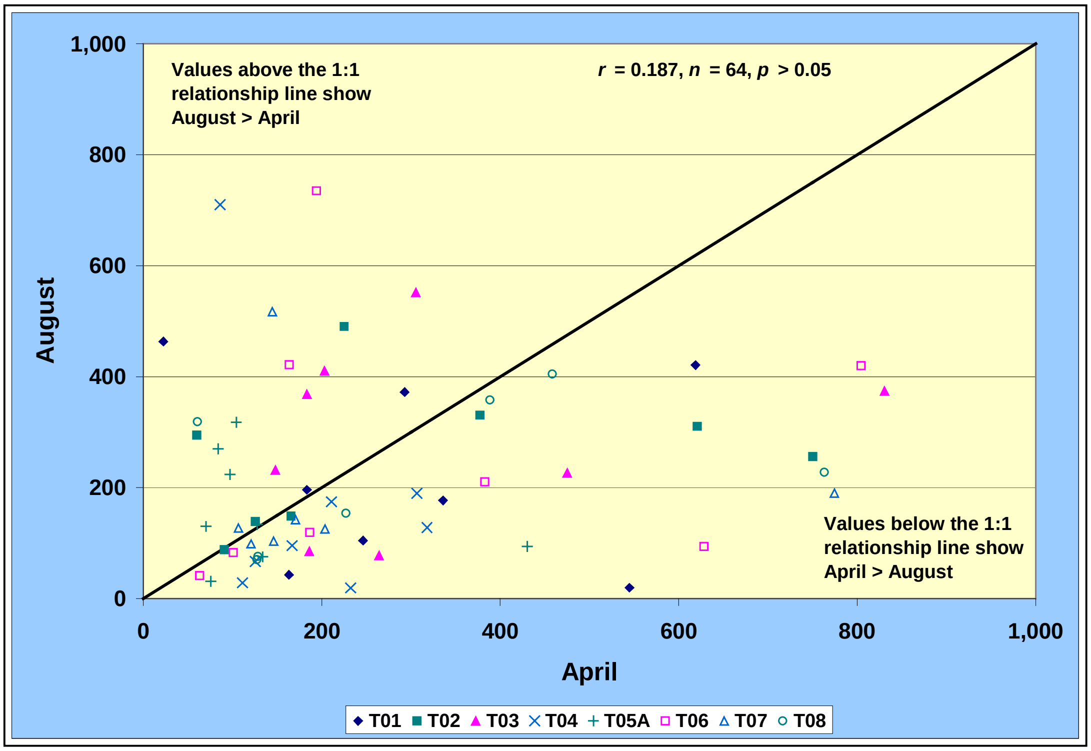


Figure 4-10. Comparison of April and August station mean values for *Clostridium perfringens* (cfu/g dw/% fines), normalized to percent fines, from 1993 to 2000.

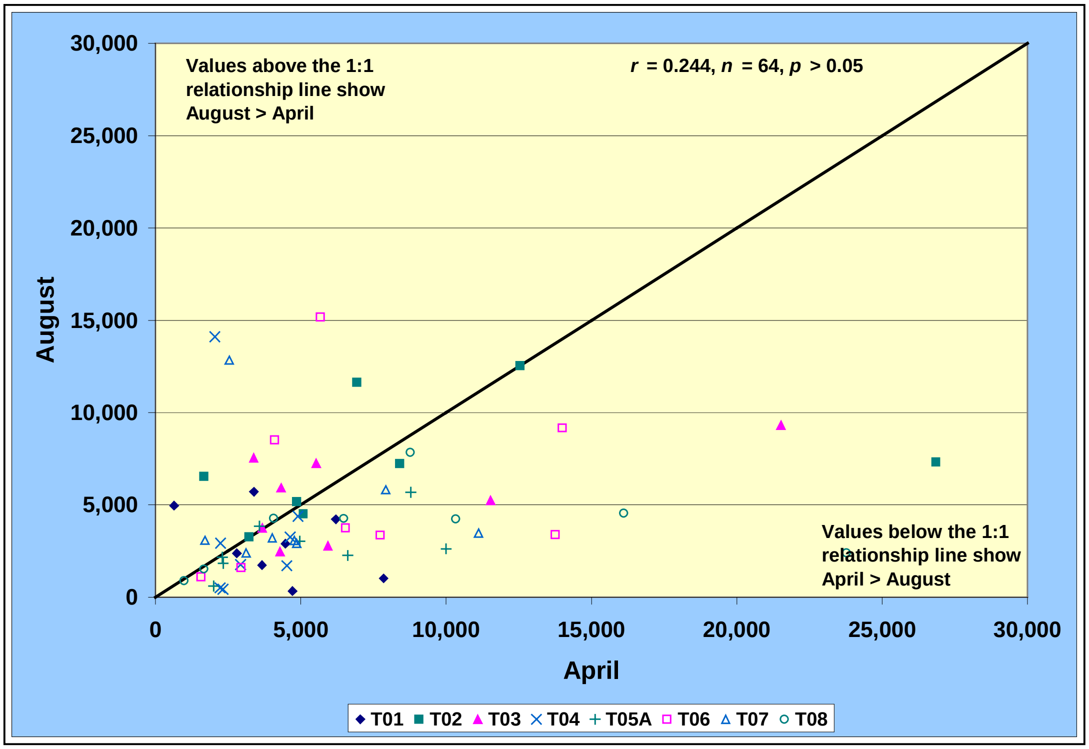


Figure 4-11. Comparison of April and August station mean values for *Clostridium perfringens* (cfu/g dw/% TOC), normalized to TOC, from 1993 to 2000.

4.2.4 Correspondence within Ancillary Measurements

Station mean values from all April and August surveys (Appendices C-2 and C-3) were included in the correlation analysis to evaluate the correspondence within bulk sediment properties and *Clostridium perfringens* over time. Correlation coefficients for April and August surveys were determined by sampling year across all stations and are presented in Table 4-3 and Table 4-4, respectively.

Table 4-3. Correspondence within bulk sediment properties and against *Clostridium perfringens* for April surveys from 1993 to 2000.

Year	TOC by Fines			*Clostridium perfringens* by Fines			*Clostridium perfringens* by TOC		
	r	*n*	*p*	*r*	*n*	*p*	*r*	*n*	*p*
1993	0.909	8	<0.01	0.756	8	<0.05	0.843	8	<0.01
1994	0.896	8	<0.01	0.479	8	>0.05	0.585	8	>0.05
1995	0.883	8	<0.01	0.831	8	<0.05	0.528	8	>0.05
1996	0.914	8	<0.01	0.707	8	>0.05	0.580	8	>0.05
1997	0.351[a]	8	>0.05	0.233[a]	8	>0.05	0.760	8	<0.05
1998	0.807	8	<0.05	0.798	8	<0.05	0.972	8	<0.01
1999	0.759	8	<0.05	0.754	8	<0.05	0.879	8	<0.01
2000	0.929	8	<0.01	0.892	8	<0.01	0.843	8	<0.01

[a] Grain size data for stations T07 and T08 in 1997 are "anomalous". Correlation between percent fines and TOC in 1997 improved when these stations were excluded from the correlation analysis ($r = 0.900$, $n = 6$, $p < 0.05$). Similarly, the correlation between percent fines and *Clostridium perfringens* in 1997 also improved when these stations (T07, T08) were excluded from the correlation analysis ($r = 0.496$, $n = 6$, $p > 0.05$).

Table 4-4. Correspondence within bulk sediment properties and against *Clostridium perfringens* for September 1991 and August surveys from 1992 to 2000.

Year	TOC by Fines			*Clostridium perfringens* by Fines			*Clostridium perfringens* by TOC		
	r	*n*	*p*	*r*	*n*	*p*	*r*	*n*	*p*
1991	0.087[a]	8	>0.05	0.148	8	>0.05	0.552	8	>0.05
1992	0.939	8	<0.01	0.511	8	>0.05	0.381	8	>0.05
1993	0.712	8	<0.05	0.323	8	>0.05	0.561	8	>0.05
1994	0.843	8	<0.01	0.334	8	>0.05	0.660	8	>0.05
1995	0.888	8	<0.01	0.664	8	>0.05	0.762	8	<0.05
1996	0.963	8	<0.01	0.925	8	<0.01	0.919	8	<0.01
1997	0.899	8	<0.01	0.790	8	<0.05	0.712	8	<0.05
1998	0.616[b]	8	>0.05	0.791	8	<0.05	0.906	8	<0.01
1999	0.797	8	<0.05	0.632	8	>0.05	0.344	8	>0.05
2000	0.909	8	<0.01	0.486	8	>0.05	0.417	8	>0.05

[a] Percent fines data for station T08 in 1991 is unusually high (see Appendix C-1, Figure C-1-8). Correlation between percent fines and TOC in 1991 improved when this station was excluded from the correlation analysis ($r = 0.780$, $n = 7$, $p < 0.05$).

[b] TOC data for station T04 in 1998 unusually high, likely due to a storm event in June 1998. The correspondence between percent fines and TOC in 1998 improved when this station (T04) was excluded from the correlation analysis ($r = 0.982$, $n = 7$, $p < 0.01$).

April—With the exception of 1997, sediment grain size correlated strongly with TOC across all years, (Table 4-3, Figure 4-12). Grain size results for stations T07 and T08 in 1997 are clear outliers suggesting that these data are unusual. The correlation between bulk sediment properties and *Clostridium perfringens* in 1997 was also evaluated. Interestingly, *Clostridium perfringens* also correlated poorly against grain size in 1997 (r = 0.233), while the r value was considerably stronger (r = 0.760) when the correlation was performed against TOC (Table 4-3). This suggests that the grain size data for stations T07 and T08 in 1997 are unusual and do not fit typical patterns. The correspondence between percent fines and TOC in 1997 improved considerably when stations T07 and T08 were excluded from the correlation analysis (r = 0.900, n = 6, $p < 0.05$).

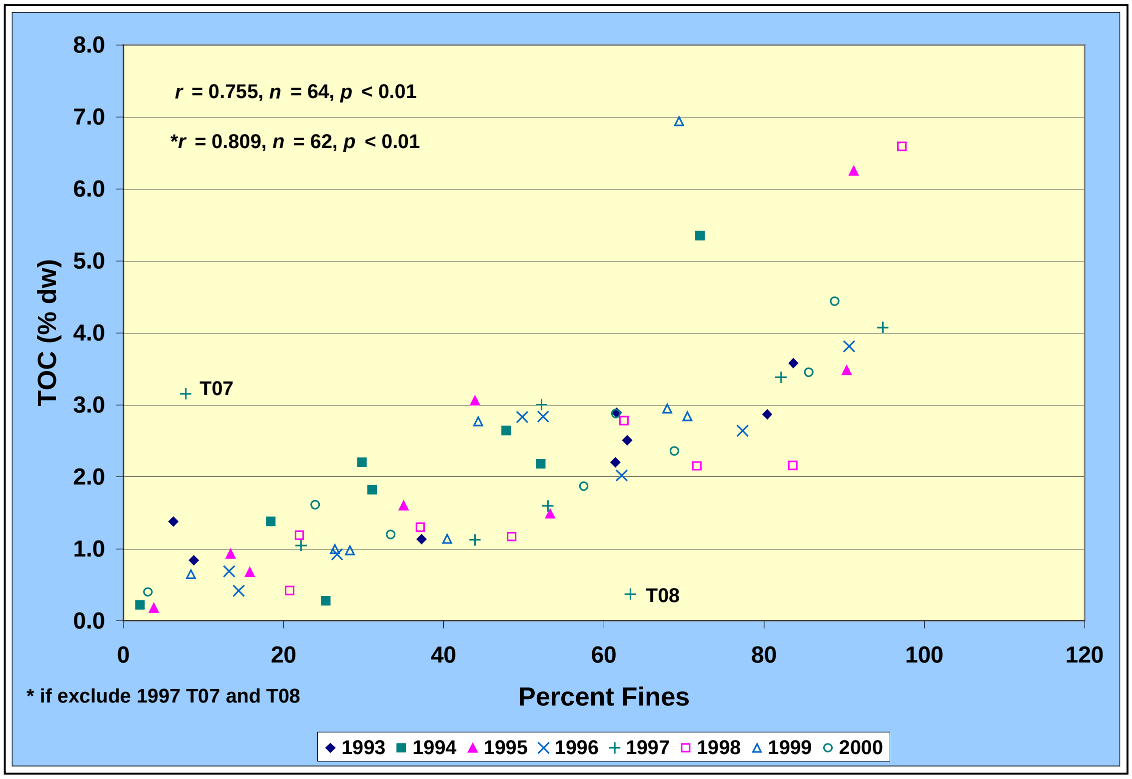


Figure 4-12. Correspondence between total organic carbon content and percent fines in sediments collected at Traditional stations in April 1993–2000.

The correspondence between *Clostridium perfringens* and TOC, and to a smaller extent percent fines, has improved since 1998 compared to earlier years (Table 4-3 and Figure 4-14), suggesting that variability in *Clostridium perfringens* concentrations in the spring is influenced by bulk sediment properties. Further, this suggests that prior to the late 1990s, other factors (*e.g.*, proximity to continuous source) confounded the expected relationship between the tracers and the indicators of how depositional the sites are. With few exceptions (*i.e.*, 1995, 1996, 2000), the correspondence between *Clostridium perfringens* and bulk sediment properties was stronger across all years when the correlation was performed against TOC (Table 4-3).

August—With the exception of 1991 and 1998, sediment grain size correlated strongly with TOC across all years, Table 4-4, Figure 4-15). Station T08 in 1991 had an unusually high percent fines and was a clear outlier on this plot (Figure 4-15). The correspondence between percent fines and TOC in 1991 improved considerably by excluding this station from the correlation analysis (r = 0.780, n = 7, $p < 0.05$, Table 4-4). TOC content at station T04 in 1998 was also a clear outlier and was likely influenced by a storm event in June 1998 (Lefkovitz *et al.* 1999). The correlation between percent fines and TOC in 1998

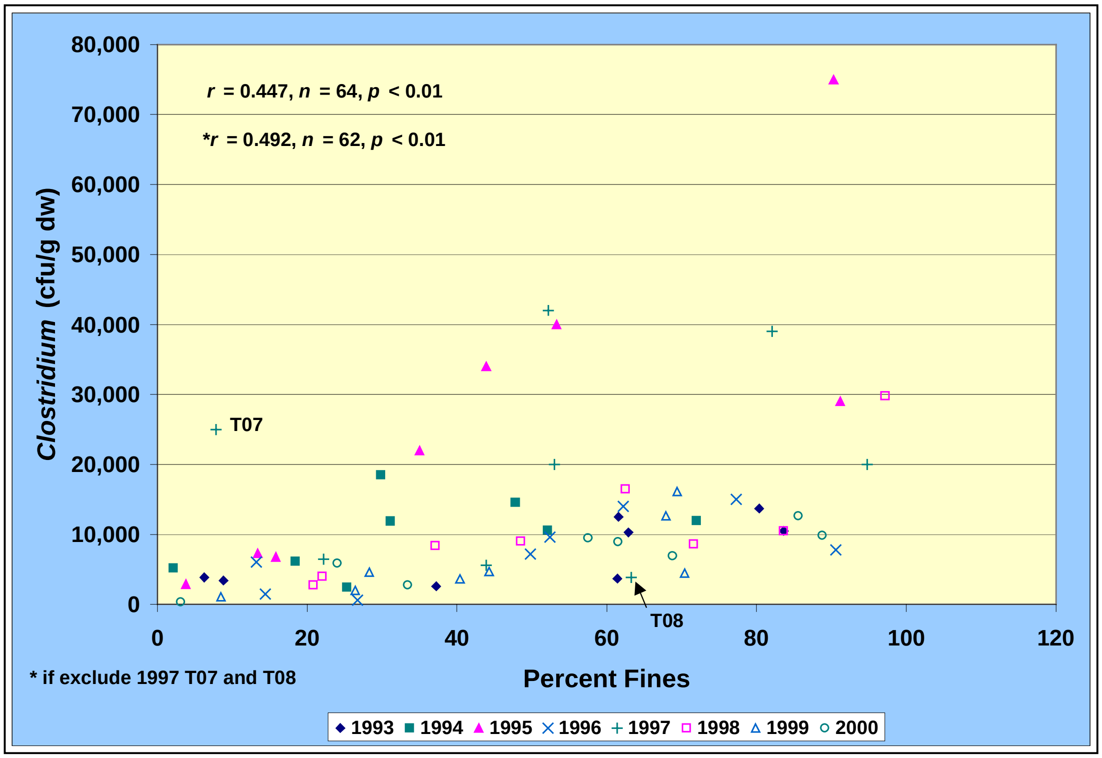


Figure 4-13. Correspondence between *Clostridium perfringens* and percent fines in sediments collected at Traditional stations in April 1993–2000.

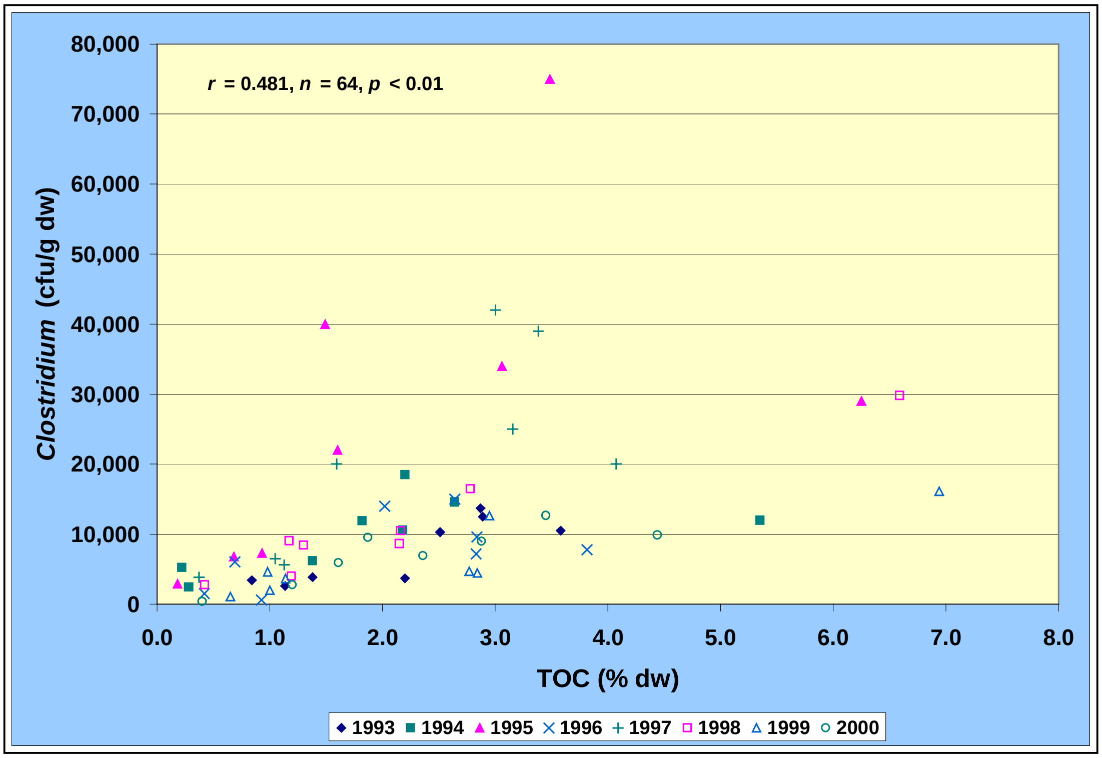


Figure 4-14. Correspondence between *Clostridium perfringens* and total organic carbon content in sediments collected at Traditional stations in April 1993–2000.

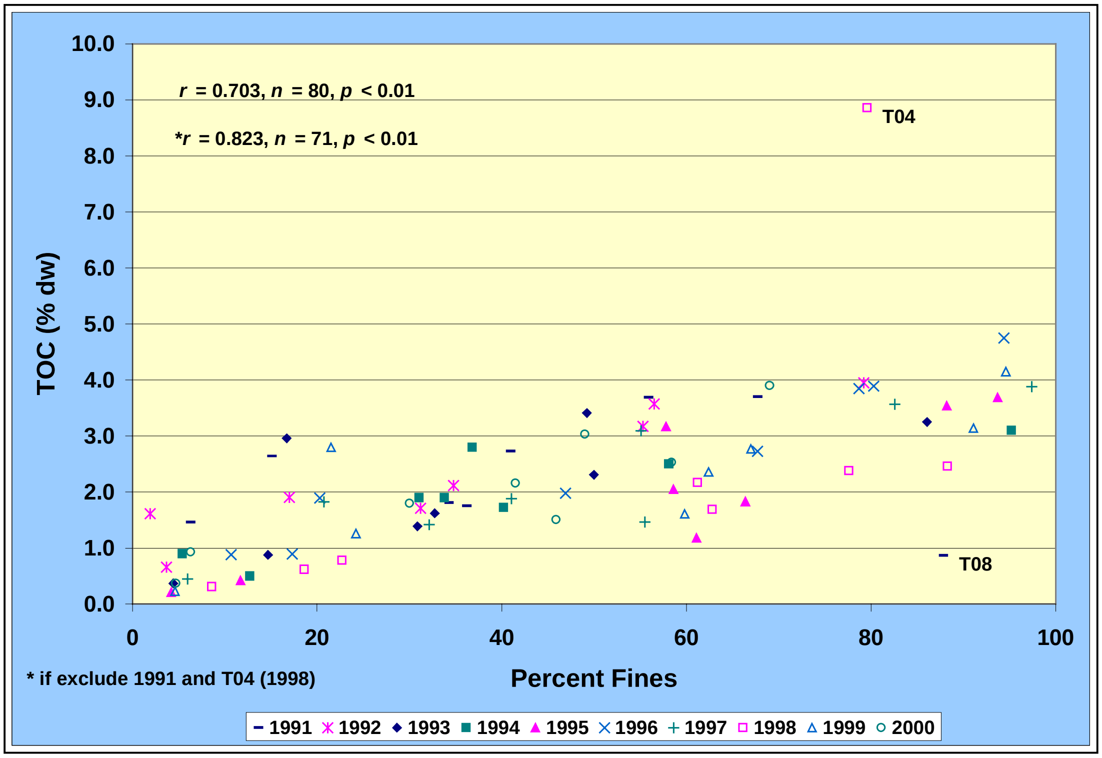


Figure 4-15. Correspondence between total organic carbon content and percent fines in sediments collected at Traditional stations in September 1991 and August 1992–2000.

improved considerably when station T04 was excluded from the analysis ($r = 0.982$, $n = 7$, $p < 0.01$, Table 4-4). The overall correlation between percent fines and TOC across all years, excluding 1991 and station T04 in 1998, also improved considerably ($r = 0.823$, $n = 71$, $p < 0.01$, Figure 4-15).

Clostridium perfringens correlated well with grain size and TOC for some years (*i.e.*, 1996, 1997, and 1998), but not others (Table 4-4). The overall correspondence between *Clostridium perfringens* and percent fines across all years improved considerably when results from 1991 and station T04 in 1998 were excluded from the correlation analysis ($r = 0.417$, $n = 72$, $p < 0.01$, Figure 4-16). Results from 1991 were excluded due to potential influences of sludge disposal to the harbor. Station T04 in 1998 was also excluded due to a likely influence from a storm activity in June 1998.

The correspondence between *Clostridium perfringens* and bulk sediment properties degraded after 1998, suggesting that independent processes are emerging resulting from a decrease in TOC to the system following secondary treatment coming on-line in August 1997 and cessation of Nut Island discharges in July 1998.

With the exception of 1995–1997, the correspondence within bulk sediment properties and against *Clostridium perfringens* was generally stronger in April relative to August surveys (compare *r* values between Tables 4-3 and 4-4). The weaker correspondence in August could be related to either 1) bioturbation and mixing of the surface sediment, 2) TOC burn-off which the earlier presentation (Figure 4-5) suggests is not substantial, or 3) poorer response of the *Clostridium perfringens* spores, *i.e.* not preserved (see Figure 4-9 which suggests August values are lower than April). This could suggest that spores are not as well preserved in the warmer months, or that *Clostridium perfringens* are not a conservative tracer of the effluent. Further examination (*e.g.*, literature review) is warranted to assess bioturbation and survival of *Clostridium perfringens* in sediment and factors that cause it to be preserved or not preserved.

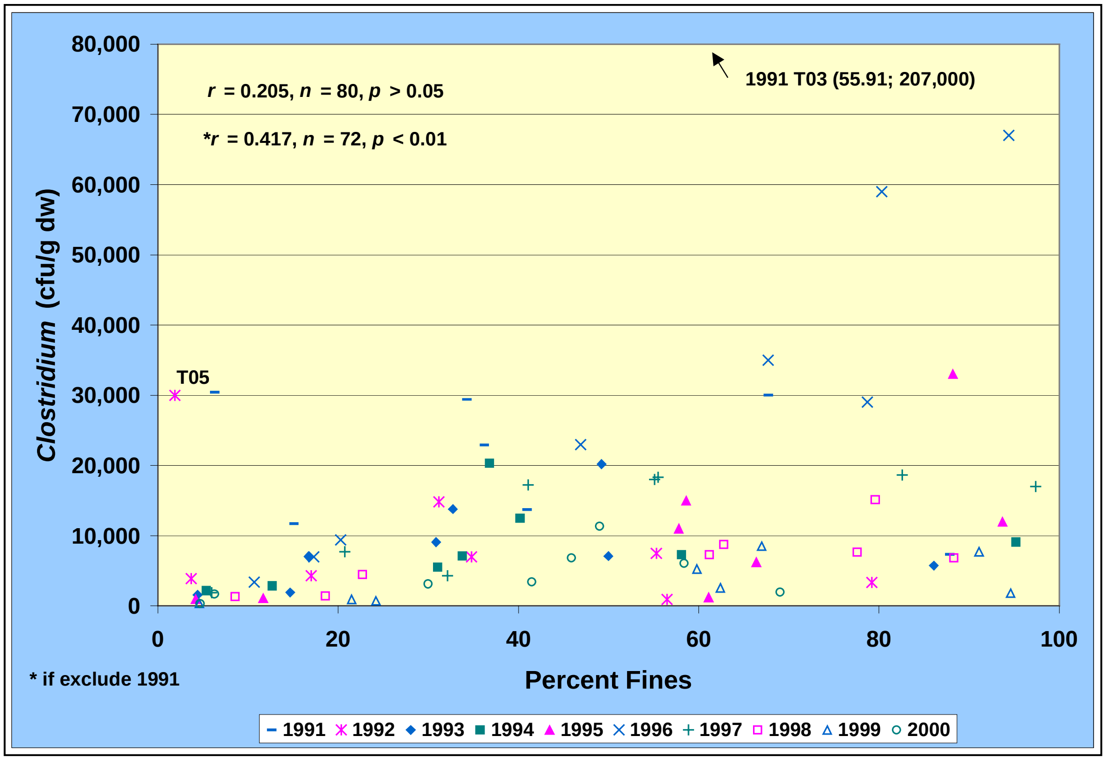


Figure 4-16. Correspondence between *Clostridium perfringens* and percent fines in sediments collected at Traditional stations in September 1991 and August 1992–2000.

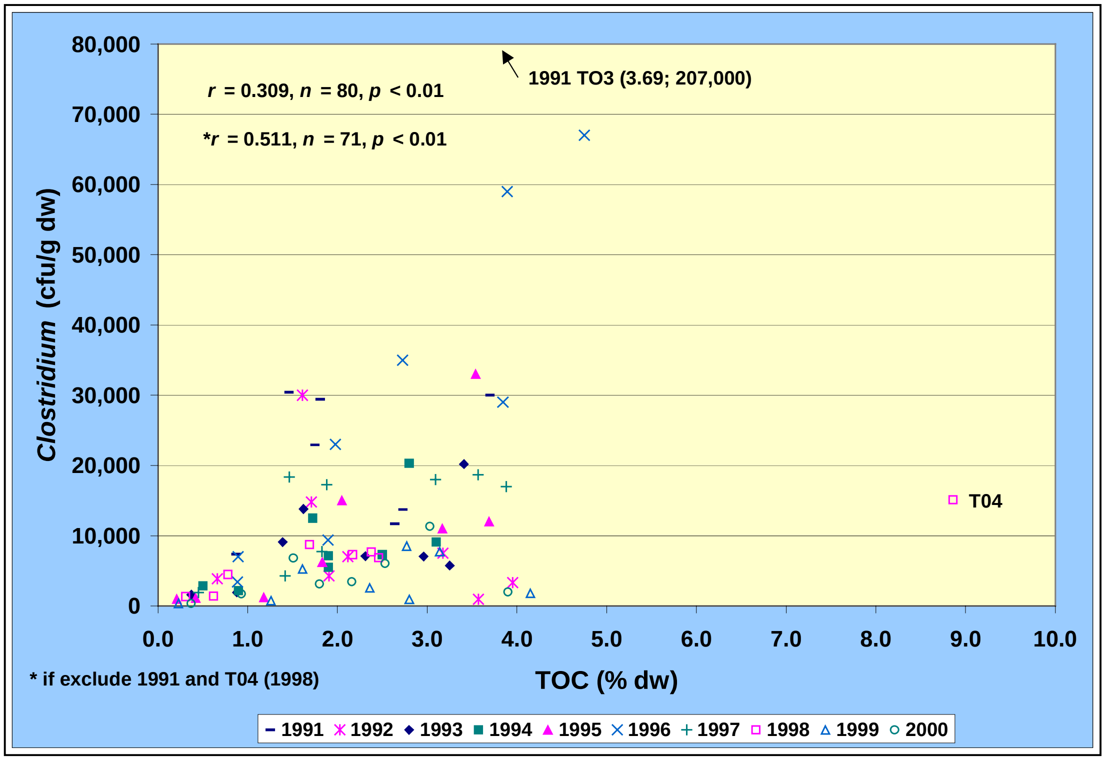


Figure 4-17. Correspondence between *Clostridium perfringens* and total organic carbon content in sediments collected at Traditional stations in September 1991 and August 1992–2000.

4.3 Conclusions

Grain size – Patterns in sediment grain size composition in 2000 were within ranges observed during previous years, suggesting that the spatial and temporal characteristics of sediment grain size in 2000 were not substantially different from previous years (1991–1999). Patterns in sediment composition were consistent between April and August surveys of the eight Traditional Harbor stations.

With few exceptions (April 1997, August 1991 and 1998), grain size and TOC were strongly correlated across all sampling years.

TOC – The spatial and temporal distribution of TOC concentrations during April and August surveys in 2000 was also not substantially different from 1991 to 1999 because of the high variability in the historical dataset.

There were no clear year-to-year trends in TOC between April and August surveys over time. Further, seasonal peaks in TOC were not clearly evident when TOC from the Benthic Nutrient Flux and Traditional Harbor programs were compared. This could be related to station locations and the lower number of stations sampled in the Benthic Nutrient Flux program. Regardless, a more detailed investigation would be required to determine if there is a strong seasonal cycle in TOC within the sediment of Boston Harbor.

Clostridium – Variability in *Clostridium perfringens* concentrations appeared to settle down over time and between 1998 and 2000 the system seemed to be more stable. In addition, the overall abundance of *Clostridium perfringens* spores appeared to decrease since 1998, suggesting that *Clostridium perfringens* has shown a response to facility improvements implemented to clean-up Boston Harbor (*e.g.,* secondary treatment and the cessation of Nut Island discharges), demonstrating that *Clostridium perfringens* have served as a good tracer.

Clostridium perfringens results for April surveys generally correlated well with bulk sediment properties in recent years, indicating that grain size and TOC are likely controlling factors in the spring. Interestingly, the correlation between *Clostridium perfringens* and bulk sediment properties for August surveys degraded after 1998, suggesting that independent processes (*e.g.*, bioturbation) are emerging resulting from a decrease in TOC to the system following secondary treatment coming on-line in August 1997 and cessation of Nut Island discharges in July 1998.

Further, the correspondence between *Clostridium perfringens* and bulk sediment properties was generally weaker in August compared to April, which may be contributed to either bioturbation and mixing of sediment, TOC burn-off, or poor preservation of *Clostridium* spores during the warmer months. Additional review of the data and literature is recommended to evaluate bioturbation and survival of *Clostridium perfringens* in sediment and factors that cause it to be preserved or not preserved. Additionally, as the source of sewage contamination decreases, the continued use of *Clostridium perfringens* as a tracer should be evaluated to consider it's overall value.

5.0 2000 SOFT-BOTTOM INFAUNAL COMMUNITIES

by Robert J. Diaz and Roy K. Kropp

5.1 Methods

5.1.1 Laboratory Analyses

Samples were rinsed with fresh water over 300-μm-mesh screens and transferred to 70–80% ethanol for sorting and storage. To facilitate the sorting process, all samples were stained in a saturated, alcoholic solution of Rose Bengal at least overnight, but no longer than 48 h. After rinsing with clean alcohol, small amounts of the sample were placed in glass dishes, and all organisms, including anterior fragments of polychaetes, were removed and sorted to major taxonomic categories such as polychaetes, arthropods, and mollusks. After samples were sorted, the organisms were sent to taxonomists for identification and enumeration. Identifications were made at the lowest practical taxonomic level, usually species. Taxonomic responsibilities for the 2000 Boston Harbor studies are listed in Appendix D-1.

About 10% of the animals present in sample T06 replicate 1 (HT00202F), collected in Summer 2000, were in poor condition (*i.e.*, they appeared partly decomposed). This problem was most notable for *Ampelisca* and *Polydora cornuta*. The poor condition made it difficult to obtain accurate identifications and counts. Abundance results for sample T06 replicate 1 will be qualified by MWRA to indicate that the abundance data are questionable. The qualifier used to flag these data was defined by MWRA, as "w – this datum should be used with caution, see comment field."

Sample T03 replicate 3 (HT00205FFA1), collected in Summer 2000, was lost during shipment to the sorting laboratory.

5.1.2 Data Analyses

Preliminary Data Treatment — Prior to performing any of the analyses of the 2000 and 1991–2000 MWRA datasets, several modifications were made. Several non-infaunal taxa were excluded (listed in Appendix D-2). Data for a few taxa were pooled. Usually this involved pooling data for a taxon identified to a level higher than species (*e.g.*, genus) with those data for a species within the higher taxon. This pooling was done only when only a single species of the higher taxon was identified. For example, *Unciola irrorata* (an amphipod) was the only species of the genus found in the Harbor, so that any amphipods identified only to the genus (*Unciola* spp.) were treated as if they were *U. irrorata*. Because the identification of some taxa has been inconsistent through the duration of the project, data for some species were pooled to a higher-level taxon. For example, the polychaetes *Pholoe tecta* and *Pholoe* spp. were merged with *Pholoe minuta* for these analyses. It is likely that the two taxa are the same species, but have not been consistently identified throughout the program. All such changes are listed in Appendix D-2.

Faunal data treatments in this report largely follow those used in the 1999 harbor monitoring report (Kropp *et al.* 2001). All analyses performed in this report that involve multi-year comparisons were performed on a unified dataset that was treated consistently. Therefore, all comparisons within this report are internally consistent.

A "SAMPLE_ID" to "STAT_ID" and "REP" conversion table for the 2000 samples is provided in Appendix D-2.

Diversity Analysis — The software package BioDiversity Professional, Version 2 (© 1997 The Natural History Museum / Scottish Association for Marine Science) was used to perform calculations of total species, log-series alpha, Shannon's Diversity Index (*H'*), the maximum *H'* (Hmax), and Pielou's Evenness (*J'*). Shannon's *H'* was calculated by using $\log_2$ because that is closest to Shannon's original intent. Pielou's (1966) *J'*, which is the observed *H'* divided by Hmax, is a measure of the evenness component of diversity. BioDiversity Pro is available at http://www.sams.ac.uk/dml/projects/benthic/bdpro/indep.htm. Magurran (1988) describes all of the diversity indices used here.

5.1.3 Total Species Richness Analysis

The general approach outlined by Brown *et al*. (2001) was used to examine total species richness in the Boston Harbor system (*i.e*., all stations combined). The purpose of this analysis was to detect large-scale patterns in species richness that might offer insights not available from analyses performed at smaller scales (*i.e*., per sample). The first step in the analysis was to pool data from all Harbor stations within one year, then to create a simple presence-absence matrix in which a species was counted as "present" if it appeared at least one station during the year, that is, no weight was given to abundance or the numbers of stations at which a species occurred. After the matrix was constructed, the next step determined the year-to-year change in the composition of species present in the Boston Harbor system by tallying the number of species present in one year that were not present in the preceding year and the number absent in a year that were present the year before. The next step examined the effect on species richness if either appearances species or disappearances of species was the only process operating on the system. This was done by using the September 1991 data set as a starting point and tallying the numbers of initial appearances in a year of species that were not seen in 1991 (appearances) and by counting the number initial disappearances in a year of species that were found in 1991.

5.1.4 Cluster & Ordination

Cluster analyses were preformed with the program COMPAH96 (available on E. Gallagher's web page, http://www.es.umb.edu/edgwebp.htm), originally developed at the Virginia Institute of Marine Science in the early 1970's. The station and species cluster groups were generated using unweighted pair group mean average sorting (UPGMA) and chord normalized expected species shared (CNESS) to express similarity (Gallagher 1998). For calculation of CNESS the random sample size constant (*m*) was set to 15 for the 2000 data and to 20 for the combined analysis of 1991–2000 data (Kropp *et al.* 2000). For the species analysis, similarity was calculated from normalized hypergeometric standardization of Pearson's product moment correlation coefficient (*r*). In the combined year analysis, 1991–2000, the three replicate grabs for a station were summed. At T03 in Summer 2000 there were only two replicates, so the two replicates were summed and multiplied by 1.5.

5.2 Results and Discussion

5.2.1 2000 Station T06 Sample Handling Problem

The sorting laboratory reported that about 10% of the animals present in stations T06, replicate 1 (HT00202F) collected in Summer 2000 were in poor condition and that the problem was most noticeable for *Ampelisca* spp. and *Polydora cornuta*. The data were examined to determine whether or not this problem had any impact on the resulting analyses. Infaunal total abundance (Table 5-3) was considerably lower for replicate 1 (4,012 individuals) versus the other two replicates (10,505 and 10,247 individuals). The variation among replicates was large (coefficient of variation, CV, = 45%). Although this CV was the highest found for station T06, other Harbor stations have shown much greater variation during some surveys. If the problem affected identification of *Ampelisca* and *Polydora*, then the relative proportion of individuals identified to species might be expected to be lower for replicate 1 than for the other two.

However, the proportion identified to species level was slightly greater for replicate 1 (98%) than for the other two (94–95%). Abundances of *Ampelisca* and *Polydora cornuta* were lower for replicate 1 than for replicates 1 and 2, although this was true for most of the other species identified among the samples. A cluster analysis using Bray-Curtis Similarity (with group average sorting) of the 2000 replicate data (Appendix D-3) showed that replicate 1 from station T06 collected in Summer was more similar to the other two Summer replicates than to any other Harbor sample. While the potential impact of the problem on the data for replicate 1 cannot be discounted completely, the station "signature" was retained by the sample and the possibility that the differences among the replicates simply represents natural spatial variation also can't be convincingly excluded.

5.2.2 2000 Descriptive Community Measures

Abundance — Among individual Harbor samples collected in Spring 2000, infaunal abundance varied about 16-fold, ranging from 366 to 5,858 individuals/0.04 m^2 (9,400–146,450/m^2) at stations T05A (rep 2) and T06 (rep 3), respectively (Table 5-1). Mean (and standard deviation, SD) abundance per sample in Spring ranged from 482 (SD = 31.5) to 5,294 (SD = 965.9) individuals/0.04 m^2 at stations T02 and T06, respectively (Table 5-1; Figure 5-1). Abundance was very variable at station T01 where the values for individual replicates ranged from 376 (rep 3) to 1,865 (rep 1) individuals/0.04 m^2 (Table 5-1). Much of the discrepancy among replicates was attributable to very large numbers of *Polydora* spp. in the rep 1 (1,124) sample versus the rep 2 (124) and rep 3 (33) samples.

Annelid worms were the most abundant higher-level infaunal taxon among the Spring 2000 Harbor samples (Table 5-2). Annelids accounted for more than 89 % of the infauna at 4 of the Harbor stations (T01, T02, T04, T07) sampled in Spring, with the highest percentage, 99 %, at station T04. Crustaceans were the second highest contributors to infaunal abundance at three stations. The highest proportions of crustaceans occurred at stations T06 (45.5%) and T03 (48 %). Molluscs were relatively important contributors to infaunal abundance at two stations; T05A (24 %) and T08 (20.5 %).

Among the Summer samples, infaunal abundance was very low and variable at station T04 (Table 5-3), ranging from 26 to 289 individuals per sample (mean = 130, standard deviation = 139.9). Among the remaining 7 stations, infaunal abundance varied about 24-fold, ranging from 454 to 10,676 individuals/0.04 m2 (11,350–266,900/m^2) at stations T05A (rep 3) and T03 (rep 2), respectively (Table 5-1). Mean (SD) abundance per sample in Summer (excluding station T04) ranged from 602 (194.1) to 10,515 (227.7) individuals/0.04 m^2 at stations T05A and T03, respectively (Table 5-3; Figure 5-2).

Table 5-1. Descriptive ecological parameters for samples collected from Boston Harbor in Spring 2000.

	Abundance Total	Abundance Species[a]	Species	*H'*	*J'*	Log-series Alpha			Abundance Total	Abundance Species[a]	Species	*H'*	*J'*	Log-series Alpha
T01-1 [b]	1865	668	49	4.4	0.8	12.2	**Mean**	T01	1021	547	41	4.2	0.8	10.4
T01-2	822	668	42	3.7	0.7	10.0		T02	482	335	25	3.3	0.7	6.4
T01-3	376	304	32	4.4	0.9	9.0		T03	4320	4158	37	3.1	0.6	5.7
T02-1	516	307	25	3.5	0.7	6.4		T04	1042	866	13	1.9	0.5	2.3
T02-2	475	287	22	3.2	0.7	5.6		T05A	487	370	37	3.8	0.7	10.2
T02-3	454	410	29	3.2	0.7	7.1		T06	5294	5280	36	2.6	0.5	5.3
T03-1	5239	5011	40	3.1	0.6	5.9		T07	489	472	23	2.5	0.6	5.1
T03-2	4465	4357	37	3.1	0.6	5.6		T08	1465	1399	37	3.3	0.6	7.0
T03-3	3257	3105	35	3.0	0.6	5.5								
T04-1	948	907	10	1.9	0.6	1.6	**SD**	T01	764.2	210.2	8.5	0.38	0.10	1.63
T04-2	807	647	15	2.0	0.5	2.7		T02	31.5	66.0	3.5	0.14	0.04	0.79
T04-3	1370	1045	15	1.6	0.4	2.5		T03	998.9	968.5	2.5	0.05	0.01	0.23
T05A-1	541	429	34	3.7	0.7	8.7		T04	293.0	202.1	2.9	0.18	0.08	0.61
T05A-2	366	271	33	3.8	0.8	9.9		T05A	105.0	86.3	5.5	0.09	0.02	1.75
T05A-3	554	410	43	3.9	0.7	12.1		T06	965.9	963.6	0.6	0.07	0.01	0.28
T06-1	4179	4167	37	2.7	0.5	5.6		T07	85.9	83.4	4.0	0.34	0.05	1.19
T06-2	5846	5829	36	2.6	0.5	5.1		T08	355.4	348.3	7.8	0.18	0.03	1.42
T06-3	5858	5843	36	2.6	0.5	5.1								
T07-1	434	423	19	2.4	0.6	4.1	**CV**	T01	75	38	21	9	12	16
T07-2	445	424	27	2.9	0.6	6.4		T02	7	20	14	4	6	12
T07-3	588	568	23	2.3	0.5	4.8		T03	23	23	7	2	2	4
T08-1	1216	1163	33	3.1	0.6	6.3		T04	28	23	22	10	16	27
T08-2	1307	1235	32	3.3	0.7	6.0		T05A	22	23	15	2	3	17
T08-3	1872	1799	46	3.4	0.6	8.6		T06	18	18	2	3	2	5
								T07	18	18	17	13	10	23
								T08	24	25	21	6	4	20

[a] Includes only individuals identified to species
[b] The total abundance figure includes >1,100 Polydora spp.

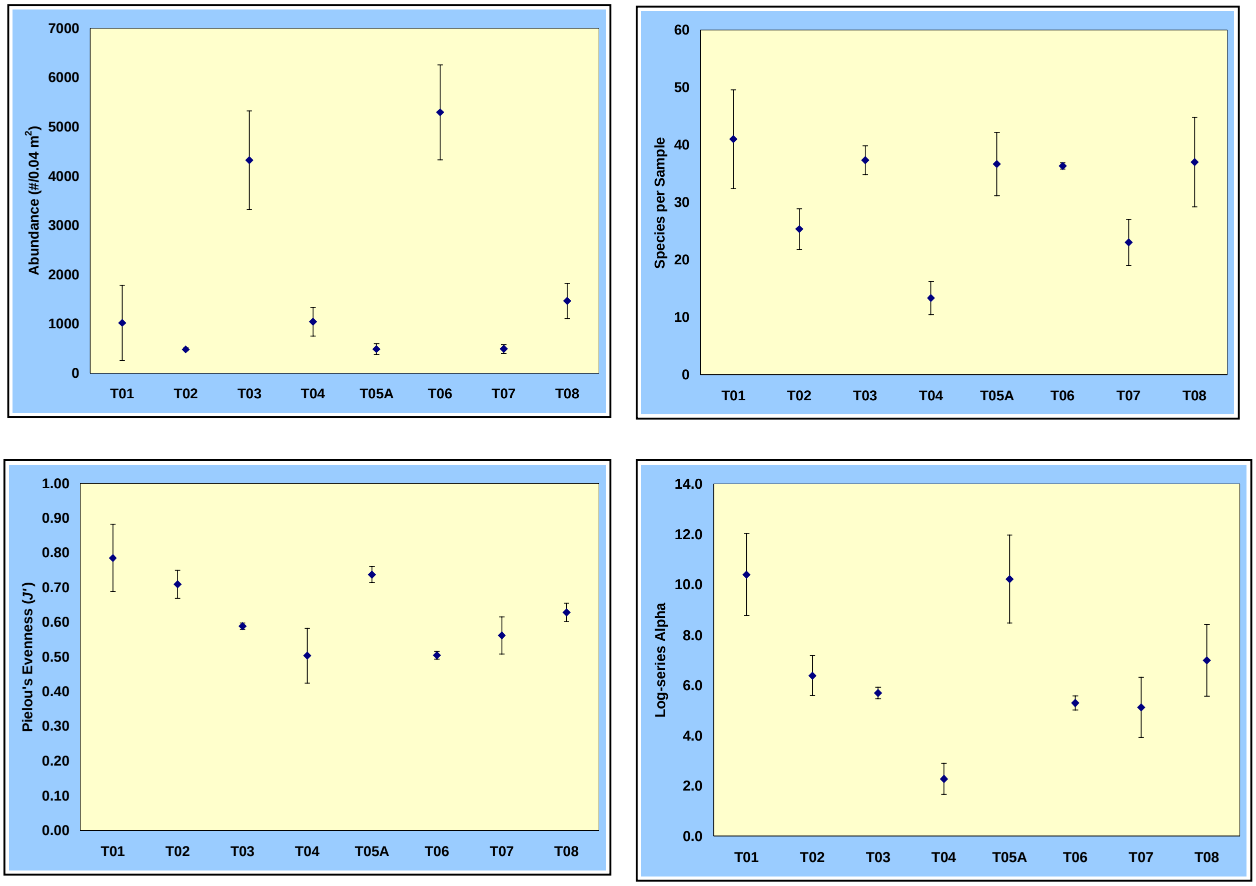


Figure 5-1. Infaunal abundance, numbers of species, evenness, and log-series alpha values for Boston Harbor samples collected in Spring 2000.

Table 5-2. Relative contribution of higher-level taxa to infaunal abundance among Spring 2000 Boston Harbor samples.

	Total Abundance					Percent			
	Annelida	Crustacea	Mollusca	Other	Total	Annelida	Crustacea	Mollusca	Other
T01	909	49	58	4	1021	89.1%	4.8%	5.7%	0.4%
T02	460	5	8	9	482	95.4%	1.1%	1.6%	1.9%
T03	2130	2075	108	7	4320	49.3%	48.0%	2.5%	0.2%
T04	1033	3	5	1	1042	99.1%	0.3%	0.4%	0.1%
T05A	267	94	118	9	487	54.8%	19.3%	24.2%	1.8%
T06	2662	2410	211	11	5294	50.3%	45.5%	4.0%	0.2%
T07	443	36	8	2	489	90.5%	7.4%	1.7%	0.4%
T08	1094	37	300	33	1465	74.7%	2.5%	20.5%	2.3%

Table 5-3. Descriptive ecological parameters for samples collected from Boston Harbor in Summer 2000.

	Abundance Total	Abundance Species[a]	Species	*H'*	*J'*	Log-series Alpha			Abundance Total	Abundance Species[a]	Species	*H'*	*J'*	Log-series Alpha
T01-1	865	846	38	3.5	0.7	8.2	**Mean**	T01	738	719	33	3.4	0.7	7.1
T01-2	654	630	31	3.4	0.7	6.8		T02	995	985	30	2.7	0.5	6.0
T01-3	695	680	30	3.3	0.7	6.4		T03	10515	10443	43	3.2	0.6	5.7
T02-1	874	866	27	2.4	0.5	5.3		T04	130	129	5	0.8	0.4	1.1
T02-2	1566	1557	30	2.6	0.5	5.3		T05A	602	592	22	2.6	0.6	4.6
T02-3	545	532	32	3.1	0.6	7.5		T06	8255	7852	37	2.6	0.5	5.1
T03-1	10354	10271	45	3.2	0.6	6.1		T07	1035	1030	24	2.7	0.6	4.3
T03-2	10676	10615	40	3.2	0.6	5.3		T08	1682	1629	39	3.1	0.6	7.2
T03-3														
T04-1	289	287	5	0.4	0.2	0.9	**SD**	T01	111.9	113.1	4.4	0.11	0.02	0.92
T04-2	26	25	3	0.5	0.3	0.9		T02	521.1	522.8	2.5	0.39	0.07	1.28
T04-3	75	75	6	1.6	0.6	1.5		T03	227.7	243.2	3.5	0.03	0.02	0.57
T05A-1	531	517	24	2.6	0.6	5.2		T04	139.9	139.1	1.5	0.65	0.22	0.38
T05A-2	822	816	23	2.5	0.6	4.4		T05A	194.1	197.9	2.6	0.05	0.03	0.60
T05A-3	454	442	19	2.6	0.6	4.0		T06	3676.5	3383.6	6.0	0.10	0.02	0.61
T06-1	4012	3947	31	2.5	0.5	4.6		T07	309.8	309.2	3.1	0.25	0.07	0.39
T06-2	10505	9904	43	2.7	0.5	5.8		T08	832.6	822.9	8.6	0.03	0.04	1.12
T06-3	10247	9706	38	2.5	0.5	5.0								
T07-1	739	734	21	2.7	0.6	4.0	**CV**	T01	15	16	13	3	2	13
T07-2	1357	1351	27	2.5	0.5	4.8		T02	52	53	8	14	12	21
T07-3	1010	1006	23	3.0	0.7	4.2		T03	2	2	8	1	3	10
T08-1	2460	2392	48	3.1	0.6	8.5		T04	108	108	33	79	61	35
T08-2	804	757	31	3.2	0.6	6.5		T05A	32	33	12	2	5	13
T08-3	1783	1738	37	3.1	0.6	6.6		T06	45	43	16	4	3	12
								T07	30	30	13	9	12	9
								T08	49	51	22	1	7	16

[a] Includes only individuals identified to species

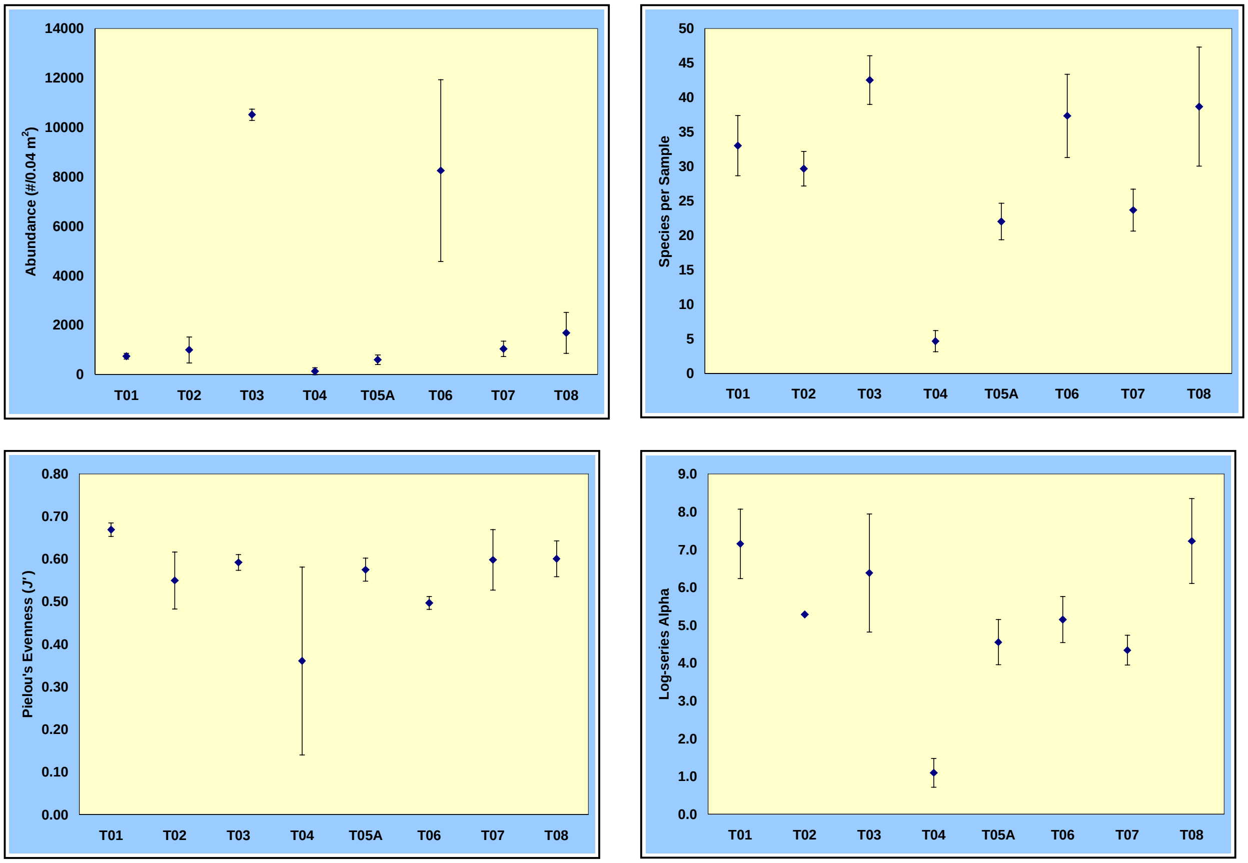


Figure 5-2. Infaunal abundance, numbers of species, evenness, and log-series alpha values for Boston Harbor samples collected in Summer 2000.

Annelids were the most significant contributors to infaunal abundance at seven of the Harbor stations sampled in Summer (Table 5-4). Annelids accounted for 52–97 % of the infauna at the stations where they were the predominant taxon. Crustaceans were the most numerous major taxon at station T06 (64 %) in Summer and were almost as important as annelids at station T03 (46 % versus 52 %, respectively). Molluscs were relatively unimportant contributors to infaunal abundance in Summer except at station T05A where they accounted for 18% of the infaunal abundance.

Numbers of Species — As for abundance, the number of species found at Station T04 in Spring 2000 was low, 10–15 per replicate (mean = 13, SD = 2.9). Among the remaining stations, the total numbers of species per sample collected in Spring 2000 ranged from 19 to 49 at stations T07 (rep 1) and T01 (rep 1), respectively (Table 5-1). In Spring, mean (SD) numbers of species per sample (excluding Station T04) ranged from 23 (4.0) to 41 (8.5) species at stations T07 and T01, respectively (Table 5-1; Figure 5-1).

Among the higher-level taxa collected in Spring, annelid worms contributed the highest percentage of species, accounting for about 44–78 % of the species collected at each Harbor station (Table 5-5). Crustaceans and molluscs accounted for up to 30 % and up to 22 % of the species collected at each Harbor station, respectively.

Table 5-4. Relative contribution of higher-level taxa to infaunal abundance among Summer 2000 Boston Harbor samples.

	Total Abundance					Percent			
	Annelida	Crustacea	Mollusca	Other	Total	Annelida	Crustacea	Mollusca	Other
T01	675	16	46	1	738	91.5%	2.2%	6.2%	0.1%
T02	876	103	16	0	995	88.0%	10.4%	1.6%	0.0%
T03	5472	4858	173	13	10515	52.0%	46.2%	1.6%	0.1%
T04	124	0	5	0	130	95.6%	0.3%	4.1%	0.0%
T05A	445	47	110	0	602	73.9%	7.8%	18.3%	0.0%
T06	2791	5301	157	5	8255	33.8%	64.2%	1.9%	0.1%
T07	1003	14	18	1	1035	96.8%	1.3%	1.7%	0.1%
T08	1138	352	187	5	1682	67.7%	20.9%	11.1%	0.3%

Table 5-5. Relative contribution of higher-level taxa to infaunal species numbers among Spring 2000 Boston Harbor samples.

	Number of Species					Percent			
	Annelida	Crustacea	Mollusca	Other	Total	Annelida	Crustacea	Mollusca	Other
T01	27	8	4	2	41	66.7%	18.7%	10.6%	4.1%
T02	20	2	2	2	25	77.6%	6.6%	6.6%	9.2%
T03	18	11	6	2	37	49.1%	29.5%	17.0%	4.5%
T04	10	1	1	1	13	75.0%	10.0%	7.5%	7.5%
T05A	20	10	3	3	37	55.5%	27.3%	9.1%	8.2%
T06	16	10	8	2	36	44.0%	27.5%	22.0%	6.4%
T07	15	5	2	1	23	66.7%	21.7%	7.2%	4.3%
T08	21	6	7	3	37	57.7%	17.1%	18.0%	7.2%

The number of species found at station T04 in Summer 2000, was very low, 3–6 per replicate (mean = 5, SD = 1.5; Table 5-3). Among the remaining Harbor stations, the total numbers of species per sample collected in Summer ranged from 19 to 48 at stations T05A (rep 3) and T08 (rep 1), respectively (Table 5-3). In Summer, mean (SD) numbers of species per sample (excluding station T04) ranged from 22 (2.6) to 43 (3.5) species at stations T05A and T03, respectively (Table 5-3; Figure 5-2).

Among the samples collected in Summer, the proportional contributions of annelid worms was highest at all stations, accounting for about 47–70 % of the species collected (Table 5-6). Crustaceans and molluscs accounted for about 7–28 % and about 12–36 % of the species collected at each Harbor station, respectively.

Table 5-6. Relative contribution of higher-level taxa to infaunal species numbers among Summer 2000 Boston Harbor samples.

	Number of Species					Percent			
	Annelida	Crustacea	Mollusca	Other	Total	Annelida	Crustacea	Mollusca	Other
T01	22	5	5	1	33	66.7%	14.1%	16.2%	3.0%
T02	21	5	4	<1	30	69.7%	16.9%	12.4%	1.1%
T03	25	10	7	2	43	57.6%	22.4%	15.3%	4.7%
T04	3	0	2	0	5	57.1%	7.1%	35.7%	0.0%
T05A	15	4	3	0	22	68.2%	18.2%	13.6%	0.0%
T06	18	10	7	2	37	47.3%	27.7%	18.8%	6.3%
T07	17	3	4	0	24	70.4%	11.3%	16.9%	1.4%
T08	24	7	6	2	39	61.2%	18.1%	16.4%	4.3%

Diversity — As measured by the traditional Shannon index (*H'*), diversity among Boston Harbor samples collected in Spring 2000 varied from about 1.6 at station T04 (rep 3) to about 4.4 at station T01 (reps 1 and 3; Table 5-1). Evenness (*J'*) among Harbor samples ranged from 0.4 to 0.9 (stations T04, rep 3 and T01, rep 3, respectively). Within-station variation was low (CV ≤ 16) at all stations (Table 5-1; Figure 5-1). Log-series alpha varied considerably among Harbor stations, ranging from 1.6 at station T04 (rep 1) to 12.2 at station T01 (rep 1). Mean (SD) log-series alpha per station ranged from 2.3 (0.61) at station T04 to 10.2–10.4 (1.75–1.63) at stations T05A and T01, respectively (Table 5-3; Figure 5-2). The log-series alpha values calculated for station T01 were the highest reported for any replicate or station mean throughout the 10 years of the harbor study. Within-station variation in log-series alpha among the Harbor stations was relatively low at most stations (CV ≤ 17) (Table 5-1; Figure 5-1).

Diversity (*H'*) among individual Boston Harbor samples collected in Summer 2000 varied from 0.4 at station T04 (rep 1) to about 3.5 at station T01 (rep 1; Table 5-3). In Summer, evenness among Harbor samples except T04 (reps 1 and 2) ranged from 0.5 to 0.7. Within-station variation was low (CV ≤ 12) at all stations except T04 (CV = 61) (Table 5-3; Figure 5-2). Log-series alpha varied considerably among Summer samples, ranging from 0.9 at station T04 (reps 1 and 2) to 8.5 at station T08 (rep 1). Mean (SD) log-series alpha per station ranged from 1.1 (0.38) at station T04 to 7.1–7.2 (0.92–1.12) at stations T01 and T08, respectively (Table 5-3; Figure 5-2). Within-station variation in log-series alpha among the Summer samples was highest at stations T04 (CV = 35, but was generally low (CV < 20) elsewhere (Table 5-3; Figure 5-2).

Most Abundant Species — The 12 most abundant species found at each Harbor station in Spring and Summer 2000 are listed in Appendix D-4. Perhaps the most striking change in the most abundant species in Spring 2000 versus that in previous years was the appearance of *Tubificoides* sp. 2 as the predominant species at stations T01 and T02. There is only one record of this oligochaete worm occurring in the Harbor prior to 2000 (Spring 1995, one individual). Mean abundance of *Tubificoides* sp. 2 at the two stations was 99.3 (SD = 76.2) and 90.7 (SD = 5.1) individuals/0.04 m^2, respectively. *Tubificoides* sp. 2 also occurred at station T04.

Two species of oligochaete worms, *Tubificoides apectinatus* and *T.* nr. *pseudogaster*, were important contributors to abundances at many of the Harbor stations, although less so than in Spring 1999. *T. apectinatus* was the top-ranked species at station T07, whereas *T.* nr. *pseudogaster* was top-ranked at station T06. One or both of the two species occurred among the 12 most abundant species at all other Harbor stations except station T04. At station T04, the polychaete *Capitella capitata* complex (48%) was the most abundant species (Appendix D-4). The amphipod taxon *Ampelisca* spp. was the most abundant taxon at station T03 and the archiannelid polychaete *Polygordius* sp. A was the most abundant species at station T08. *Tellina agilis*, a small clam, was the most abundant species at station T05A. In Spring, the 12 most abundant taxa accounted for about 76–100% of the infaunal abundance at each station.

Compared to Spring 2000, the relative numerical importance of the spionid polychaete, *Polydora cornuta*, was much greater in Summer. *P. cornuta* was the most abundant species at station T02 and ranked among the 12 most abundant species at all other stations except stations T04 and T08. The amphipod *Ampelisca* spp. was the most abundant taxon at stations T03, and T06 and ranked among the 12 most abundant species at all other stations except station T05A. As in Summer 1999, station T04 was numerically dominated by *Streblospio benedicti*, which comprised about 86 % of its total infaunal abundance. In Summer, the 12 most abundant taxa accounted for about 92–100% of the infaunal abundance at each station.

5.2.3 2000 Harbor Multivariate Analysis

Station Patterns — Station cluster analysis of infaunal data based on summed replicates and all 130 taxa that occurred in 2000 indicated that between station similarity was stronger than seasonality (Spring to Summer) in determining station patterns. Spring and Summer samples from Stations T01, T05A, T08, and T04 joined together in individual groups, groups III to VI respectively. Basically, for these four stations the difference between spring and summer species composition and abundance was less than between stations. Seasonal and station differences were about the same for Stations T02 and T07, which formed group II, and for T03 and T06, which formed group I (Figure 5-3). The high degree of separation between the stations in the cluster analysis was indicative of the varied benthic habitats found within the harbor. Station T04, inner Dorchester Bay, continued to be the most dissimilar of all stations and formed the last group to join the dendrogram with the greatest difference in CNESS dissimilarity. Its removal from the analysis did not change the relationship between any of the other seven stations. T04 also had the lowest community structure statistics for both seasons (Tables 5-1, 5-3).

Overall, the cluster grouping of stations reflected the infaunal community response to physical parameters (sediment properties and depth) and associated stressors (organic loading). Groups I, II, and III were composed of finer sediment stations with higher community structure statistics that were predominantly dominated by biological processes with successional Stage II communities; Stations T03 and T06 had *Ampelisca* spp. tube mats, and highest OSI values (Figure 5-3). Groups IV and V, Stations T05A in President Roads and T08 in Hingham Bay, were coarser sediment stations with lower community structure statistics and dominated by physical processes and Stage I communities. Group VI was T04, the most physically stressed (shallowest water depth and RPD layer, and highest TOC) of all the stations.

Group	Station	Season	Mean Phi	Sediment Class	Surface Process	Amphi-pods	SS	RPD (cm)	OSI	Total Abund.	Log-series Alpha
I	T03	Sp	6.9							4320	5.7
	T06	Sp	6.2							5294	5.3
	T03	Su	4.2	SI	BIOG	MAT	II	4.9	9.0	10515	6.4
	T06	Su	4.5	SI	BIOG	MAT	II	2.1	6.3	8255	5.1
II	T02	Sp	5.3							482	6.4
	T02	Su	4.8	SIFS	BIOG	+	I/II	1.0	3.0	995	5.3
	T07	Su	4.7	SIFS	BIO&PHY	-	I/II	1.2	3.7	1035	4.3
	T07	Sp	5.0							489	5.1
III	T01	Sp	3.3							1021	10.4
	T01	Su	3.8	FSSI	PHYS	-	I	1.3	3.7	738	7.1
IV	T05A	Sp	4.4							487	10.2
	T05A	Su	3.0	FSMSGRPB	PHYS	-	I	1.4	3.0	602	4.6
V	T08	Sp	2.5							1465	7.0
	T08	Su	2.5	FSMS	BIO&PHY	-	I	2.5	4.7	1682	7.2
VI	T04	Sp	6.5							1042	2.3
	T04	Su	5.0	SI	PHYS	-	I	0.6	1.3	130	1.1

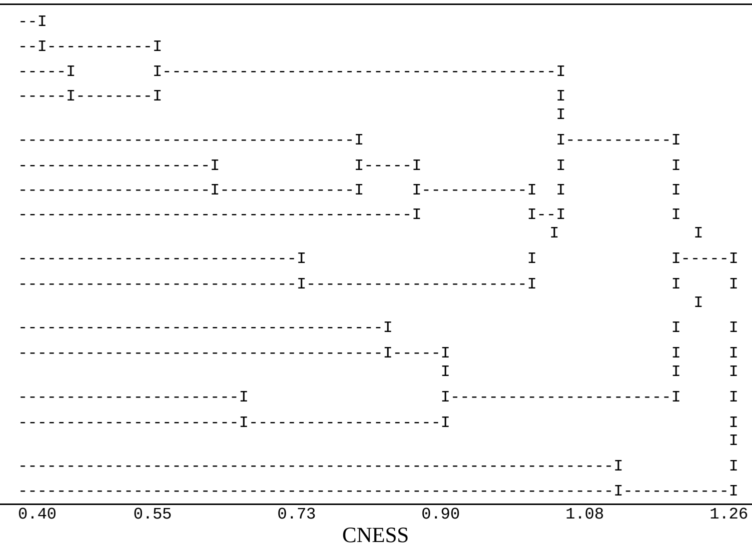


Figure 5-3. Dendrogram for Boston Harbor 2000 infauna, summed replicates with Gallagher's CNESS (*m* = 15) and group average (UPGMA) sorting. Mean Phi is from Spring and Summer grab data (Section 4). Other variables are Summer from sediment profile images (Section 3).

Species Patterns — For the species pattern analysis only taxa with >3 occurrences (66 of 130) were included. At this cut level there was no change in the stations group patterns compared to the analysis with all taxa included. This indicated the dominance exerted by the common taxa over community structure patterns. Five primary species groups formed at about the 0.1 CNESS dissimilarity level with groups B, D, and E containing the top 10 numerical dominants, groups A and B subdominants, and group C the less abundant taxa (Figure 5-4). Many of the species groups were strongly associated with specific stations groups (Table 5-7).

Group A' was composed of the less abundant (grand sum <200 individuals for all grabs), mostly non-polychaete taxa, which were scattered across all station groups. The *Capitella capitata* complex and *Paranais litoralis* formed a distinct subgroup A" that only occurred primarily at T04. Both these species have cosmopolitan distributions and opportunistic life histories, and are known to colonize high organic and disturbed habitats. The other capitellid polychaete in the collection, *Mediomastus californiensis,* occurred at all stations expect T04 and was in subgroup D'.

For the most part group B contained the species dominant at coarser sediment stations (T05 and T08) and represented the sand-dwelling component of the harbor fauna. It was about evenly split into two subgroups, B' having species abundant in both muddy sand group I (*Unciola irrorata*) and sandy groups IV and V (*Spiophanes bombyx* and *Tellina agilis*) and B" species being primarily in group V (*Polygordius* sp. A).

Overall, group C was composed of the least abundant taxa in the analysis (grand sum <100 individuals for all grabs) with *Prionospio steenstrupi* in subgroup C" the only exception. Most of the taxa in-group C were polychaetes with a few amphipod and bivalve species that primary occurrence at silty station group III and had secondary occurrences at all other station groups except VI (T04). *Prionospio steenstrupi*, the most abundant infaunal species at the nearfield stations, and *Dyopedos monacanthus*, a whip amphipod, formed subgroup C" that occurred primarily at group I and were likely associated with biogenic activities of *Ampelisca* spp. *Dyopedos monacanthus* was found to be associated with Ampelisca spp. tube mats in previous years (Kropp *et al*. 2000, 2001).

Group D species was composed primarily of annelids, 12 polychaetes and two oligochaete taxa, with two bivalves, the nemertean *Cerebratulus lacteus*, and *Cancer irroratus* the only decapod in the analysis. Three of the top 10 abundance species, the annelids *Tubificoides apectinatus, Polydora cornuta*, and *Aricidea catherinae,* were in-group D. Subgroup D' species preferred mixed muddy-sand stations and were predominantly found at station groups I, II, and III with >85 to 90% of individuals. Subgroup D", which contained *Streblospio benedicti*, *Ensis directus,* and *Tubificoides* sp. 2, had an affinity for T04. *Streblospio benedicti* was the third most abundant species at Station T04 with about 300 individuals/ 0.12 m^2 in both the Spring and Summer. The dominant species in subgroup D' was the oligochaete *Tubificoides apectinatus*, a common North Atlantic coast marine oligochaete (Brinkhurst 1986), which was the third most abundant species in the 2000 data but did not occur at T04. Many of the group D species corresponded to those comprising a muddy sand-dwelling fauna consistently identified in previous years (see Kropp *et al.* 2000, 2001).

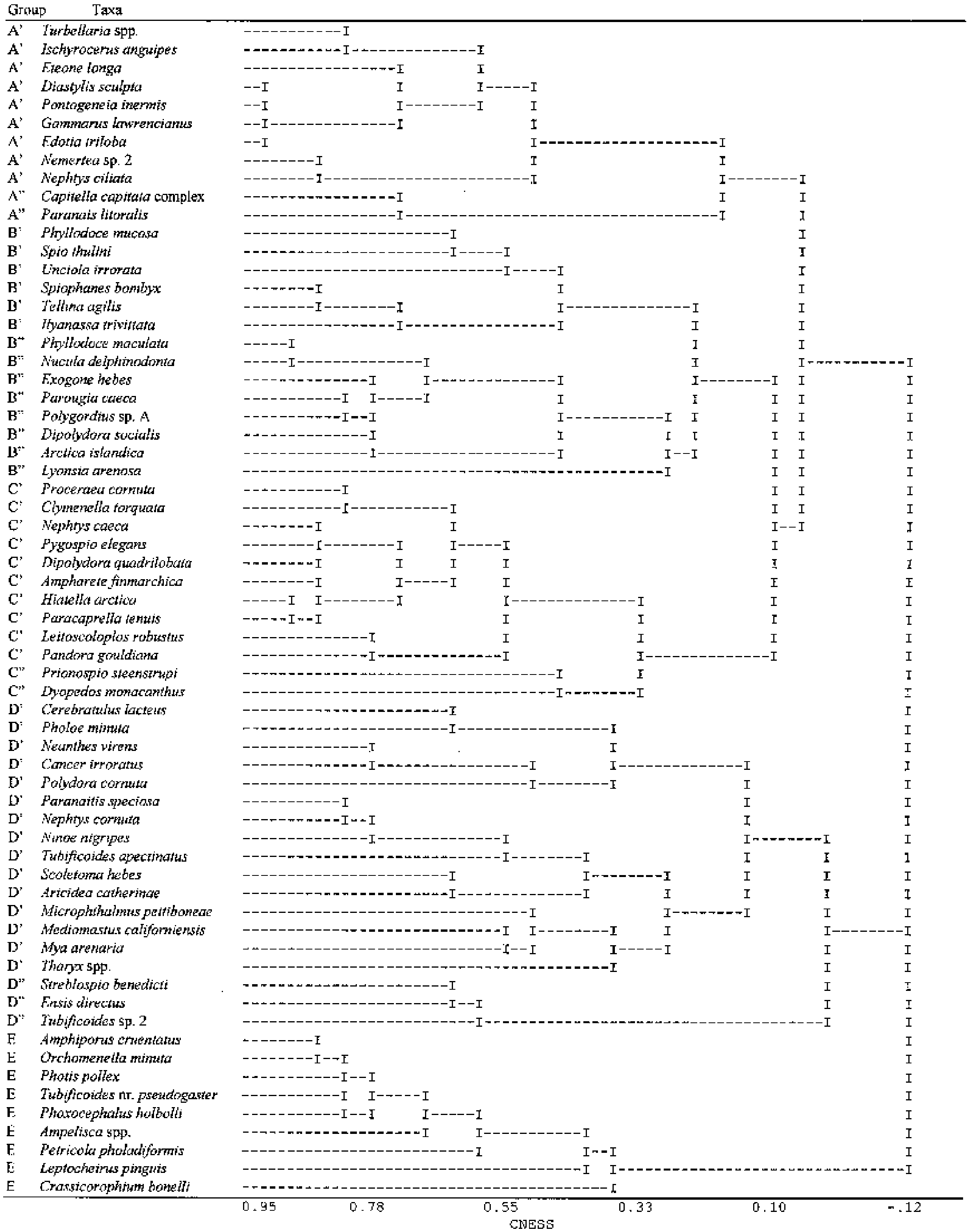


Figure 5-4. Species dendrogram for Boston Harbor 2000 infauna, summed replicates with Gallagher's CNESS (m = 15) and group average (UPGMA) sorting. Taxa with ≤3 occurrences were dropped.

Table 5-7. Average abundance of species (#/0.12 m^2) and percent abundance by cluster group for 2000 harbor infauna. Relationships between stations and taxa are shown in Figures 5-3 and 5-4. Blank indicates the species did not occur in the station group. A zero (0) indicates species abundance was <0.5 individuals/0.12 m2. Occurrence total is based on spring and summer samples (maximum of 16).

			Average Abundance (ind/0.12 m2)						Percent Abundance (%)							
			T03	T02					T03	T02						
Species	Major		T06	T07	T01	T05A	T08	T04	T06	T07	T01	T05A	T08	T04	Total	Numerical
Group	Taxon	Taxa	I	II	III	IV	V	VI	I	II	III	IV	V	VI	Ocurrences	Rank
A'	Tur	*Turbellaria* spp.	2	1	2	2		1	38	13	25	19		6	6	50
A'	Amp	*Ischyrocerus anguipes*	2		8	5			27		45	27			4	46
A'	Iso	*Eteone longa*	1	1	1	2	3	3	9	13	9	17	26	26	7	47
A'	Cum	*Diastylis sculpta*	1	0	1	5	1		20	7	7	60	7		5	51
A'	Amp	*Pontogeneia inermis*	1			4			30			70			4	56
A'	Amp	*Gammarus lawrencianus*	1		3	64		1	3		4	93		1	7	33
A'	Iso	*Edotia triloba*	14	0	1	26	20		36	1	1	35	26		11	32
A'	Nem	*Nemertea* sp. 2	1	6	5	6	2	1	4	44	20	22	6	4	10	41
A'	Pol	*Nephtys ciliata*	2	2		4			35	30		35			6	48
A"	Pol	*Capitella capitata* complex	20	17	16	25	20	618	5	5	2	3	3	82	15	13
A"	Oli	*Paranais litoralis*		1	107	1		416		0	20	0		79	4	20
B'	Pol	*Phyllodoce mucosa*	38	2	3	5	18		73	3	2	5	17		11	29
B'	Pol	*Spio thulini*	10			2	3		83			6	10		7	42
B'	Amp	*Unciola irrorata*	270	3	22	59	24		83	1	3	9	4		13	15
B'	Pol	*Spiophanes bombyx*	2	1	36	535	1114		0	0	2	32	66		11	7
B'	Biv	*Tellina agilis*	89	13	81	239	367	8	20	3	9	27	41	1	16	10
B'	Gas	*Ilyanassa trivittata*	146	11	49	98	151	5	47	4	8	16	24	1	15	18
B"	Pol	*Phyllodoce maculata*	2				3		64				36		5	52
B"	Biv	*Nucula delphinodonta*	60				156		43				57		5	24
B"	Pol	*Exogone hebes*	2		42	5	209		1		16	2	81		8	25
B"	Pol	*Parougia caeca*	1		1		4		18		9		73		4	53
B"	Pol	*Polygordius* sp. A	0	1	1	16	898	1	0	0	0	2	98	0	10	9
B"	Pol	*Dipolydora socialis*	48	15	59	41	472		14	4	8	6	68		14	14

Table 5-7. Average abundance of species (#/0.12 m^2) and percent abundance by cluster group for 2000 harbor infauna. (con't)

			Average Abundance (ind/0.12 m2)						Percent Abundance (%)							
			T03	T02					T03	T02						
Species	Major		T06	T07	T01	T05A	T08	T04	T06	T07	T01	T05A	T08	T04	Total	Numerical
Group	Taxon	Taxa	I	II	III	IV	V	VI	I	II	III	IV	V	VI	Ocurrences	Rank
B"	Biv	*Arctica islandica*	1			1	3		36			9	55		4	54
B"	Biv	*Lyonsia arenosa*	26	4	10		30		52	8	10		30		11	30
C'	Pol	*Proceraea cornuta*	1		2		1		29		57		14		5	63
C'	Pol	*Clymenella torquata*	1	2	15		19		4	9	38		49		8	36
C'	Pol	*Nephtys caeca*			15	6	9				50	20	30		6	38
C'	Pol	*Pygospio elegans*		0	11	4	6	1		2	51	16	26	5	8	44
C'	Pol	*Dipolydora quadrilobata*	2	2	22	1	10	3	7	8	52	1	24	7	9	34
C'	Pol	*Ampharete finmarchica*	1	1	7		10		5	10	33		51		8	45
C'	Biv	*Hiatella arctica*	1	0	1		1		56	11	22		11		7	59
C'	Amp	*Paracaprella tenuis*		1	7		1			17	78		6		4	49
C'	Pol	*Leitoscoloplos robustus*		1	1		2			50	20		30		4	57
C'	Biv	*Pandora gouldiana*	1	1	2		1		27	36	27		9		7	55
C"	Pol	*Prionospio steenstrupi*	39	4	6	3	16		71	7	5	2	14		13	28
C"	Amp	*Dyopedos monacanthus*	12	1	3	1	1		79	9	9	2	2		6	39
D'	Nem	*Cerebratulus lacteus*	1		1		1		63		25		13		5	60
D'	Pol	*Pholoe minuta*	5	4	8		3		32	30	27		11		9	40
D'	Pol	*Neanthes virens*	0	2	1				13	75	13				5	61
D'	Dec	*Cancer irroratus*	1	1	1				33	50	17				5	64
D'	Pol	*Polydora cornuta*	1172	456	228	35	6	84	65	25	6	1	0	2	12	4
D'	Pol	*Paranaitis speciosa*		2	1					75	25				5	62
D'	Pol	*Nephtys cornuta*		145	4					99	1				6	23
D'	Pol	*Ninoe nigripes*	3	11	6		1		17	64	16		3		11	37
D'	Oli	*Tubificoides apectinatus*	1594	588	2	37	18		72	27	0	1	0		13	3
D'	Pol	*Scoletoma hebes*	18	21	9		6		39	45	9		6		11	31
D'	Pol	*Aricidea catherinae*	1322	212	110	20	221		77	12	3	1	6		14	5
D'	Pol	*Microphthalmus pettiboneae*	30	112	289	22	36		10	36	46	3	6		14	17

Table 5-7. Average abundance of species (#/0.12 m^2) and percent abundance by cluster group for 2000 harbor infauna. (con't)

			Average Abundance (ind/0.12 m2)						Percent Abundance (%)							
			T03	T02					T03	T02						
Species	Major		T06	T07	T01	T05A	T08	T04	T06	T07	T01	T05A	T08	T04	Total	Numerical
Group	Taxon	Taxa	I	II	III	IV	V	VI	I	II	III	IV	V	VI	Ocurrences	Rank
D'	Pol	*Mediomastus californiensis*	56	24	13	1	1		64	28	7	1	1		14	26
D'	Biv	*Mya arenaria*	8	2	1		1		75	18	2		5		10	43
D'	Pol	*Tharyx* spp.	261	96	36	76	27	4	61	22	4	9	3	0	16	12
D"	Pol	*Streblospio benedicti*	3	112	92	6		312	1	35	14	1		49	12	16
D"	Biv	*Ensis directus*	0		3	1	1	1	10		50	20	10	10	5	58
D"	Oli	*Tubificoides* sp. 2		100	370			20		34	63			3	6	19
E	Nem	*Amphiporus cruentatus*	19				3		94				6		6	35
E	Amp	*Orchomenella minuta*	422	1	2	6	12		98	0	0	1	1		9	11
E	Amp	*Photis pollex*	820	2	3	19	23	1	97	0	0	1	1	0	13	8
E	Oli	*Tubificoides* nr. *pseudogaster*	3651	15	118	10	58		97	0	2	0	1		13	2
E	Amp	*Phoxocephalus holbolli*	966	1		2	12		99	0		0	1		8	6
E	Amp	*Ampelisca* spp.	6506	99	27	19	482	4	95	1	0	0	4	0	16	1
E	Biv	*Petricola pholadiformis*	77	0	1	1	4		97	0	1	0	2		9	27
E	Amp	*Leptocheirus pinguis*	211	10	6	1	2		94	4	1	0	0		10	22
E	Amp	*Crassicorophium bonelli*	229				1		100				0		5	21

Group E, composed primarily of amphipods, contained four of the top 10 abundant species and was concentrated at station group I (T03 and T06) with 94 to 100% of all individuals (Table 5-7). Very few individuals, 1 to 4%, of group E species occurred in the other stations groups, with virtually none occurring at Station T04. *Ampelisca* spp., which consists of two species (*abdita* and *vadorum*), was about a third of all individuals in 2000. *Ampelisca* spp., which construct a fine-sediment tube that can protrude as much as 2 cm above the bottom, was the primary biogenic structure producer among the infauna and likely provided the substrate or sedimentary conditions for high abundances of the other group E species, such as *Crassicorophium bonelli* and *Tubificoides* nr. *pseudogaster*. The infaunal predator *Amphiporus cruentatus* was also strongly associated with group I stations.

Biogenic activity of *Ampelisca* spp. was very important to infaunal community structure within the Harbor. Removal of *Ampelisca* spp. from the cluster analysis had no affect on the station groupings and little affect on species groupings. Virtually the same taxa rejoined to form similar species groups (Figure 5-5). Species most strongly associated with *Ampelisca* spp. formed group E in both analyses (Figures 5-3 and 5-5). In the no-*Ampelisca* analysis group E included five additional species from groups characterized as having lower abundances and that had similar distributions as the *Ampelisca* spp. One of the additional species was the whip amphipod *Dyopedos monacanthus*, which in the *Ampelisca* analysis grouped with the less abundant taxa in group C. *Dyopedos* sediment profile images showed that *Dyopedos* was associated with *Ampelisca* spp tubes (Kropp *et al*. 1999). Species with no apparent association with *Ampelisca* spp. formed groups A and B in both analyses.

5.2.4 Descriptive Community Measures: 1991–2000 Harbor-wide Patterns

Although the samples collected during the MWRA Harbor monitoring represent many habitats and have shown strong geographic character, there are Harbor-wide patterns of change in the various ecological metrics that have become noticeable. Despite the large variability inherent in collecting samples from different locations within the Harbor, and at different times of the year, it is useful to combine the Harbor data to look for general patterns that might be related to changes in the Harbor's ecosystem resulting from the intense clean-up activities occurring since the early 1990s. Typically, the infaunal communities in the Harbor have shown strong seasonal signals in abundance, species numbers, and diversity. These cyclic changes sometimes obscure within season patterns that may be of interest. Therefore, much of the following presentation considers the Spring and Summer samplings separately.

Abundance — Total infaunal abundance in the Harbor was low in September 1991 (~1,065 individuals/0.04 m^2, Figure 5-6a), increased sharply through Summer 1993 (~5,723 individuals/0.04 m^2), decreased between Summer 1995 and Summer 1996, then increased to its highest value (~7,784 individuals/0.04 m^2) in Summer 1997. The Summer 1997 value represented a seven-fold overall increase in abundance in the Harbor since 1991. Since 1997, infaunal abundance has declined rapidly and steadily, reaching its lowest level in eight years in Summer 2000 (~2,667 individuals/0.04 m^2). This rapid decline represented about a three-fold decrease in abundance in four years. However, the pattern for Spring samples is not the same. Although there was a gradual increase from Spring 1992 through 1996 and a gradual decrease since (Figure 5-6a), abundances were relatively consistent from 1992 through 2000 (CV = 18.4). In summary, abundances in Summer were high from 1992 to 1997 (except 1996), but have declined since while Spring abundances have slowly increased with the result that there was relatively little difference between the two seasons in 2000.

Species Numbers — One of the most noticeable features of the change in species numbers in the Harbor during the monitoring program was the very dramatic increase between Summer 1991 and Summer 1992 (Figure 5-6b) when the number of species per sample almost doubled (from 17 to 32). Since 1992, the changes in species numbers per sample in Summer have not been substantial. The peak number of

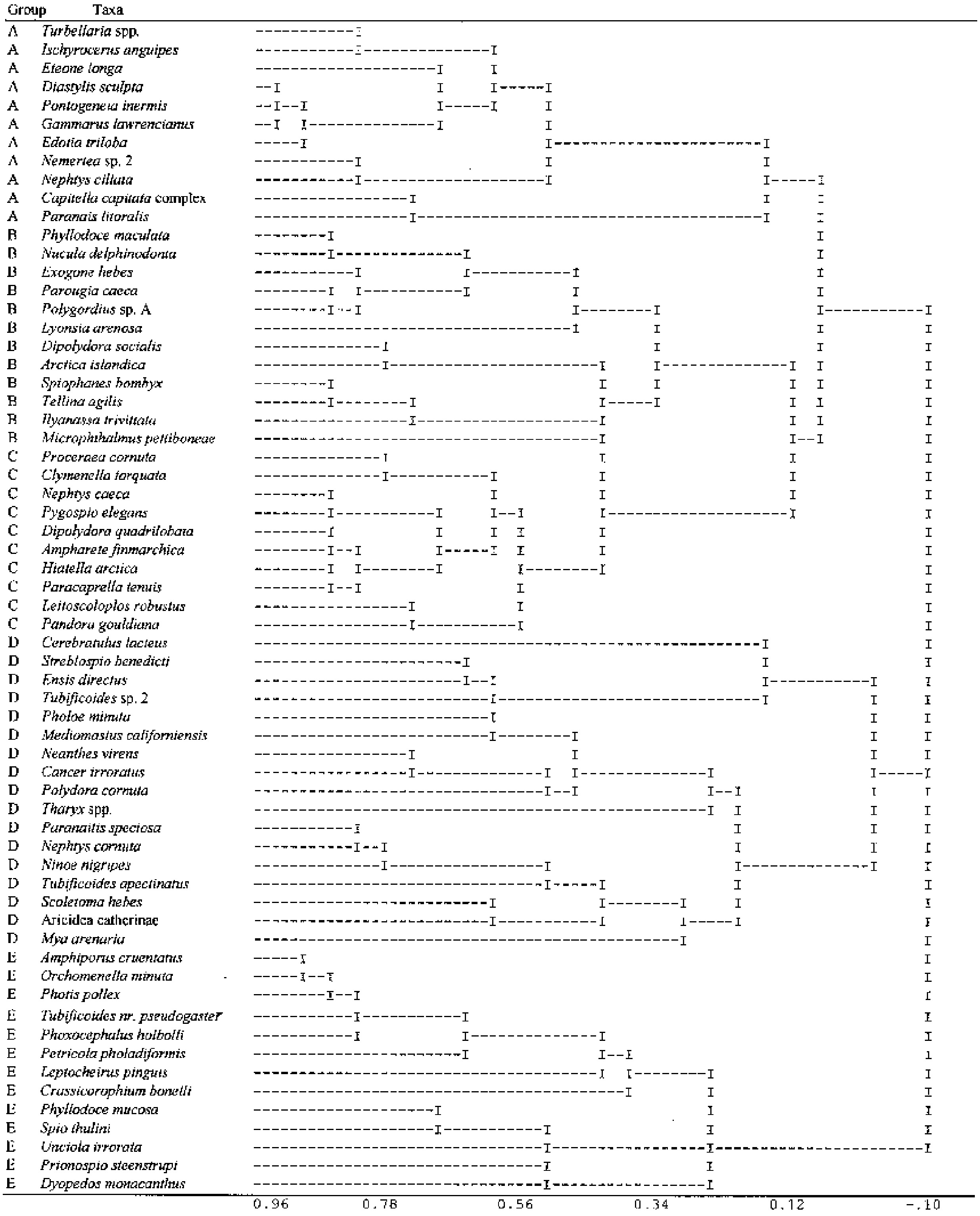


Figure 5-5. Species dendrogram for Boston Harbor 2000 infauna with *Ampelisca* spp. removed, summed replicates with Gallagher's CNESS (m = 15) and group average (UPGMA) sorting. Taxa with ≤3 occurrences were dropped.

species per sample (40) was reached in 1998, but has declined since, reaching the lowest value (28, also found in 1996) found since inception of the monitoring program (Figure 5-6b). In contrast, the number of species per sample found in Spring has increased gradually since 1992 (from 22 to 31). The net effect of these patterns is that from 1992 to 1995 there were considerable differences in the species numbers per sample between Spring and Summer with Summer values being higher. Since then, with the exception of 1998, these differences have been much less distinct, with values in Spring 1996 and 2000 exceeding those found in Summer.

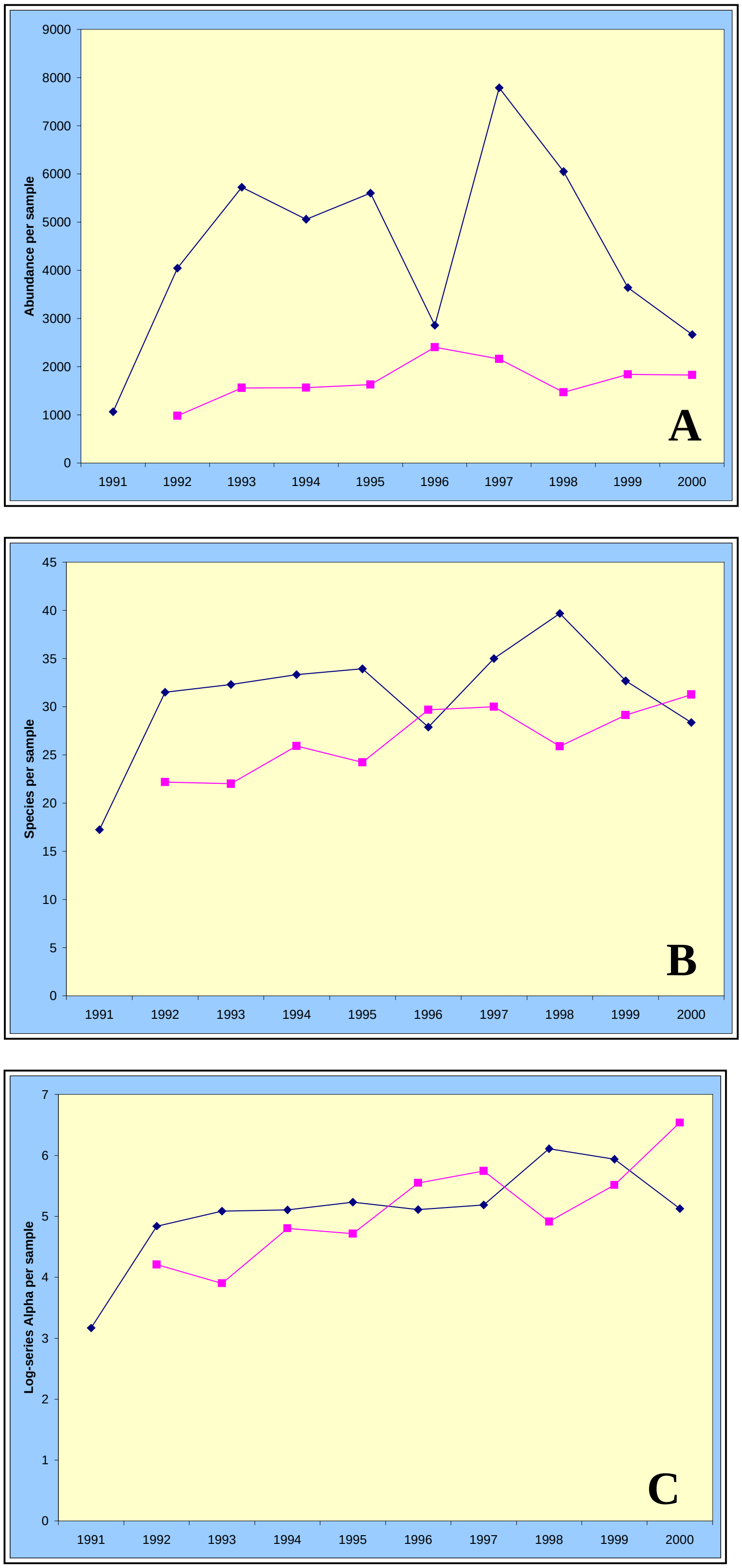
Species Diversity — The patterns shown by average diversity (log-series alpha) per sample are somewhat similar to those shown by species numbers. There was a large increase in diversity between September 1991 and Summer 1992 (from 3.2 to 4.8), but not much change since (except higher values in 1998 and 1999; Figure 5-6c). Again, Spring diversity values have shown a different pattern (Figure 5-6c), gradually increasing throughout the program such that the Spring 2000 value was the highest measured (6.5). As before, it appears the net change has resulted in a lessening of the differences between Spring and Summer samples, especially since 1995–1996.

Total Species Richness — From survey to survey there is considerable change in the species collected among the Harbor samples (Figure 5-7a). As many as 49 species have been found during one survey (Summer 1998) that were not present in the preceding survey. Similarly, as many as 42 species found during a survey may not be found during the ensuing cruise (Summer 1992 to Spring 1993). These total survey-to-survey changes have involved up to 65 species (Spring to Summer 1998).

In addition to the year-to-year changes evident in the Harbor, there has been much overall change since 1991. The species accumulation curve (Figure 5-7b, upper curve) shows that species were added to the Boston Harbor species pool very rapidly, about 19 new species per survey, through Summer 1994. From Spring 1995 through Spring 1998, the rate of species accumulations slowed to about seven new species per survey. The species accumulation rate has slowed even further since Summer 1998, with an average of three new species appearing during each survey. The Summer 1998 survey was unusual in that 15 species not previously found in the Harbor occurred among that survey's samples. The slowing rate of new species accumulations is an indication that the maximum pool of species available to the Harbor's infaunal ecosystem is being approached. The final data point on the species accumulation curve estimates that the pool is currently about 252 species.

The species disappearance curve (Figure 5-7b, lower curve), which records the first disappearance of species found in 1991, shows that rate of species "loss" was relatively high as 24 species found in 1991 had been absent during at least one survey through Spring 1993. This rate of species disappearances has slowed substantially with only three 1991 species being "lost" from Spring 1994 through Summer 2000. This curve provides an estimate of the Harbor infaunal community's "core" species, *i.e*., those present in every survey. This core group is now estimated to be about 34 species.

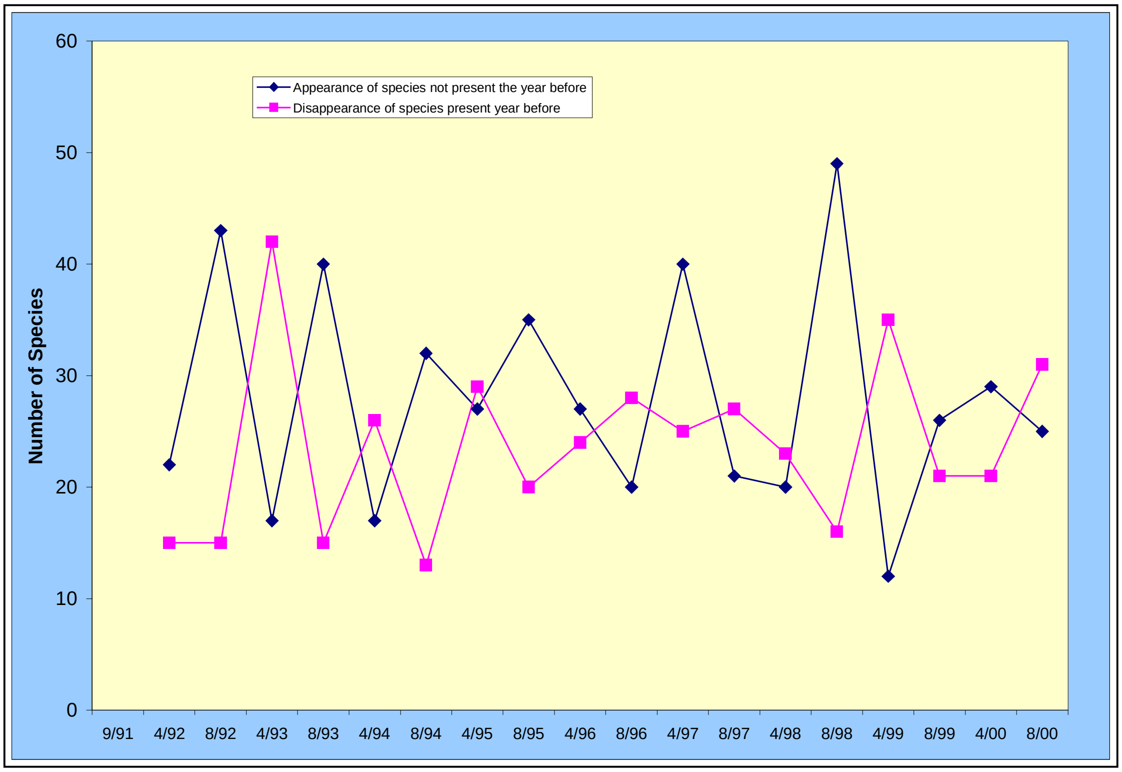
The species number per survey curve (Figure 5-7b, filled circles) shows an interesting trend. During the early monitoring period, there was a strong seasonal difference in the number of species found during a survey with Summer samples always having more species than those from the previous Spring's survey. This pattern was evident from 1992 through 1995. However, the pattern reversed in 1996 and 1997 (Spring samples had more species than Summer samples), and again in 2000. In 1999, the Spring (98) and Summer (101) species numbers were essentially equal.



◆ = Summer ■ = Spring

Figure 5-6. Boston Harbor infaunal abundance (a), number of species (b), and log-series alpha per sample (c) 1991-2000 calculated as mean values of all samples per survey.

A



B

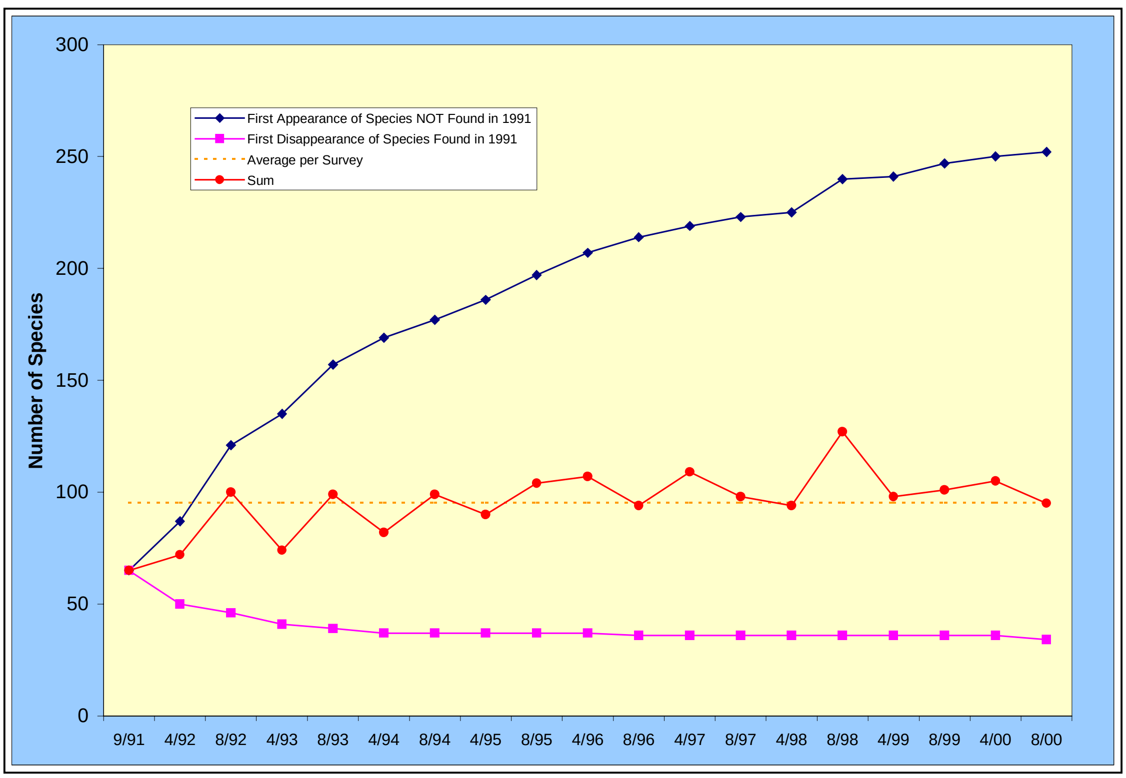


Figure 5-7. Harbor-wide total species richness patterns in Boston Harbor 1991-2000, with all species data pooled, showing year-to-year changes in species numbers (a) and the cumulative species changes (b).

Ancillary Parameters — Given the patterns of change observed in the Harbor infaunal communities during the monitoring program, it is appropriate to look for correlative changes in those communities' physical environment. Certain factors within the physical environment are known to correlate with the infauna that inhabits an area (Snelgrove and Butman 1994). During the Harbor monitoring two of the most reasonable of such features, sediment grain-size distribution and sediment total organic carbon (TOC) content, are measured. The two are often well-correlated with infaunal metric such as abundance, diversity, and species composition.

As mentioned in Section 4, sediment grain-size distribution at most stations has varied somewhat throughout the program. As indicated by the coefficient of variation (CV), stations T04 (CV = 12%) and T08 (CV = 108%) have shown the least and most variation in the percentage of fine sediments (= silt+clay) over the course of the monitoring program. Variation among the remaining stations has been moderate (CVs = 26%–58%). Despite this variation, there do not appear to have been changes within a station that can be related to improvements in the discharges made to the Harbor (*e.g.*, cessation of sludge discharge or changes in effluent discharges). That is, there is no recognizable pattern of change in grain size distribution during the duration of the monitoring. Also, changes in the various infaunal community ecological parameters measured do not appear to be related to changes in grain-size distribution within stations.

Descriptive statistical evaluation (calculation of the CV) of the sediment TOC content has indicated that there has been much variation within stations throughout the monitoring program (Section 4). However, the actual changes in TOC content are relatively minor (except at station T04), especially in terms of what they might mean to the infauna. There have not been large changes in TOC content at the stations most likely affected by the cessation of sludge discharge (T01, T03, T05A), nor effluent (T06, in addition to the previous three). Any of the infaunal community changes that have occurred in the Harbor do not appear to be related to sediment TOC content.

5.2.5 Descriptive Community Measures: 1991–2000 Station Patterns

Abundance — Among Summer samples, infaunal abundance at three stations showed rapid increases early in the program, reaching maximum values in 1992 (T01), 1993 (T06), or 1994 (T02), then declining steadily through 2000 (Figure 5-8). At stations T01 and T02, Summer infaunal abundance in 2000 was similar to (T01) or less than (T02) the abundance during Summer of the year prior to the peak abundance year. The net result is that abundances at these stations now are very similar to what they were prior to the rapid increase in infaunal animals. While the same general pattern also occurred at station T06, the decrease from the peak abundance year to 2000 has not been as great as the decline at the other two stations. The other pattern of interest for these three stations is that the infaunal abundances measured in Spring of each year have not shown the same pattern as the Summer abundances (Figure 5-8). During the monitoring program, Spring abundances have varied, but have not shown a distinct peak year, and are now somewhat similar to what they were early in the program. Spring abundances at station T06, however, showed a relatively gradual increase from 1995 through 1997, but have remained relatively consistent since. At stations T03 and T05A, Summer infaunal abundances have shown two peak years, in 1993 and 1997 (T03), and in 1995 and 1997 (T05A). Between the peak years, abundances declined by almost 50% or more through 1996. In Summer 1997, abundances at these two stations were dramatically higher (by ~14,000–21,000 individuals/0.04 m^2) than they were the previous year. At both stations, these second abundance peaks (21,959 at T03; 21,319 at T05A) were the highest average abundances recorded in the Harbor during the monitoring program. Again the general patterns of infaunal abundances in Spring at these two stations differed from the Summer patterns. During the monitoring program, Spring abundances have fluctuated periodically but were similar in 2000 to what they were earlier in the program. At station T07, the pattern of infaunal abundance in Summer is most similar to that shown by stations T01 and T02 (large increase early in the program, followed by decrease by 2000 to 1991–1992

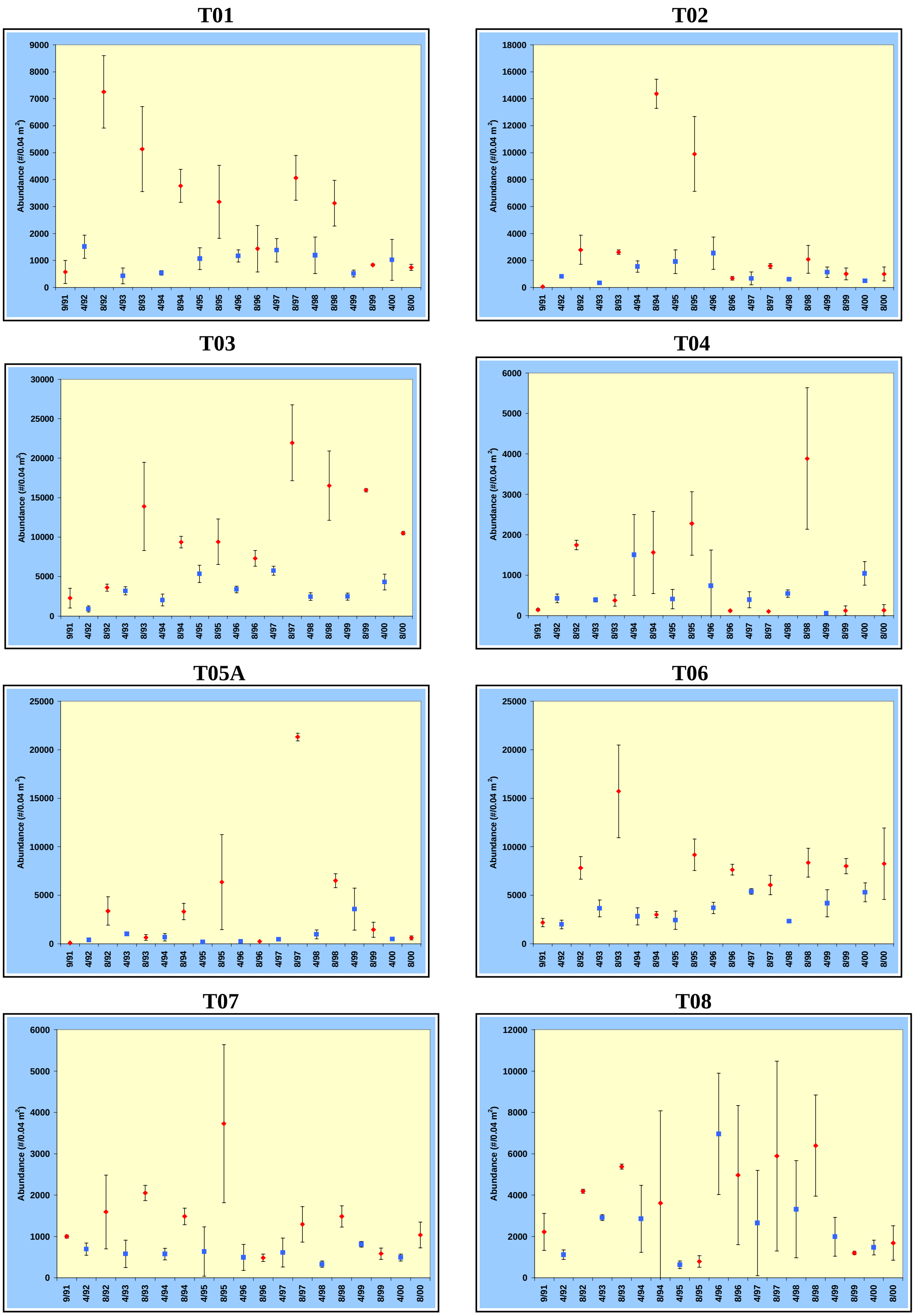


Figure 5-8. Mean and standard deviation abundance per sample (by station) in Boston Harbor 1991-2000. Diamonds denote Summer samples; squares denote Spring samples.

levels), but the peak abundance year was in 1995 (Figure 5-8). Spring abundance at station T07 has been relatively consistent throughout the program. The patterns of infaunal abundance at station T08 are difficult to characterize (Figure 5-8). One of the most noticeable features is the high variability that was in evidence particularly from 1994 through 1998. There has been no single peak abundance year at the station. Spring abundances have fluctuated through out the program about as much as Summer abundances.

Numbers of Species — Patterns of change in the average numbers of species per sample are not easy to characterize at the station-by-station level. One observation is that, in general, at most stations there are likely to be more species found per sample now (2000) than there were very early in the program (1991–1992). This generality is more applicable to the Summer samples than the Spring samples (Figure 5-9). The increase in species numbers is most obvious for stations T01, T02, T03, T06, and possibly T07. It is also true that even though the 2000 species numbers were higher than the those from the early years, they were not the highest recorded at each station during the program. Stations T05A and T08 deviate somewhat from the generality. At station T05A, species numbers increased through 1997, but have declined since then such that the Summer 2000 value (22) was not much greater than the Spring 1992 value (16) and represented a substantial decrease from the peak value (56) recorded in Summer 1997. At station T08, species numbers have fluctuated throughout the program and in 2000 were similar to or slightly less than the 1991–1992 values.

The second general observation is that the earlier portion of the monitoring program showed fairly strong seasonal differences in species numbers with a decrease in numbers from Summer to the following Spring and an increase in numbers from Spring to the following Summer (Figure 5-9). This strong seasonal pattern was evident at most stations until about 1995 or 1996, at which time the pattern weakened considerably or broke down altogether. At several stations, T01, T02, T07, and T08, the seasonal pattern does not appear to have been reestablished. At stations T03 and T06, the seasonal differences in species numbers weakened after 1995, but were not completely lost. It appeared to become reestablished after 1997.

Species Diversity — The most obvious feature of the patterns of species diversity, as measured by log-series alpha, throughout the program is that at every station except station T08 diversity was higher in 2000 than it was in 1991 (Figure 5-10). It is also noticeable that most of the increase in diversity occurred by Summer 1992 and that there generally has been a more modest change since then although there has been some variation from season to season and year to year. Stations T01 and T05A experienced very high diversities in Spring 2000 (log-series alpha > 10), followed by a sharp decline in Summer 2000. At station T05A, the Summer 2000 diversity value was the lowest measured at the station since 1994. Species diversity has been particularly consistent at stations T03 and T06 since 1992. Diversity at station T08 has not shown any discernible pattern during the program and has been relatively consistent, particularly since 1995.

Total Species Richness — Two general patterns are discernible among the species accumulation curves calculated for the harbor stations. The first pattern can be described for stations T01, T02, and T05A. At these stations, the number of species present in 1991 was very low (8–11) at T02 and T05A to moderate (30) at T01. The data for station T02 are used to illustrate this pattern (Figure 5-11). However, by Summer 1992, 42–52 species not seen in 1991 had appeared at each station. Species accumulations have continued at each station since 1992, but at much lower rates. The accumulation rate at station T01 may be slowing as only four species have been added since 1998. The second general pattern in species accumulations within the Harbor occurred at stations T03, T06, T07, and T08. The data for station T06 are used to illustrate this pattern (Figure 5-12). This pattern also included a rapid rate of accumulation from 1991 through 1992, but the rate was much lower (24–29) species than that described above. The rates of species accumulations at each station continued steadily from 1992 to 2000, although the rate at

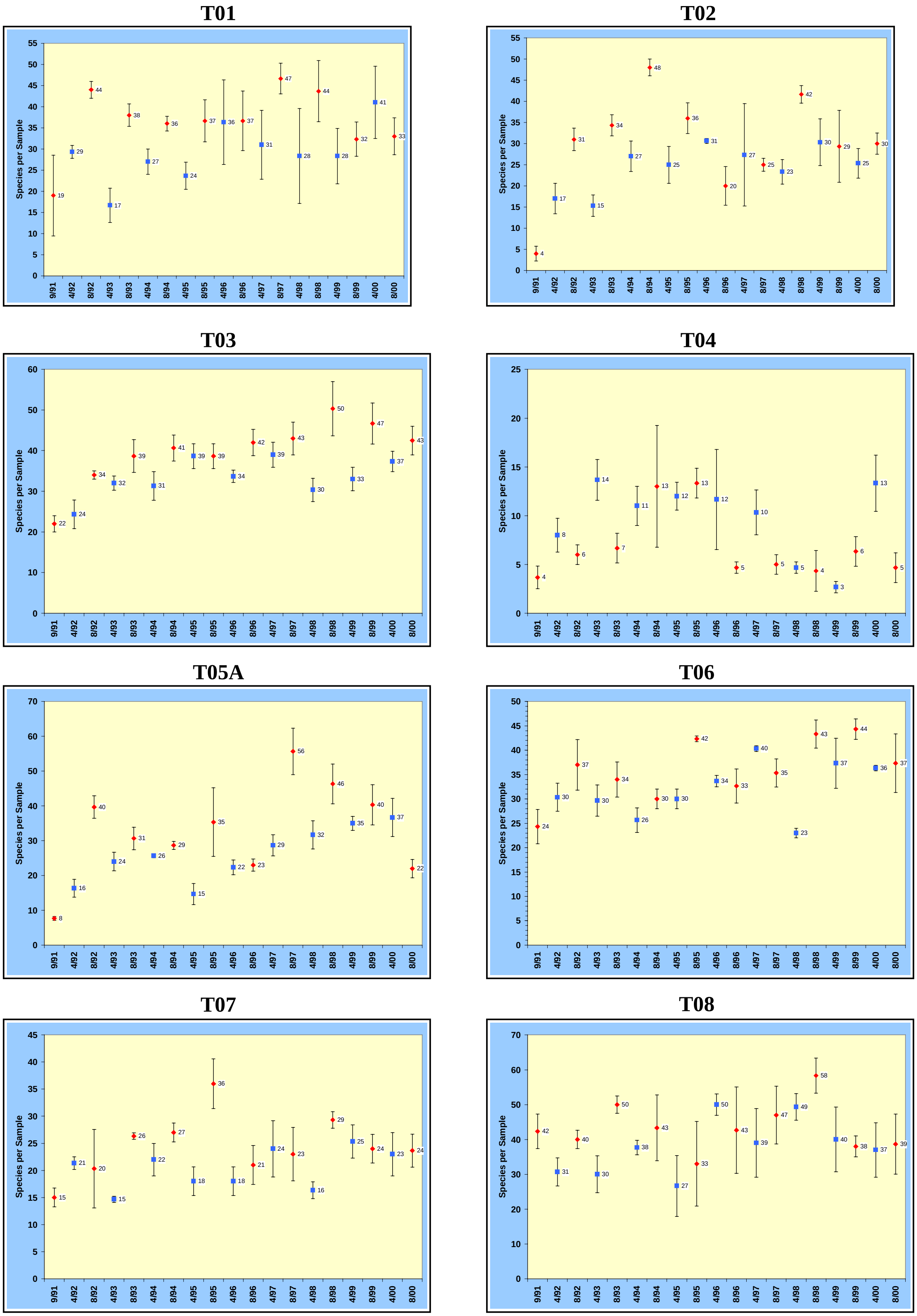


Figure 5-9. Mean and standard deviation number of species per sample (by station) in Boston Harbor 1991-2000. Diamonds denote Summer samples; squares denote Spring samples.

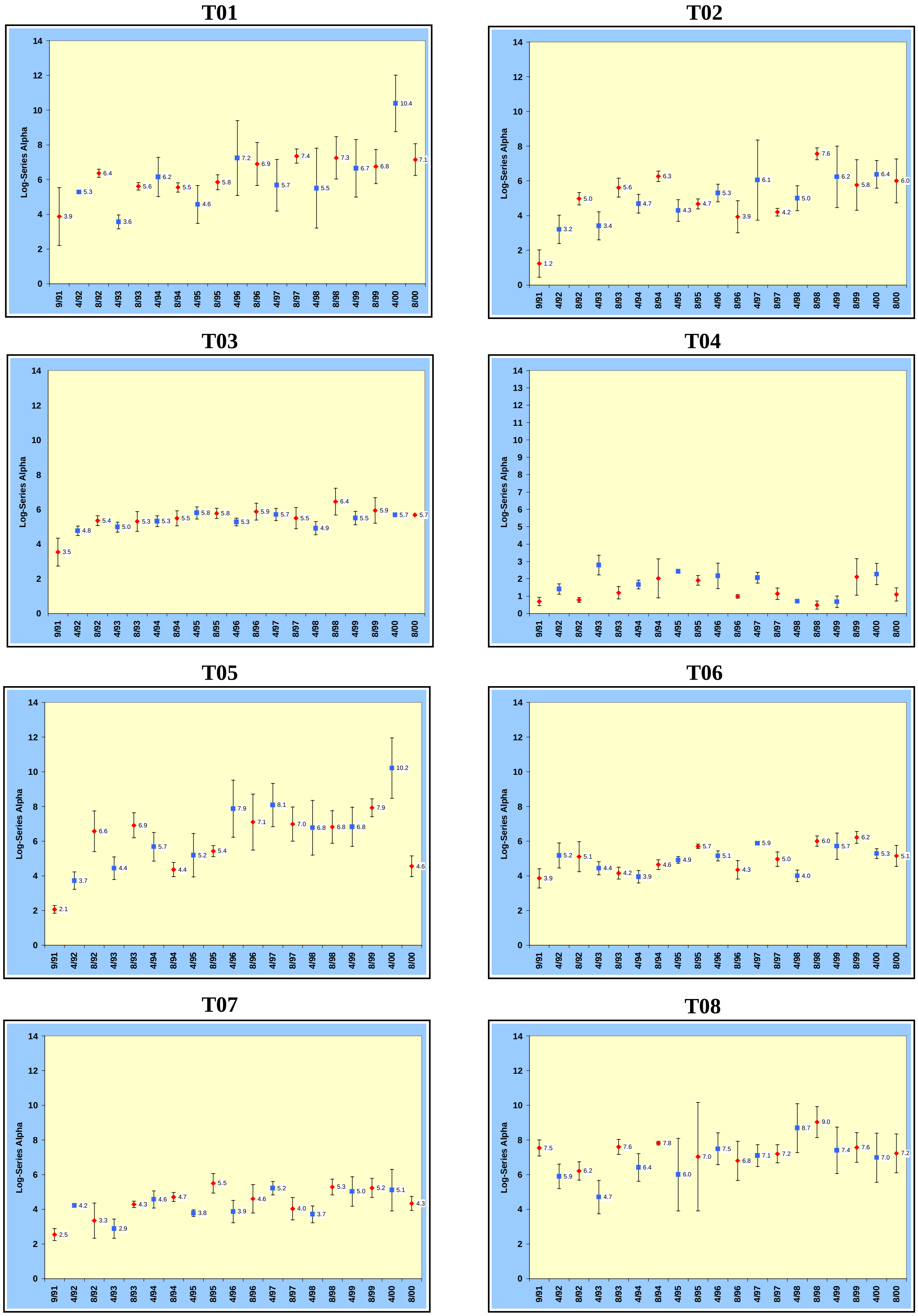


Figure 5-10. Mean and standard deviation log-series alpha per sample (by station) in Boston Harbor 1991-2000.

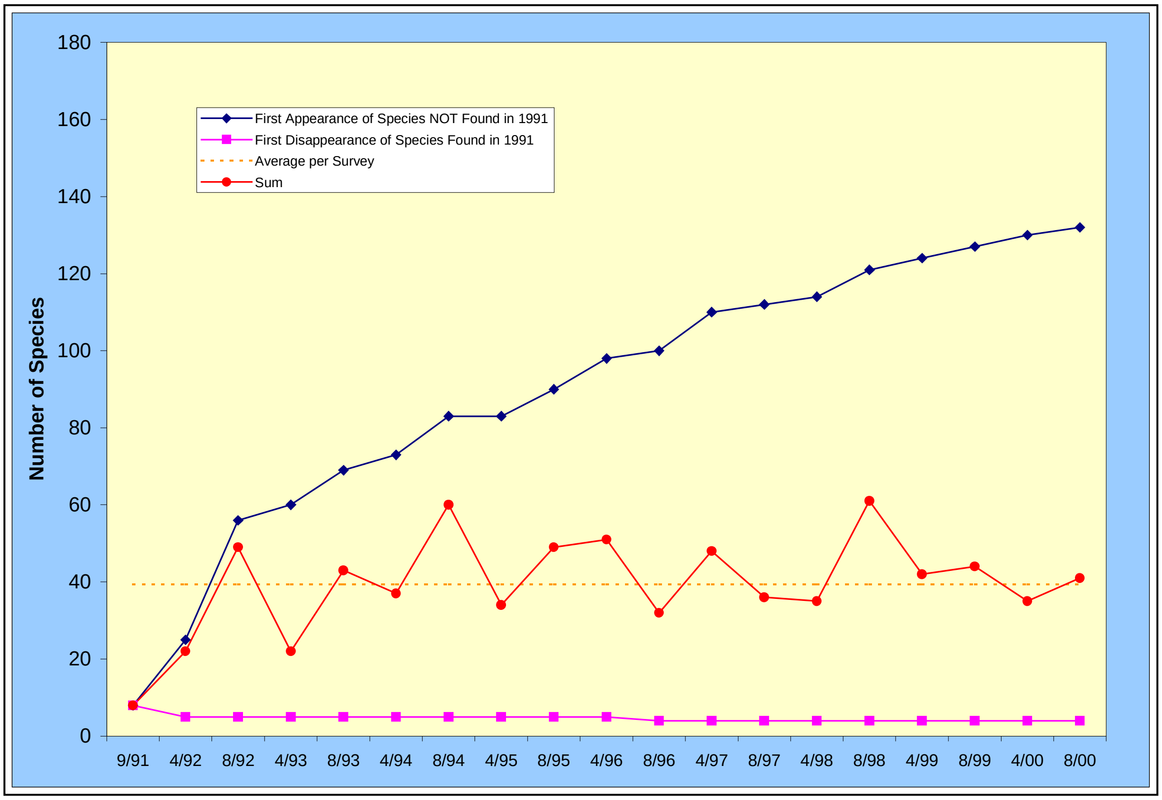


Figure 5-11. Total cumulative species richness curve for Boston Harbor station T02, 1991-2000.

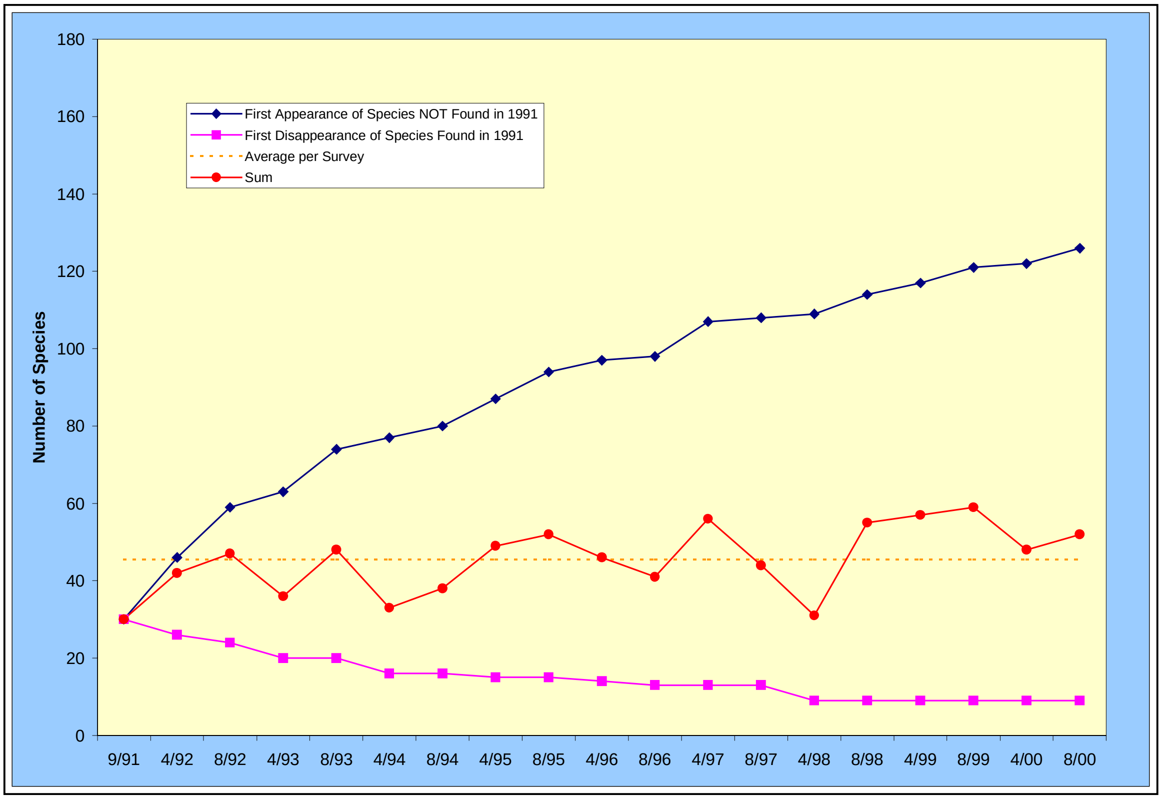


Figure 5-12. Total cumulative species richness curve for Boston Harbor station T06, 1991-2000.

station T08 may show signs of slowing. The species accumulation curve provides an estimate of the total species pool available for the areas studied. It is interesting that, even with very different initial species numbers (8–30) and very different initial colonization rates (24–52 species by Summer 1992), the estimates of the total species pool for stations T01, T02, T03, T05A, and T06 are remarkably similar (126–138 species). Species pool estimates for stations T08 (170) and T07 (102) differ appreciably.

The rate at which the estimate of the number of core species (those present every survey) at the Harbor stations was reached has followed two main paths. At two stations, T02 (Figure 5-11) and T07, the estimate of the core species was reached quickly (*i.e*., the estimate was within one species of the 2000 estimate by Spring 1993). At most of the other stations, the estimate was reached more slowly, with the earliest close estimate (within one species) occurring in Summer 1995 (T08).

5.2.6 Multivariate Community Analyses: 1991–2000

Station patterns—Infaunal communities patterns from 1991 to 2000 were primarily related to strong within-station similarity, with temporal trends being of secondary importance. At the eight-group level, three stations formed exclusive or nearly exclusive groups; Station T04 in inner Dorchester Bay (group II), T08 in Hingham Bay (group VI), and T05A in President Roads (groups III and VII) (Table 5-8). Group VII was the only exclusive seasonal grouping and contained four summer collections at T05A. Despite this, Spring and Summer infaunal composition at T05A, and also T08, was similar over the ten-year period with little differentiation between these seasons. Within groups I, II, and V there were subgroups that split primarily by season. Station T04, group II, exhibited the strongest seasonal variation with subgroup II' being all Summer collections and subgroup II'' all Spring samples. Group I was T01 and T02 on Deer Island Flats with subgroup I' primarily Spring and subgroup I'' Summer. Subgroup I' also contained Station T04 for 1996. Group V was similar to group II and was primarily composed of T07 in Quincy Bay with a few occurrences of T01 and T02 in later years. Group IV was primarily T03 off Long Island and T06 off Peddocks Island with three Spring occurrences of T08 when many species associated with *Ampelisca* spp. tube mats were present. Group VIII was the last group to join the dendrogram and weakly related to any of the infaunal patterns. It contained T05 in its original location and R06 both sampled only up to 1992, and T04 for 1998. *Capitella capitata* complex was responsible for group VIII's position in the analysis with 63% of its total ten-year abundance.

Over the ten-year period, Stations T01, T02, T03, T04, T06, T07, and T08 maintained a high degree of within station similarity with at least 75% (15 of 19) of the sampling periods within the same cluster group (Table 5-8). Any disturbance of infaunal communities by the major events that occurred near the initiation of the T-station monitoring in 1991, the October sever storm and December sewage discharge abatement at the inner harbor outfall, was not obvious. Cluster analysis and community structure analyses indicated that infauna at the T-stations was not dominated by temporal trends.

Species Patterns — Species cluster analysis of the 1991 to 2000 infaunal data was done on a reduced set of data that included only taxa with >9 occurrences at the 152 station-season-year combinations. Over the ten-year period 251 taxa occurred at the T-stations. Of these, 101 were included in the analysis.

Table 5-8. Station group summary for 1991 to 2000 infaunal data based on Gallagher's CNESS and group average sorting. Su is summer and Sp spring collection.

		1991	1992		1993		1994		1995		1996		1997		1998		1999		2000		
Group	**Station**	**Su**	**Sp**	**Su**	**Sp**	**Su**	**Sp**	**Su**	**Sp**	**Su**	**Sp**	**Su**	**Sp**	**Su**	**Sp**	**Su**	**Sp**	**Su**	**Sp**	**Su**	**Dendrogram**
I'	**T01**	Su					Sp		Sp		Sp	Su	Sp				Sp				
	T02	Su	Sp		Sp		Sp		Sp		Sp	Su	Sp								
	T04										Sp	Su									-------------I
I"	**T01**		Sp	Su	Sp	Su		Su		Su					Sp	Su		Su		Su	I
	T02			Su		Su		Su		Su					Sp	Su		Su	Sp		I--------I
II'	**T04**	Su		Su		Su		Su		Su				Su				Su		Su	I I
II"	**T04**		Sp		Sp		Sp		Sp				Sp				Sp		Sp		-------------I I
III	**T03**	Su	Sp																		I
	T05A				Sp	Su	Sp		Sp		Sp	Su	Sp		Sp		Sp	Su	Sp	Su	-------------I I
IV'	**T03**			Su			Sp	Su	Sp		Sp	Su	Sp		Sp	Su	Sp	Su	Sp	Su	I I
	T06	Su	Sp	Su	Sp		Sp	Su	Sp	Su	Sp	Su	Sp	Su		Su	Sp	Su	Sp	Su	I I
	T08				Sp						Sp		Sp								-----I I I
IV"	**T03**				Sp	Su				Su				Su							I I I
	T06					Su									Sp						I-------I I--I
V'	**T01**													Su							I I--I I I
	T02													Su						Su	I I I I I
	T07	Su	Sp	Su		Su		Su		Su											-----I I I I I
V"	**T02**																Sp		Sp		I I-----I I
	T07				Sp		Sp		Sp		Sp	Su	Sp	Su	Sp	Su	Sp	Su	Sp	Su	I I I
VI'	**T08**	Su		Su		Su	Sp	Su				Su		Su	Sp						I I I
VI"	**T08**		Sp						Sp	Su						Su	Sp	Su	Sp	Su	-------------I I I
VII	**T05A**							Su		Su				Su		Su					----------------I I
VIII'	**T05**	Su		Su																	I
VIII"	**R06**		Sp																		-------------------------I
	T04														Sp	Su					

At the six group level patterns were related to the species' general life history strategies (Figure 5-13). Group A was the largest species group and overall contained the taxa that preferred coarser sediment from fine-sand to pebbles. Group A' dominated by the polychaetes *Tharyx* spp. and *Chaetozone vivipara*, and the gastropod *Ilyanassa trivittata* represented Summer conditions at T01 and T02 (station group I"), and at T05A (III and VII), T03 and T06 (IV') both seasons. Group A" dominated by the polychaetes *Spiophanes bombyx* and *Polygordius* sp. A, and the bivalve *Nucula delphinodonta* predominantly occurred at Station T08 (VI). A few group A" species were also abundant at T03 and T06 (IV').

Group B was primarily composed of subdominant taxa (>25 in ranked overall abundance), the exception being the amphipod *Orchomenella minuta* that ranked 24th, that appeared to favor mixed to sandy sediments and avoid organic rich muds. The individual taxa that composed group B generally occurred in high percentages (>20% of total abundance) at all of the station groups except II" and VIII", which corresponded to Station T04.

Group C was a grouping of six taxa dominated by the polychaete *Aricidea catherinae* and the oligochaete *Tubificoides apectinatus*, the fourth and sixth most abundant species. These two species were strongly associated with T03 and T06 with >60% of their total abundance at these stations.

```
A′    ---------I
               I--I
A″    ---------I  I
                  I--I
B′    ------I     I  I
            I-----I  I
B″    ------I        I
                     I
C     ---------------I
                     I
D′    ------------I  I
                  I--I
D″    ------------I  I
                     I
E′    ------------I  I
                  I--I
E″    ------------I  I
                     I
F′    ------------I  I
                  I--I
F″    ------------I
      0.15            -.04
                    CNESS
```

Figure 5-13. Species dendrogram for 1991 to 2000 Boston Harbor infauna, summed replicates with Gallagher's CNESS (*m* = 15) and group average (UPGMA) sorting. Taxa with ≤9 occurrences were dropped. Species in each group are in Table 5-9.

Group D contained many of the more important bioturbating and biogenic structure creating polychaetes, such as the tube-builder *Polydora cornuta* the second most abundant species over the ten-year period and conveyor-belt feeders *Clymenella torquata* and *Pectinaria granulata*. *Clymenella torquata* is a large tube-building head-down deposit feeder that likely created many of the oxic voids seen in the sediment profile images (see Section 3). Group D' was all polychaetes and dominated by *Polydora cornuta*, a small sediment surface deposit feeder that constructs a thin fine-sediment tube, and *Microphthalmus pettiboneae* a medium size filter feeder that constructs a sand-grain tube at the sediment surface. Group D' taxa primarily represented Summer conditions at Stations T01 and T02 but were also common at T03 and T06 in both Spring and Summer. Group D'' had a similar pattern but was composed of less abundant species.

Group E were species that either created or were closely associated with biogenic structures. Group E' contained the major biogenic structure building amphipods, including *Ampelisca* spp. that was one of the most abundant and widely occurring taxa over the ten-year period. There were also three other tube-building amphipods in E' that were very abundant and broadly distributed (*Crassicorophium bonelli*, *Leptocheirus pinguis*, and *Unciola irrorata*). While broadly distributed these dominant amphipod species primarily occurred at T03 and T06 with >60% of their total collection abundance. Group E'' was primarily the oligochaete *Tubificoides* nr. *pseudogaster*, which was the third most abundant and widely distributed species.

Group F was composed basically of opportunistic annelids, the polychaetes *Streblospio benedicti* and *Capitella capitata* complex and the oligochaete *Paranais litoralis* (Table 5-9a). The latter two species, which composed most of Group F', are typically found in high abundance in organic-enriched sediments and were strongly associated with T01 and T02 Summer conditions (station group I''), T04 Springs (II''), and T04 1998 conditions (VIII''). Group F'' was composed of opportunistic species that were more eurytopic with regard to sediments and also occur in lower organic sediments, including *Streblospio benedicti*, *Mya arenaria*, and *Ensis directus*.

Table 5-9. Average infaunal abundance (individuals/0.12 m^2) and percent abundance by cluster analysis species and station groups for 1991 to 2000 infaunal data. Based on Gallagher's CNESS and group average sorting.

(a)

Group	Major Taxa	Taxa	Total		Average by subgroup (Inds/0.12 m2)													
			Abund.	Occur.	I	I"	II	II"	III	IV	IV"	V	V"	VI	VI"	VII	VIII	VIII"
A	P	*Tharyx* spp.	39849	145	173	574	3	5	336	427	505	131	106	126	55	112	8	11
A	P	*Chaetozone vivipara*	13587	47	4	567	1		113	1	7	26	1		0	353		
A	G	*Ilyanassa trivittata*	10417	136	36	57	6	0	97	75	101	31	14	114	149	290	66	142
A	B	*Tellina agilis*	5411	137	8	25	1	3	77	28	11	12	9	114	157	62	24	3
A	I	*Edotia triloba*	5296	103	1	13			51	25	48	2	0	34	11	708	2	2
A	P	*Mediomastus californiensis*	2816	118	8	28		0	10	42	19	15	7	15	10	18	5	2
A	P	*Nephtys caeca*	1436	88	12	21		0	12	3	1	4	1	18	8	80	1	0
A	A	*Dyopedos monacanthus*	1397	68	9	1		0	10	20	43	1	1	2	2	20		
A	O	*Tubificoides benedeni*	1385	55	1	1	0	3	66	1	0		0	0	0	14	149	1
A	C	*Diastylis sculpta*	531	55	2	1			9	7	3		0	7	1	18	1	
A	P	*Nephtys ciliata*	402	47	0	6	0		7	3	1	3	1	3	0	9		
A	A	*Gammarus lawrencianus*	305	33	0	1		0	12	1	1	0		1	0	6	5	5
A	B	*Cerastoderma pinnulatum*	256	44	0	1			0	4	3	0	0	3	3	11		
A	A	*Pontogeneia inermis*	147	21	0				5	1	0				0	9	1	
A	P	*Chaetozone* cf. *Setosa*	132	20	0	0			4	0		0		6	1			
A	A	*Metopella angusta*	62	19	0	0			0	0	1			3	2	2	1	
A	A	*Jassa marmorata*	37	14	0	0			0	0	0			0	0	5		
A	A	*Argissa hamatipes*	27	18	0	0			0	0			0	0	0	0		
A	P	*Dipolydora caulleryi*	21	11	0	0		0	1	0	0					0	1	
A"	P	*Spiophanes bombyx*	14155	69	2	14			113	6		3	0	814	663	61		
A"	B	*Nucula delphinodonta*	11146	49	0	0		0	0	142	26		0	505	283			
A"	P	*Polygordius* sp. A	9902	61	0	2	0		28	13	0	0	1	345	711	146		
A"	P	*Exogone hebes*	5413	86	6	17		0	4	12	2	6	0	367	193	6	1	0
A"	P	*Prionospio steenstrupi*	2449	102	2	10			5	22	12	5	5	74	72	20	4	
A"	B	*Lyonsia arenosa*	1550	82	2	6			1	17	30	18	1	43	13	5	1	
A"	P	*Pygospio elegans*	785	56	2	6		0	6	1		1	0	55	9	8		
A"	Ph	*Phoronis architecta*	251	35	0					2	1		0	7	15			
A"	P	*Monticellina baptisteae*	241	30	0	0			0	3	0		0	13	5	1		
A"	P	*Parougia caeca*	208	33	0	0			0	1		0	0	13	8	1	1	
A"	B	*Arctica islandica*	117	25	0	1			0	1	1		0	0	6	0		

Table 5-9. Average infaunal abundance (individuals/0.12 m^2) and percent abundance by cluster analysis species and station groups for 1991 to 2000 infaunal data. Based on Gallagher's CNESS and group average sorting. (con't)

Group	Major Taxa	Taxa	Total		Average by subgroup (Inds/0.12 m2)													
			Abund.	Occur.	I	I"	II	II"	III	IV	IV"	V	V"	VI	VI"	VII	VIII	VIII"
A"	P	*Monticellina dorsobranchialis*	60	15	0				0	1				1	2			
A"	P	*Aglaophamus circinata*	59	23	0	0			0	0		0	0	2	0	4	1	
B	A	*Orchomenella minuta*	4792	72	5	1			2	99	117	1	0	16	10	119		
B	P	*Dipolydora socialis*	3594	97	32	33			13	21	9	14	10	13	142	3	1	
B	P	*Polydora aggregata*	1497	22	30	33			1	0	0	42	0					1
B	P	*Dipolydora quadrilobata*	848	90	15	11		1	1	5	4	2	1	7	6	0	1	2
B	B	*Hiatella arctica*	792	57	2	1			0	3	34	0	0	8	2	86	6	
B	N	Nemertea sp. 2	635	38	1	10	1	13	10	0		0	7	1	7	3		
B	A	*Paracaprella tenuis*	181	14	1	1	14			0		3			0		5	
B	A	*Aeginina longicornis*	143	10	0	6	2								1	1	1	
B	P	*Fabricia stellaris stellaris*	101	19	4	0		1	1	0			1		0	1		
B	P	*Spio filicornis*	92	26	1	1				0	1		0	2	1	1	5	
B	P	*Ampharete finmarchica*	75	33	0	1			0	0		0		1	3	1		
B	P	*Leitoscoloplos robustus*	71	31	0	0		0		0		1	1	3	1			
B	B	*Pandora gouldiana*	51	29	0	0				0		2	0	0	0			
B	A	*Proboloides holmesi*	43	12	1	0			0	0		0		0	1	0	6	
B	P	*Eumida sanguinea*	22	11	0	0				0	0	0			0	1	1	
B	G	*Lacuna vincta*	17	11	0	0			0	0		0			0			
B"	A	*Ischyrocerus anguipes*	369	43	3	4			3	2	1			1	12	4	7	3
B"	P	*Proceraea cornuta*	269	45	1	7	1		0	1	2	2	0	1	2	0	15	0
B"	B	*Spisula solidissima*	24	10	0	0				0		0		0	1	0		
B"	C	*Tanaissus psammophilus*	20	11	0	0			0	0				2	0		1	
C	P	*Aricidea catherinae*	98020	135	37	65	1	0	93	1534	1125	619	383	2496	762	36	10	1
C	O	*Tubificoides apectinatus*	52956	120	1	8	3	1	333	887	439	478	596	103	206	114	3	11
C	P	*Scoletoma hebes*	3857	79	5	7				52	23	17	33	87	56	0		
C	P	*Nephtys cornuta*	3603	49	3	25	7	0	1	1		58	164			4		
C	P	*Nephtys incisa*	19	10	0	0				0		1	0	0		2		
C	N	*Micrura* spp.	18	12	0	0			0	0		0	0		1	1		
D	P	*Polydora cornuta*	193891	126	64	2921	5	83	64	1492	5599	1036	122	266	76	10430	128	2

Table 5-9. Average infaunal abundance (individuals/0.12 m^2) and percent abundance by cluster analysis species and station groups for 1991 to 2000 infaunal data. Based on Gallagher's CNESS and group average sorting. (con't)

Group	Major Taxa	Taxa	Total		Average by subgroup (Inds/0.12 m2)													
			Abund.	Occur.	I	I"	II	II"	III	IV	IV"	V	V"	VI	VI"	VII	VIII	VIII"
D	P	*Microphthalmus pettiboneae*	8698	129	68	226	2	2	35	32	13	55	59	19	23	3	58	1
D	P	*Clymenella torquata*	4651	62	10	193			1	3	4	38	0	44	23	0		
D	P	*Spio thulini*	2739	89	1	50		2	1	29	29	4	0	28	3	8	166	
D	P	*Pholoe minuta*	1516	91	4	45			1	5	3	24	4	5	8	15	4	
D	P	*Asabellides oculata*	1335	88	5	46	1	2	1	6	5	8	2	7	2	2		
D	P	*Eteone longa*	1214	79	1	29	0	3	2	9	8	6	1	3	1	29	28	0
D	P	*Ninoe nigripes*	655	101	5	5			1	7	3	6	8	4	2	0		
D	P	*Polycirrus* cf. *haematodes*	286	21	0	8			0	0		1	7	0	2			
D	P	*Pherusa affinis*	181	44	0	3				2	1	1	0	1	1	3	1	
D	P	*Pectinaria granulata*	60	27	0	1			0	0	0	0	0	0	0	2	3	
D"	P	*Spio limicola*	1424	45	29	9			25	8		5	2	1	1	9	3	4
D"	P	*Neanthes virens*	411	76	1	5	0	0	0	5	6	1	1	2	1	2	16	
D"	N	*Cerebratulus lacteus*	38	25	0	0			0	1	0		0	0	0	1		
D"	B	*Mulinia lateralis*	24	10	0	1	2					0	0					
D"	B	*Musculus niger*	18	11	0					0	1			1	0		1	
E	A	*Ampelisca* spp.	398049	143	168	1596	8	3	64	6900	4564	1559	95	5065	1055	11489	8	1
E	A	*Crassicorophium bonelli*	36177	62	0	14				90	5451	1		10	1	36	3	0
E	A	*Phoxocephalus holbolli*	31132	96	1	4		0	5	722	986	4	2	52	30	65	130	
E	A	*Leptocheirus pinguis*	26935	106	6	80		0	1	387	1463	73	9	71	109	399	1	
E	A	*Unciola irrorata*	26350	103	2	48			24	318	1085	13	3	108	36	1700	3	
E	A	*Photis pollex*	20717	121	14	48	0	0	13	441	453	2	1	41	32	384	2	0
E	P	*Phyllodoce mucosa*	8459	97	5	79			12	115	175	3	1	127	46	123	9	
E	A	*Crassicorophium crassicorne*	1352	26	0	0				2	145			52	1	0		
E	C	*Diastylis polita*	1099	14	0				6	0			0	0	0	250		
E	P	*Phyllodoce maculata*	851	47	0	7				7	68	0		6	2	1		
E	P	*Harmothoe imbricata*	655	41	0	2	0			5	20		0	36	3	2	12	
E	D	*Cancer irroratus*	375	60	1	2	0		0	4	16	2	0	3	1	4	4	
E	N	*Amphiporus cruentatus*	274	20	0	0			0	4	1		0	3	6	14		
E	An	*Ceriantheopsis americanus*	50	15	0	0				1	1					1		

Table 5-9. Average infaunal abundance (individuals/0.12 m^2) and percent abundance by cluster analysis species and station groups for 1991 to 2000 infaunal data. Based on Gallagher's CNESS and group average sorting. (con't)

Group	Major Taxa	Taxa	Total		Average by subgroup (Inds/0.12 m2)													
			Abund.	Occur.	I	I"	II	II"	III	IV	IV"	V	V"	VI	VI"	VII	VIII	VIII"
E"	O	*Tubificoides* nr. *pseudogaster*	152245	141	916	988	6	7	512	2774	943	151	109	309	344	140	2815	8
E"	B	*Petricola pholadiformis*	1277	56	3	1			2	31	10		0	8	2	6		0
E"	B	*Mysella planulata*	148	27	1	0		0	0	3	0		0	0		1		
E"	A	*Monocorophium tuberculatum*	135	15	0					4		1	0	1				
F	P	*Capitella capitata* complex	25577	138	27	56	6	907	25	16	10	14	6	35	17	17	1269	4515
F	O	*Paranais litoralis*	3213	14	0	118		153	0			0	0		0			2
F	P	*Spio setosa*	188	26	4	5		3	0	0		0	0	0				1
F	P	*Eteone heteropoda*	35	13	0	0		3			0							
F"	P	*Streblospio benedicti*	74117	126	817	1470	2304	412	14	7	6	946	221	1	1	16	30	12
F"	B	*Mya arenaria*	1666	108	18	6	2	2	7	22	6	30	2	1	2	7		7
F"	B	*Ensis directus*	523	67	0	3	2	0	3	1		19	2	12	7	9	2	0
F"	T	*Turbellaria spp.*	488	57	6	0	9	11	2	2	1	0	2	8	3	1		
F"	P	*Paranaitis speciosa*	79	37	1	1	1		0	0		2	1	0				

Table 5-9. Average infaunal abundance (individuals/0.12 m^2) and percent abundance by cluster analysis species and station groups for 1991 to 2000 infaunal data. Based on Gallagher's CNESS and group average sorting. (con't)

Group	Major Taxa	Taxa	Percent of total by subgroup													(b)
			I	I"	II	II"	III	IV	IV"	V	V"	VI	VI"	VII	VIII	VIII"
A	P	*Tharyx* spp.	7	26	0	0	12	35	8	3	4	3	1	1	0	0
A	P	*Chaetozone vivipara*	0	75	0	0	12	0	0	2	0	0	0	10	0	0
A	G	*Ilyanassa trivittata*	6	10	0	0	13	24	6	3	2	9	11	11	1	4
A	B	*Tellina agilis*	3	8	0	0	20	17	1	2	2	17	23	5	1	0
A	I	*Edotia triloba*	0	4	0	0	13	16	5	0	0	5	2	53	0	0
A	P	*Mediomastus californiensis*	5	18	0	0	5	50	4	5	4	4	3	3	0	0
A	P	*Nephtys caeca*	14	27	0	0	12	7	1	2	1	10	5	22	0	0
A	A	*Dyopedos monacanthus*	11	2	0	0	10	48	19	1	1	1	1	6	0	0
A	O	*Tubificoides benedeni*	1	1	0	1	67	3	0	0	0	0	0	4	21	0
A	C	*Diastylis sculpta*	5	2	0	0	23	41	4	0	0	10	1	13	0	0
A	P	*Nephtys ciliata*	2	29	0	0	24	22	1	6	2	5	0	9	0	0
A	A	*Gammarus lawrencianus*	2	4	0	1	57	14	1	0	0	4	1	8	3	5
A	B	*Cerastoderma pinnulatum*	1	4	0	0	2	53	6	0	0	9	8	17	0	0
A	A	*Pontogeneia inermis*	3	0	0	0	47	24	1	0	0	0	1	23	1	0
A	P	*Chaetozone* cf. *Setosa*	1	5	0	0	45	7	0	2	0	36	5	0	0	0
A	A	*Metopella angusta*	2	2	0	0	5	13	5	0	0	42	19	10	3	0
A	A	*Jassa marmorata*	3	5	0	0	14	11	3	0	0	3	5	57	0	0
A	A	*Argissa hamatipes*	4	4	0	0	15	44	0	0	15	4	11	4	0	0
A	P	*Dipolydora caulleryi*	5	15	0	5	49	7	5	0	0	0	0	5	10	0
A"	P	*Spiophanes bombyx*	0	2	0	0	11	1	0	0	0	46	37	2	0	0
A"	B	*Nucula delphinodonta*	0	0	0	0	0	42	1	0	0	36	20	0	0	0
A"	P	*Polygordius* sp. A	0	0	0	0	4	4	0	0	0	28	57	6	0	0
A"	P	*Exogone hebes*	2	6	0	0	1	7	0	1	0	54	28	0	0	0
A"	P	*Prionospio steenstrupi*	1	7	0	0	3	29	3	2	3	24	24	3	0	0
A"	B	*Lyonsia arenosa*	3	7	0	0	1	36	11	11	1	22	7	1	0	0
A"	P	*Pygospio elegans*	4	13	0	0	10	2	0	2	0	56	9	4	0	0
A"	Ph	*Phoronis architecta*	0	0	0	0	0	27	1	0	0	22	49	0	0	0
A"	P	*Monticellina baptisteae*	0	1	0	0	2	34	0	0	0	44	15	1	0	0
A"	P	*Parougia caeca*	0	1	0	0	1	13	0	0	0	49	32	1	0	0

Table 5-9. Average infaunal abundance (individuals/0.12 m^2) and percent abundance by cluster analysis species and station groups for 1991 to 2000 infaunal data. Based on Gallagher's CNESS and group average sorting. (con't)

Group	Major Taxa	Taxa	Percent of total by subgroup													
			I	I"	II	II"	III	IV	IV"	V	V"	VI	VI"	VII	VIII	VIII"
A"	B	*Arctica islandica*	1	9	0	0	5	35	5	0	3	2	40	1	0	0
A"	P	*Monticellina dorsobranchialis*	0	0	0	0	3	48	0	0	0	17	32	0	0	0
A"	P	*Aglaophamus circinata*	3	3	0	0	2	22	0	7	2	27	3	29	2	0
B	A	*Orchomenella minuta*	2	0	0	0	0	68	15	0	0	3	2	10	0	0
B	P	*Dipolydora socialis*	15	17	0	0	5	19	1	3	4	3	32	0	0	0
B	P	*Polydora aggregata*	34	39	0	0	0	1	0	25	0	0	0	0	0	0
B	P	*Dipolydora quadrilobata*	31	24	0	1	2	21	3	2	3	7	5	0	0	1
B	B	*Hiatella arctica*	4	3	0	0	0	12	26	0	0	8	2	43	1	0
B	N	Nemertea sp. 2	3	29	1	14	23	2	0	1	16	1	9	2	0	0
B	A	*Paracaprella tenuis*	6	12	61	0	0	1	0	14	0	0	2	0	5	0
B	A	*Aeginina longicornis*	1	79	12	0	0	0	0	0	0	0	6	1	1	0
B	P	*Fabricia stellaris stellaris*	67	2	0	8	8	2	0	0	8	0	1	4	0	0
B	P	*Spio filicornis*	20	21	0	0	0	13	4	0	4	18	4	5	10	0
B	P	*Ampharete finmarchica*	7	28	0	0	1	12	0	4	0	12	29	3	0	0
B	P	*Leitoscoloplos robustus*	0	10	0	4	0	21	0	7	21	28	8	0	0	0
B	B	*Pandora gouldiana*	12	16	0	0	0	23	0	30	8	6	6	0	0	0
B	A	*Proboloides holmesi*	33	12	0	0	9	2	0	2	0	2	9	2	28	0
B	P	*Eumida sanguinea*	32	5	0	0	0	27	9	5	0	0	5	9	9	0
B	G	*Lacuna vincta*	12	6	0	0	6	53	0	18	0	0	6	0	0	0
B"	A	*Ischyrocerus anguipes*	13	17	0	0	10	19	2	0	0	3	25	4	4	2
B"	P	*Proceraea cornuta*	7	48	3	0	1	7	4	8	0	4	6	0	11	0
B"	B	*Spisula solidissima*	0	25	0	0	0	13	0	4	0	13	42	4	0	0
B"	C	*Tanaissus psammophilus*	0	5	0	0	5	5	0	0	0	70	10	0	5	0
C	P	*Aricidea catherinae*	1	1	0	0	1	52	7	6	6	20	6	0	0	0
C	O	*Tubificoides apectinatus*	0	0	0	0	9	55	5	8	17	2	3	1	0	0
C	P	*Scoletoma hebes*	2	3	0	0	0	44	4	4	13	18	12	0	0	0
C	P	*Nephtys cornuta*	2	12	2	0	0	1	0	15	68	0	0	0	0	0
C	P	*Nephtys incisa*	5	11	0	0	0	5	0	26	16	5	0	32	0	0
C	N	*Micrura* spp.	0	17	0	0	6	6	0	6	22	0	22	22	0	0

Table 5-9. Average infaunal abundance (individuals/0.12 m^2) and percent abundance by cluster analysis species and station groups for 1991 to 2000 infaunal data. Based on Gallagher's CNESS and group average sorting. (con't)

Group	Major Taxa	Taxa	Percent of total by subgroup													
			I	I"	II	II"	III	IV	IV"	V	V"	VI	VI"	VII	VIII	VIII"
D	P	*Polydora cornuta*	1	27	0	0	0	25	17	5	1	1	0	22	0	0
D	P	*Microphthalmus pettiboneae*	13	47	0	0	6	12	1	6	10	2	2	0	1	0
D	P	*Clymenella torquata*	4	75	0	0	0	2	0	7	0	8	4	0	0	0
D	P	*Spio thulini*	1	33	0	1	0	35	6	1	0	8	1	1	12	0
D	P	*Pholoe minuta*	5	54	0	0	0	11	1	14	4	3	4	4	0	0
D	P	*Asabellides oculata*	7	62	1	1	1	14	2	5	2	4	1	1	0	0
D	P	*Eteone longa*	1	43	0	2	2	26	4	5	1	2	1	9	5	0
D	P	*Ninoe nigripes*	14	13	0	0	1	35	3	8	19	4	3	0	0	0
D	P	*Polycirrus* cf. *haematodes*	1	51	0	0	1	2	0	3	36	0	5	0	0	0
D	P	*Pherusa affinis*	1	32	0	0	0	42	3	5	1	3	6	7	1	0
D	P	*Pectinaria granulata*	3	42	0	0	2	22	2	3	3	2	2	12	8	0
D"	P	*Spio limicola*	35	11	0	0	25	17	0	3	3	1	1	3	0	1
D"	P	*Neanthes virens*	4	23	1	0	1	42	9	2	5	3	2	1	8	0
D"	N	*Cerebratulus lacteus*	3	5	0	0	5	55	5	0	5	8	5	8	0	0
D"	B	*Mulinia lateralis*	0	38	50	0	0	0	0	8	4	0	0	0	0	0
D"	B	*Musculus niger*	6	0	0	0	0	17	17	0	0	39	17	0	6	0
E	A	*Ampelisca* spp.	1	7	0	0	0	57	7	4	0	10	2	12	0	0
E	A	*Crassicorophium bonelli*	0	1	0	0	0	8	90	0	0	0	0	0	0	0
E	A	*Phoxocephalus holbolli*	0	0	0	0	0	76	19	0	0	1	1	1	1	0
E	A	*Leptocheirus pinguis*	0	5	0	0	0	47	33	2	1	2	3	6	0	0
E	A	*Unciola irrorata*	0	3	0	0	1	40	25	0	0	3	1	26	0	0
E	A	*Photis pollex*	1	4	0	0	1	70	13	0	0	2	1	7	0	0
E	P	*Phyllodoce mucosa*	1	17	0	0	2	45	12	0	0	12	4	6	0	0
E	A	*Crassicorophium crassicorne*	0	0	0	0	0	4	64	0	0	31	1	0	0	0
E	C	*Diastylis polita*	0	0	0	0	8	1	0	0	0	0	0	91	0	0
E	P	*Phyllodoce maculata*	0	15	0	0	0	28	48	0	0	5	2	1	0	0
E	P	*Harmothoe imbricata*	0	4	0	0	0	24	19	0	0	44	3	1	4	0
E	D	*Cancer irroratus*	3	10	1	0	1	39	26	4	1	7	2	4	2	0
E	N	*Amphiporus cruentatus*	0	0	0	0	0	51	2	0	0	8	17	21	0	0

Table 5-9. Average infaunal abundance (individuals/0.12 m^2) and percent abundance by cluster analysis species and station groups for 1991 to 2000 infaunal data. Based on Gallagher's CNESS and group average sorting. (con’t)

Group	Major Taxa	Taxa	Percent of total by subgroup													
			I	I"	II	II"	III	IV	IV"	V	V"	VI	VI"	VII	VIII	VIII"
E	An	*Ceriantheopsis americanus*	0	2	0	0	0	88	6	0	0	0	0	4	0	0
E"	O	*Tubificoides* nr. *pseudogaster*	10	12	0	0	5	60	4	1	1	2	2	0	4	0
E"	B	*Petricola pholadiformis*	3	1	0	0	2	81	5	0	0	5	1	2	0	0
E"	B	*Mysella planulata*	14	1	0	1	2	74	1	0	3	1	0	3	0	0
E"	A	*Monocorophium tuberculatum*	0	0	0	0	0	91	0	5	1	3	0	0	0	0
F	P	*Capitella capitata* complex	2	4	0	25	1	2	0	0	0	1	1	0	10	53
F	O	*Paranais litoralis*	0	66	0	33	0	0	0	0	0	0	0	0	0	0
F	P	*Spio setosa*	35	46	0	11	3	2	0	1	1	1	0	0	0	1
F	P	*Eteone heteropoda*	17	23	0	54	0	0	6	0	0	0	0	0	0	0
F"	P	*Streblospio benedicti*	19	36	25	4	0	0	0	11	4	0	0	0	0	0
F"	B	*Mya arenaria*	18	6	1	1	6	44	2	16	2	1	1	2	0	1
F"	B	*Ensis directus*	1	9	3	0	9	5	0	33	5	18	11	7	1	0
F"	T	*Turbellaria spp.*	22	2	15	16	7	14	1	1	6	12	4	0	0	0
F"	P	*Paranaitis speciosa*	28	22	9	0	3	3	0	18	18	1	0	0	0	0

6.0 LITERATURE CITED

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APPENDICES

APPENDIX A-1

Sampling Coordinates, Grab Samples

Table A-1-1. Actual station coordinates for grab samples collected on April 25, 2000 for HT001.

Station ID	Sample ID	Latitude	Longitude	Sample Date Time	Station Depth_m
T01	HT001028	42.3492	-70.9636	04/25/2000 11:32	3.7
T01	HT001027	42.3492	-70.9637	04/25/2000 11:26	3.4
T01	HT001026	42.3492	-70.9636	04/25/2000 11:21	3.6
T01	HT001024	42.3492	-70.9636	04/25/2000 11:13	3.5
T02	HT00101E	42.3430	-71.0020	04/25/2000 10:52	6
T02	HT00101D	42.3428	-71.0020	04/25/2000 10:46	6
T02	HT00101C	42.3428	-71.0020	04/25/2000 10:38	5.8
T02	HT00101B	42.3428	-71.0020	04/25/2000 10:30	6
T03	HT001053	42.3303	-70.9622	04/25/2000 14:11	8.5
T03	HT001052	42.3302	-70.9621	04/25/2000 14:06	8.2
T03	HT001051	42.3302	-70.9620	04/25/2000 14:01	8.3
T03	HT001050	42.3302	-70.9621	04/25/2000 13:56	8.3
T04	HT001010	42.3099	-71.0414	04/25/2000 9:15	3
T04	HT00100D	42.3100	-71.0415	04/25/2000 9:04	1.8
T04	HT00100C	42.3100	-71.0415	04/25/2000 8:58	1.9
T04	HT00100A	42.3101	-71.0414	04/25/2000 8:48	2
T05A	HT00104A	42.3397	-70.9607	04/25/2000 13:37	16.4
T05A	HT001049	42.3397	-70.9607	04/25/2000 13:37	16.4
T05A	HT001047	42.3397	-70.9607	04/25/2000 13:26	16.3
T05A	HT001044	42.3396	-70.9606	04/25/2000 13:15	16.8
T06	HT00106B	42.2935	-70.9444	04/25/2000 15:40	6.3
T06	HT001069	42.2935	-70.9444	04/25/2000 15:34	5.9
T06	HT001068	42.2935	-70.9444	04/25/2000 15:28	6
T06	HT001067	42.2935	-70.9444	04/25/2000 15:23	5.9
T07	HT001061	42.2893	-70.9786	04/25/2000 14:54	5.5
T07	HT001060	42.2894	-70.9786	04/25/2000 14:50	5.6
T07	HT00105E	42.2893	-70.9785	04/25/2000 14:43	5.8
T07	HT00105D	42.2894	-70.9786	04/25/2000 14:36	5.7
T08	HT001076	42.2852	-70.9124	04/25/2000 16:33	12.6
T08	HT001075	42.2853	-70.9125	04/25/2000 16:29	12.7
T08	HT001074	42.2853	-70.9125	04/25/2000 16:25	12.5
T08	HT001072	42.2853	-70.9126	04/25/2000 16:16	12.6

Table A-1-2. Actual station coordinates for grab samples collected on August 23-25, 2000 for HT002.

Station ID	Sample ID	Latitude	Longitude	Sample Date Time	Station Depth_m
T01	HT002019	42.3492	-70.9635	08/23/2000 15:59	5.4
T01	HT00204F	42.3491	-70.9635	08/24/2000 18:11	6
T01	HT00204E	42.3491	-70.9635	08/24/2000 18:07	6
T01	HT00204B	42.3491	-70.9635	08/24/2000 17:58	5.8
T02	HT002020	42.3429	-71.0020	08/23/2000 16:37	8.1
T02	HT002047	42.3429	-71.0020	08/24/2000 17:36	8.3
T02	HT002046	42.3429	-71.0020	08/24/2000 17:30	8.1
T02	HT002045	42.3428	-71.0021	08/24/2000 17:24	8.2
T03	HT002007	42.3302	-70.9620	08/23/2000 14:38	8
T03	HT002060	42.3302	-70.9620	08/25/2000 7:34	9.2
T03	HT00205F	42.3302	-70.9619	08/25/2000 7:28	9.2
T03	HT00205E	42.3302	-70.9620	08/25/2000 7:21	9.2
T04	HT002042	42.3100	-71.0414	08/24/2000 16:54	2.6
T04	HT002041	42.3100	-71.0415	08/24/2000 16:49	3.3
T04	HT00203F	42.3100	-71.0416	08/24/2000 16:40	2.9
T04	HT00203E	42.3099	-71.0416	08/24/2000 16:35	2.1
T05A	HT002012	42.3397	-70.9606	08/23/2000 15:24	16.2
T05A	HT002065	42.3396	-70.9607	08/25/2000 7:57	17.8
T05A	HT002064	42.3396	-70.9607	08/25/2000 7:50	18.8
T05A	HT002063	42.3396	-70.9606	08/25/2000 7:44	16.7
T06	HT002033	42.2934	-70.9444	08/24/2000 15:20	4.6
T06	HT002032	42.2935	-70.9444	08/24/2000 15:15	4.5
T06	HT002031	42.2934	-70.9445	08/24/2000 15:08	4.5
T06	HT00202F	42.2934	-70.9444	08/24/2000 14:54	4.5
T07	HT00203B	42.2893	-70.9785	08/24/2000 16:00	5.6
T07	HT002039	42.2893	-70.9786	08/24/2000 15:50	5.4
T07	HT002038	42.2893	-70.9786	08/24/2000 15:44	5
T07	HT002036	42.2893	-70.9784	08/24/2000 15:37	5.2
T08	HT00202C	42.2853	-70.9125	08/24/2000 14:31	10.8
T08	HT002028	42.2853	-70.9124	08/24/2000 14:23	10.5
T08	HT002055	42.2853	-70.9125	08/24/2000 18:45	12.9
T08	HT002052	42.2854	-70.9125	08/24/2000 18:40	13.3

APPENDIX A–2

Sampling Coordinates, SPI Images

Table A-2-1. Actual station coordinates for SPI images collected August 21-23, 2000 for HR001.

Station	Rep	Date	Time (local)	Latitude	Longitude
R02	3	08/21/2000	16:40	042°20.659'N	070°57.683'W
R02	2	08/21/2000	16:38	042°20.666'N	070°57.689'W
R02	1	08/21/2000	16:37	042°20.672'N	070°57.690'W
R03	1	08/21/2000	15:50	042°21.202'N	070°58.358'W
R03	2	08/21/2000	15:51	042°21.202'N	070°58.358'W
R03	3	08/21/2000	15:55	042°21.202'N	070°58.358'W
R04	2	08/21/2000	15:24	042°21.516'N	070°58.778'W
R04	1	08/21/2000	15:22	042°21.524'N	070°58.770'W
R04	3	08/21/2000	15:25	042°21.515'N	070°58.778'W
R05	1	08/21/2000	15:34	042°21.385'N	070°58.685'W
R05	2	08/21/2000	15:39	042°21.386'N	070°58.673'W
R05	3	08/21/2000	15:42	042°21.378'N	070°58.670'W
R06	1	08/23/2000	12:14	042°19.916'N	070°57.119'W
R06	4	08/23/2000	12:21	042°19.902'N	070°57.121'W
R06	3	08/23/2000	12:19	042°19.913'N	070°57.115'W
R06	2	08/23/2000	12:17	042°19.905'N	070°57.121'W
R07	2	08/21/2000	16:07	042°20.861'N	070°58.464'W
R07	1	08/21/2000	16:05	042°20.883'N	070°58.468'W
R07	3	08/21/2000	16:08	042°20.856'N	070°58.456'W
R08	1	08/21/2000	14:26	042°20.656'N	070°59.496'W
R08	3	08/21/2000	14:34	042°20.658'N	070°59.498'W
R08	4	08/21/2000	14:35	042°20.666'N	070°59.507'W
R08	2	08/21/2000	14:33	042°20.654'N	070°59.495'W
R09	1	08/21/2000	13:19	042°20.798'N	071°00.983'W
R09	2	08/21/2000	13:21	042°20.808'N	071°00.986'W
R09	4	08/21/2000	13:33	042°20.804'N	071°00.982'W
R09	3	08/21/2000	13:29	042°20.803'N	071°00.979'W
R10	3	08/21/2000	12:58	042°21.318'N	071°02.201'W
R10	2	08/21/2000	12:56	042°21.324'N	071°02.200'W
R10	1	08/21/2000	12:56	042°21.324'N	071°02.200'W
R10	4	08/21/2000	13:01	042°21.324'N	071°02.198'W
R11	1	08/23/2000	13:02	042°19.274'N	070°58.479'W
R11	2	08/23/2000	13:03	042°19.277'N	070°58.478'W
R11	3	08/23/2000	13:04	042°19.284'N	070°58.480'W
R11	4	08/23/2000	13:05	042°19.287'N	070°58.479'W
R12	4	08/23/2000	13:15	042°19.103'N	070°58.462'W
R12	1	08/23/2000	13:11	042°19.097'N	070°58.476'W
R12	2	08/23/2000	13:13	042°19.098'N	070°58.471'W
R12	3	08/23/2000	13:14	042°19.100'N	070°58.467'W
R13	2	08/23/2000	13:22	042°19.035'N	070°58.841'W
R13	3	08/23/2000	13:23	042°19.037'N	070°58.842'W
R13	4	08/23/2000	13:25	042°19.025'N	070°58.836'W
R13	1	08/23/2000	13:21	042°19.032'N	070°58.837'W
R14	4	08/21/2000	17:40	042°19.262'N	071°00.749'W

Station	Rep	Date	Time (local)	Latitude	Longitude
R14	3	08/21/2000	17:37	042°19.269'N	071°00.754'W
R14	2	08/21/2000	17:36	042°19.272'N	071°00.757'W
R14	1	08/21/2000	17:34	042°19.274'N	071°00.767'W
R15	1	08/21/2000	17:56	042°18.941'N	071°01.182'W
R15	2	08/21/2000	17:57	042°18.939'N	071°01.183'W
R15	3	08/21/2000	17:58	042°18.938'N	071°01.176'W
R16	2	08/22/2000	18:25	042°18.956'N	070°57.676'W
R16	3	08/22/2000	18:28	042°18.953'N	070°57.675'W
R16	1	08/22/2000	18:25	042°18.948'N	070°57.675'W
R17	3	08/23/2000	13:39	042°18.295'N	070°58.622'W
R17	4	08/23/2000	13:40	042°18.285'N	070°58.626'W
R17	2	08/23/2000	13:38	042°18.292'N	070°58.625'W
R17	1	08/23/2000	13:37	042°18.288'N	070°58.623'W
R18	1	08/23/2000	17:32	042°17.324'N	070°57.678'W
R18	2	08/23/2000	17:33	042°17.329'N	070°57.663'W
R18	3	08/23/2000	17:37	042°17.324'N	070°57.664'W
R18	4	08/23/2000	17:38	042°17.334'N	070°57.665'W
R19	3	08/23/2000	17:57	042°16.920'N	070°56.268'W
R19	2	08/23/2000	17:54	042°16.918'N	070°56.273'W
R19	4	08/23/2000	18:00	042°16.917'N	070°56.266'W
R19	1	08/23/2000	17:50	042°16.915'N	070°56.268'W
R20	1	08/22/2000	17:59	042°19.503'N	070°56.098'W
R20	2	08/22/2000	18:05	042°19.487'N	070°56.106'W
R20	4	08/22/2000	18:10	042°19.489'N	070°56.091'W
R20	3	08/22/2000	18:07	042°19.493'N	070°56.108'W
R21	5	08/23/2000	14:06	042°18.527'N	070°56.780'W
R21	4	08/23/2000	14:04	042°18.528'N	070°56.778'W
R21	3	08/23/2000	14:02	042°18.530'N	070°56.776'W
R21	2	08/23/2000	14:01	042°18.531'N	070°56.774'W
R21	1	08/23/2000	13:59	042°18.529'N	070°56.795'W
R22	1	08/23/2000	14:12	042°18.013'N	070°56.371'W
R22	4	08/23/2000	14:20	042°18.020'N	070°56.362'W
R22	3	08/23/2000	14:16	042°18.016'N	070°56.365'W
R22	2	08/23/2000	14:15	042°18.021'N	070°56.364'W
R23	2	08/23/2000	14:36	042°17.628'N	070°56.991'W
R23	1	08/23/2000	14:34	042°17.637'N	070°57.003'W
R23	4	08/23/2000	14:39	042°17.625'N	070°57.003'W
R23	3	08/23/2000	14:38	042°17.630'N	070°57.005'W
R24	2	08/23/2000	14:47	042°17.780'N	070°57.506'W
R24	1	08/23/2000	14:45	042°17.777'N	070°57.494'W
R24	3	08/23/2000	14:47	042°17.783'N	070°57.506'W
R24	4	08/23/2000	14:48	042°17.786'N	070°57.512'W
R25	3	08/23/2000	18:15	042°17.479'N	070°55.723'W
R25	1	08/23/2000	18:12	042°17.482'N	070°55.716'W
R25	2	08/23/2000	18:14	042°17.471'N	070°55.721'W

Station	Rep	Date	Time (local)	Latitude	Longitude
R26	1	08/24/2000	9:52	042°16.125'N	070°55.795'W
R26	2	08/24/2000	9:54	042°16.129'N	070°55.807'W
R26	3	08/24/2000	9:56	042°16.130'N	070°55.804'W
R27	3	08/24/2000	9:07	042°16.823'N	070°54.984'W
R27	2	08/24/2000	9:06	042°16.826'N	070°54.980'W
R27	1	08/24/2000	9:04	042°16.832'N	070°54.978'W
R28	1	08/24/2000	8:49	042°16.889'N	070°54.522'W
R28	2	08/24/2000	8:54	042°16.907'N	070°54.520'W
R28	4	08/24/2000	8:57	042°16.905'N	070°54.517'W
R28	3	08/24/2000	8:56	042°16.905'N	070°54.519'W
R29	1	08/23/2000	18:31	042°17.371'N	070°55.252'W
R29	2	08/23/2000	18:32	042°17.387'N	070°55.246'W
R29	3	08/23/2000	18:35	042°17.374'N	070°55.257'W
R30	2	08/24/2000	8:26	042°17.427'N	070°54.257'W
R30	4	08/24/2000	8:28	042°17.431'N	070°54.257'W
R30	3	08/24/2000	8:27	042°17.429'N	070°54.258'W
R30	1	08/24/2000	8:25	042°17.427'N	070°54.256'W
R31	2	08/23/2000	18:44	042°18.053'N	070°55.033'W
R31	1	08/23/2000	18:43	042°18.042'N	070°55.025'W
R31	3	08/23/2000	18:47	042°18.041'N	070°55.024'W
R32	3	08/24/2000	8:18	042°17.679'N	070°53.815'W
R32	1	08/23/2000	18:58	042°17.672'N	070°53.822'W
R32	2	08/23/2000	18:59	042°17.680'N	070°53.821'W
R32	2	08/24/2000	8:16	042°17.676'N	070°53.817'W
R32	1	08/24/2000	8:15	042°17.672'N	070°53.818'W
R33	3	08/23/2000	16:21	042°17.655'N	070°59.676'W
R33	2	08/23/2000	16:20	042°17.652'N	070°59.676'W
R33	1	08/23/2000	16:19	042°17.647'N	070°59.672'W
R33	4	08/23/2000	16:22	042°17.651'N	070°59.660'W
R34	1	08/23/2000	16:30	042°17.326'N	071°00.427'W
R34	2	08/23/2000	16:33	042°17.323'N	071°00.418'W
R34	3	08/23/2000	16:34	042°17.329'N	071°00.422'W
R34	4	08/23/2000	16:35	042°17.334'N	071°00.422'W
R35	3	08/23/2000	16:48	042°17.056'N	070°59.281'W
R35	2	08/23/2000	16:47	042°17.049'N	070°59.278'W
R35	4	08/23/2000	16:50	042°17.045'N	070°59.282'W
R35	1	08/23/2000	16:46	042°17.043'N	070°59.279'W
R36	3	08/23/2000	17:00	042°16.532'N	070°59.198'W
R36	1	08/23/2000	16:57	042°16.525'N	070°59.191'W
R36	5	08/23/2000	17:07	042°16.526'N	070°59.199'W
R36	2	08/23/2000	16:59	042°16.528'N	070°59.197'W
R36	4	08/23/2000	17:06	042°16.522'N	070°59.199'W
R37	3	08/23/2000	15:35	042°17.933'N	070°59.084'W
R37	1	08/23/2000	15:33	042°17.924'N	070°59.073'W
R37	2	08/23/2000	15:34	042°17.928'N	070°59.079'W

Station	Rep	Date	Time (local)	Latitude	Longitude
R37	4	08/23/2000	15:37	042°17.927'N	070°59.074'W
R38	3	08/23/2000	17:27	042°17.084'N	070°57.826'W
R38	1	08/23/2000	17:22	042°17.070'N	070°57.825'W
R38	4	08/23/2000	17:27	042°17.085'N	070°57.826'W
R38	2	08/23/2000	17:24	042°17.077'N	070°57.825'W
R39	4	08/23/2000	15:00	042°17.734'N	070°58.217'W
R39	3	08/23/2000	14:59	042°17.731'N	070°58.210'W
R39	2	08/23/2000	14:57	042°17.735'N	070°58.221'W
R39	1	08/23/2000	14:56	042°17.731'N	070°58.214'W
R40	2	08/21/2000	17:25	042°19.727'N	071°01.420'W
R40	3	08/21/2000	17:26	042°19.725'N	071°01.421'W
R40	1	08/21/2000	17:24	042°19.731'N	071°01.415'W
R41	3	08/21/2000	18:08	042°18.659'N	071°01.458'W
R41	2	08/21/2000	18:07	042°18.667'N	071°01.469'W
R41	1	08/21/2000	18:04	042°18.674'N	071°01.490'W
R42	1	08/21/2000	17:48	042°19.191'N	071°01.469'W
R42	3	08/21/2000	17:50	042°19.189'N	071°01.473'W
R42	2	08/21/2000	17:49	042°19.190'N	071°01.474'W
R43	4	08/23/2000	15:59	042°18.398'N	071°00.127'W
R43	2	08/23/2000	15:55	042°18.403'N	071°00.136'W
R43	1	08/23/2000	15:55	042°18.401'N	071°00.136'W
R43	3	08/23/2000	15:58	042°18.392'N	071°00.125'W
R44	1	08/21/2000	14:10	042°20.622'N	071°00.120'W
R44	2	08/21/2000	14:14	042°20.620'N	071°00.127'W
R44	3	08/21/2000	14:15	042°20.621'N	071°00.134'W
R45	1	08/23/2000	12:47	042°19.700'N	070°58.045'W
R45	2	08/23/2000	12:48	042°19.707'N	070°58.048'W
R45	4	08/23/2000	12:53	042°19.700'N	070°58.049'W
R45	3	08/23/2000	12:52	042°19.694'N	070°58.054'W
R46	2	08/23/2000	18:24	042°17.455'N	070°55.328'W
R46	1	08/23/2000	18:21	042°17.463'N	070°55.332'W
R46	3	08/23/2000	18:27	042°17.457'N	070°55.326'W
R47	2	08/21/2000	16:17	042°20.674'N	070°58.727'W
R47	3	08/21/2000	16:18	042°20.677'N	070°58.725'W
R47	1	08/21/2000	16:16	042°20.671'N	070°58.726'W
R48	4	08/23/2000	15:26	042°17.612'N	070°59.266'W
R48	3	08/23/2000	15:25	042°17.610'N	070°59.267'W
R48	1	08/23/2000	15:20	042°17.612'N	070°59.283'W
R48	2	08/23/2000	15:24	042°17.606'N	070°59.263'W
R49	4	08/24/2000	9:37	042°16.398'N	070°54.483'W
R49	1	08/24/2000	9:32	042°16.392'N	070°54.497'W
R49	3	08/24/2000	9:35	042°16.394'N	070°54.487'W
R49	2	08/24/2000	9:34	042°16.392'N	070°54.490'W
R50	4	08/24/2000	9:22	042°16.506'N	070°53.930'W
R50	3	08/24/2000	9:19	042°16.492'N	070°53.915'W

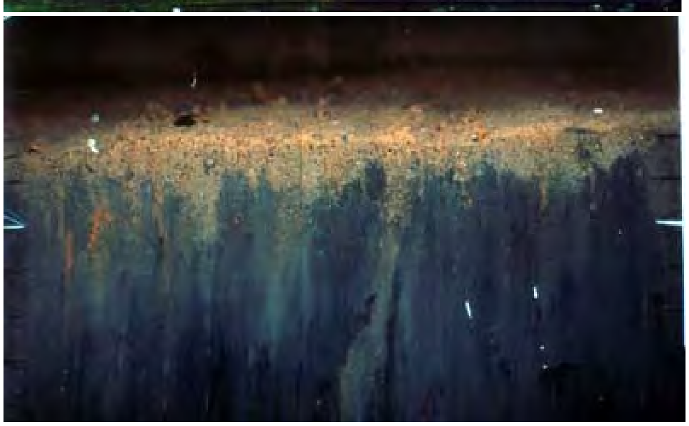
Station	Rep	Date	Time (local)	Latitude	Longitude
R50	2	08/24/2000	9:18	042°16.495'N	070°53.917'W
R50	1	08/24/2000	9:17	042°16.496'N	070°53.919'W
R51	4	08/24/2000	10:18	042°15.799'N	070°56.529'W
R51	1	08/24/2000	10:14	042°15.796'N	070°56.536'W
R51	2	08/24/2000	10:15	042°15.802'N	070°56.532'W
R51	3	08/24/2000	10:16	042°15.806'N	070°56.530'W
R52	3	08/24/2000	10:28	042°15.716'N	070°56.094'W
R52	4	08/24/2000	10:30	042°15.711'N	070°56.092'W
R52	2	08/24/2000	10:27	042°15.710'N	070°56.092'W
R52	1	08/24/2000	10:24	042°15.707'N	070°56.082'W
R53	1	08/24/2000	10:01	042°16.153'N	070°56.265'W
R53	2	08/24/2000	10:04	042°16.144'N	070°56.275'W
R53	3	08/24/2000	10:06	042°16.160'N	070°56.279'W
T01	3	08/21/2000	16:30	042°20.946'N	070°57.794'W
T01	2	08/21/2000	16:29	042°20.945'N	070°57.801'W
T01	1	08/21/2000	16:28	042°20.946'N	070°57.807'W
T01	4	08/21/2000	16:31	042°20.943'N	070°57.783'W
T02	2	08/21/2000	13:50	042°20.569'N	071°00.120'W
T02	3	08/21/2000	13:59	042°20.566'N	071°00.120'W
T02	4	08/21/2000	14:01	042°20.576'N	071°00.118'W
T02	5	08/21/2000	14:04	042°20.569'N	071°00.113'W
T02	1	08/21/2000	13:45	042°20.569'N	071°00.131'W
T03	3	08/23/2000	12:35	042°19.815'N	070°57.717'W
T03	1	08/23/2000	12:31	042°19.798'N	070°57.726'W
T03	2	08/23/2000	12:33	042°19.802'N	070°57.726'W
T03	4	08/23/2000	12:40	042°19.809'N	070°57.729'W
T04	3	08/21/2000	18:24	042°18.574'N	071°02.481'W
T04	2	08/21/2000	18:22	042°18.579'N	071°02.481'W
T04	1	08/21/2000	18:19	042°18.582'N	071°02.483'W
T05A	3	08/21/2000	16:53	042°20.335'N	070°57.619'W
T05A	2	08/21/2000	16:48	042°20.361'N	070°57.617'W
T05A	1	08/21/2000	16:46	042°20.371'N	070°57.620'W
T05A	4	08/21/2000	16:56	042°20.326'N	070°57.620'W
T06	1	08/23/2000	14:26	042°17.605'N	070°56.656'W
T06	2	08/23/2000	14:27	042°17.604'N	070°56.654'W
T06	3	08/23/2000	14:28	042°17.602'N	070°56.656'W
T06	4	08/23/2000	14:29	042°17.603'N	070°56.660'W
T07	4	08/23/2000	15:11	042°17.355'N	070°58.706'W
T07	1	08/23/2000	15:07	042°17.357'N	070°58.704'W
T07	2	08/23/2000	15:08	042°17.361'N	070°58.706'W
T07	3	08/23/2000	15:09	042°17.365'N	070°58.708'W
T08	4	08/24/2000	8:44	042°17.115'N	070°54.741'W
T08	3	08/24/2000	8:42	042°17.114'N	070°54.743'W
T08	2	08/24/2000	8:41	042°17.114'N	070°54.744'W
T08	1	08/24/2000	8:37	042°17.115'N	070°54.749'W

APPENDIX B–1

Sediment Profile Images – Reconnaissance Stations/ Traditional Stations (*see enclosed CDs*)

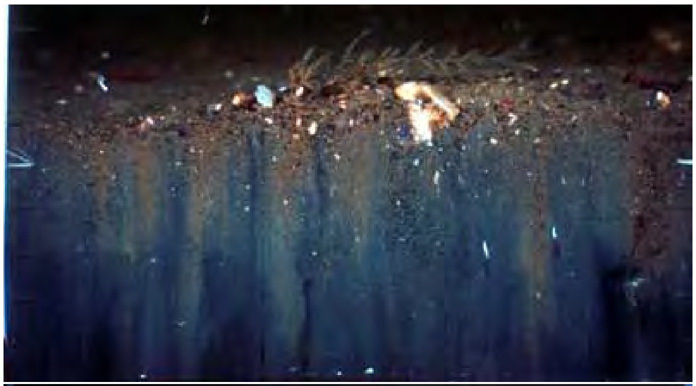
APPENDIX B-1

Sediment Profile Images-Reconnaissance Stations/Traditional Stations



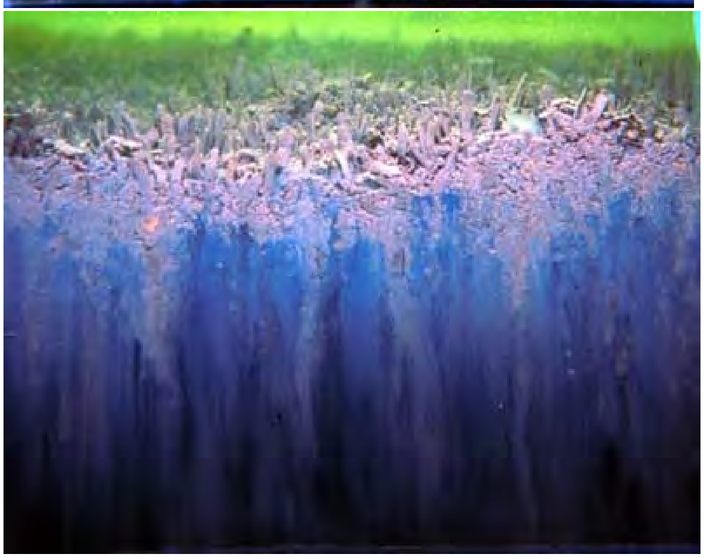
APPENDIX B-1

Sediment Profile Images-Reconnaissance Stations/Traditional Stations



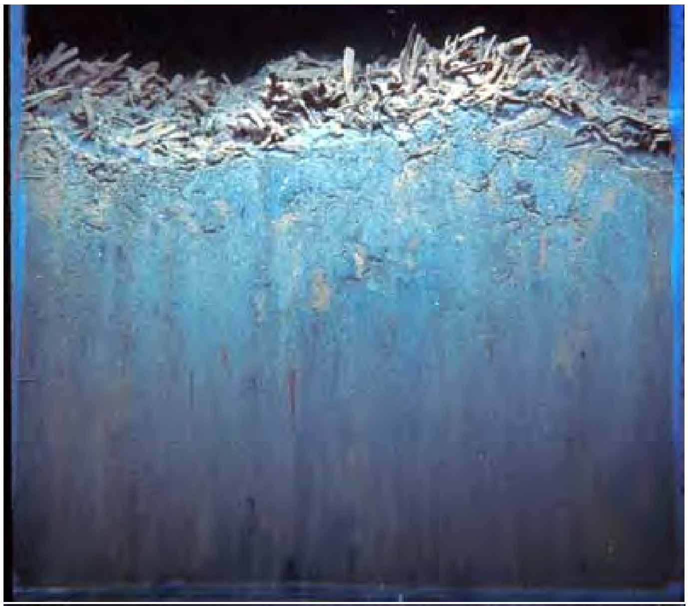
APPENDIX B-1

Sediment Profile Images-Reconnaissance Stations/Traditional Stations



APPENDIX B-1

Sediment Profile Images-Reconnaissance Stations/Traditional Stations



APPENDIX B-1

Sediment Profile Images-Reconnaissance Stations/Traditional Stations

APPENDIX B-1

Sediment Profile Images-Reconnaissance Stations/Traditional Stations

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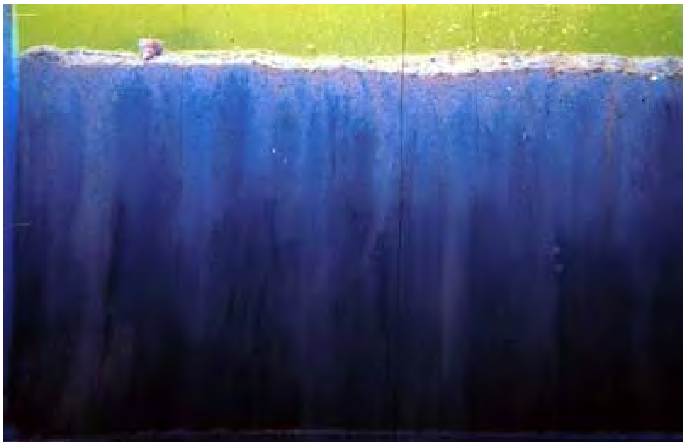
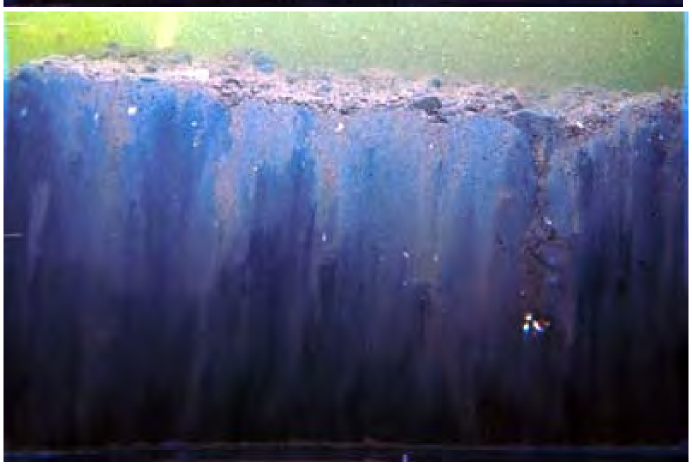


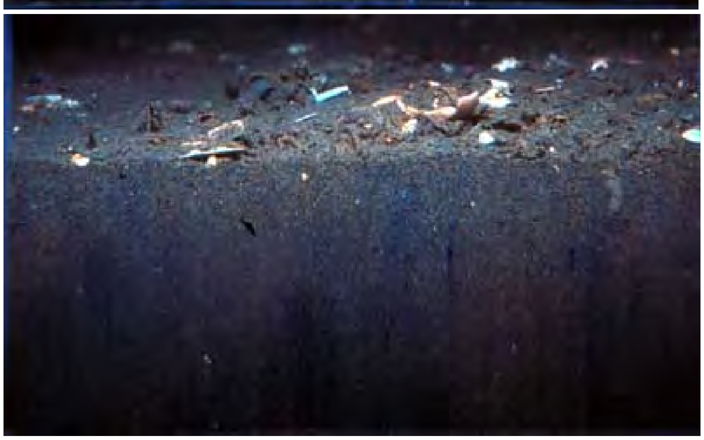


APPENDIX B-1

Sediment Profile Images-Reconnaissance Stations/Traditional Stations

APPENDIX B-1

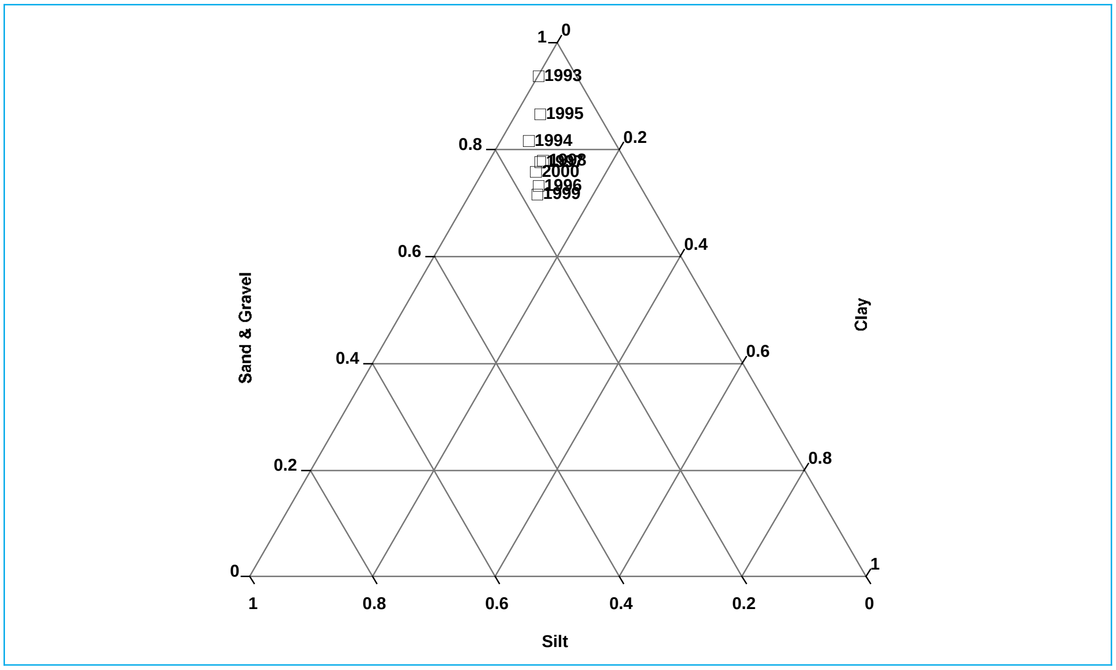
Sediment Profile Images-Reconnaissance Stations/Traditional Stations



APPENDIX C–1

Supporting Ternary Plots Showing Grain Size Composition and Line Charts Showing TOC and *Clostridium perfringens* Results, by Station and Season, across All Years

Ternary Plot



Ternary Plot

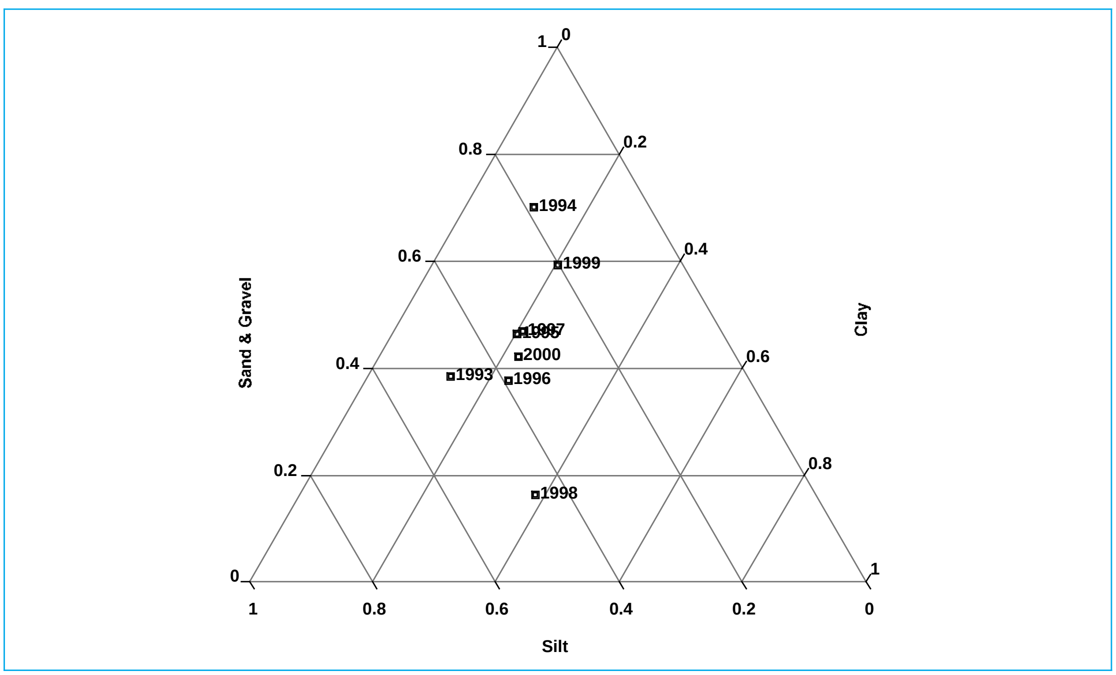
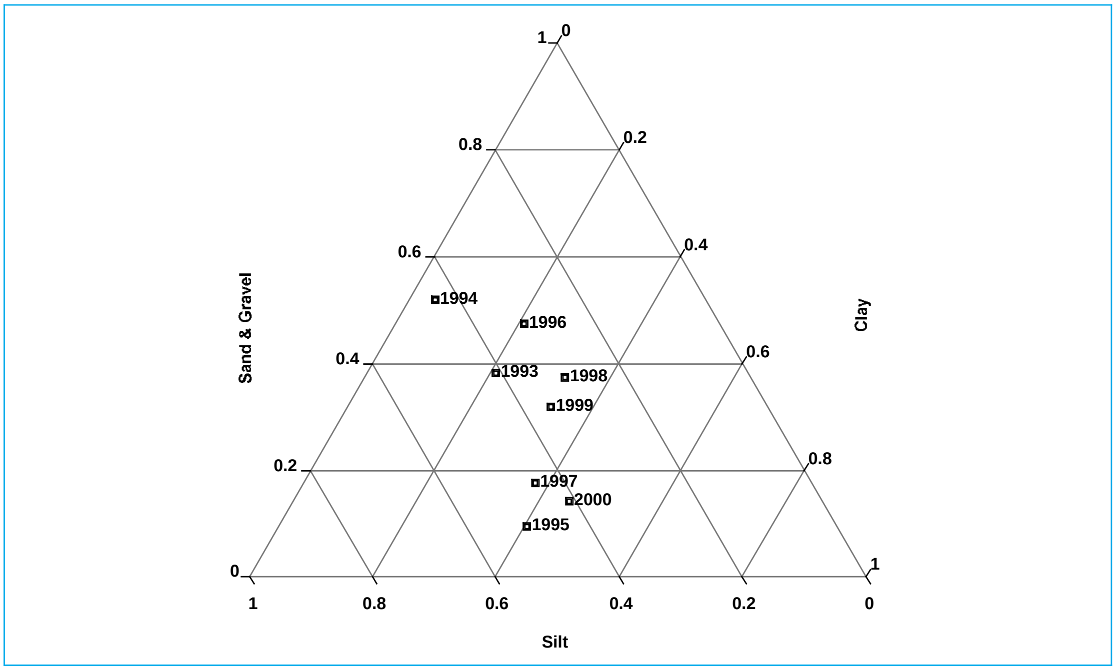


Figure C-1-1. Grain size composition from sediments collected at Traditional stations T01 (top) and T02 (bottom) in April 1993–2000.

Ternary Plot



Ternary Plot

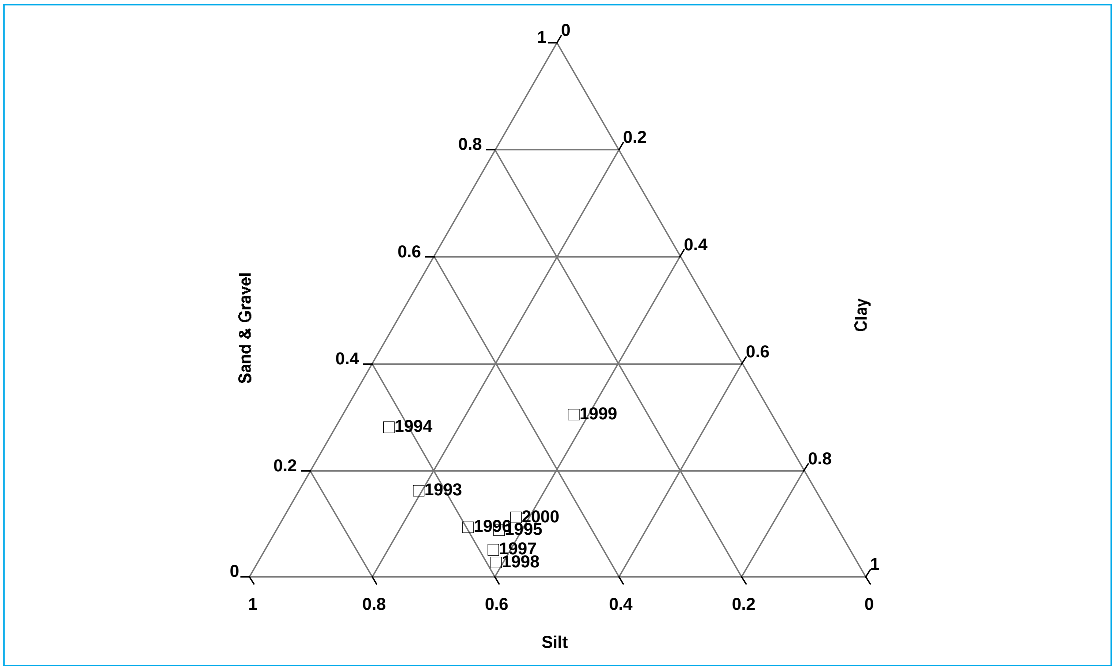
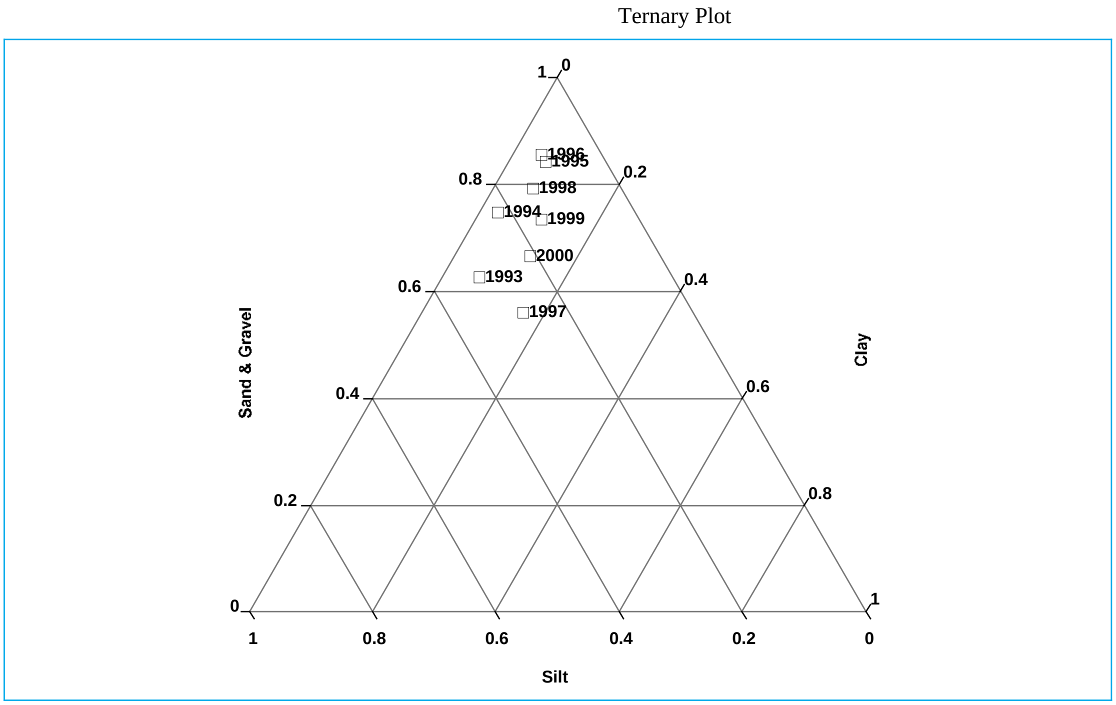


Figure C-1-2. Grain size composition from sediments collected at Traditional stations T03 (top) and T04 (bottom) in April 1993–2000.



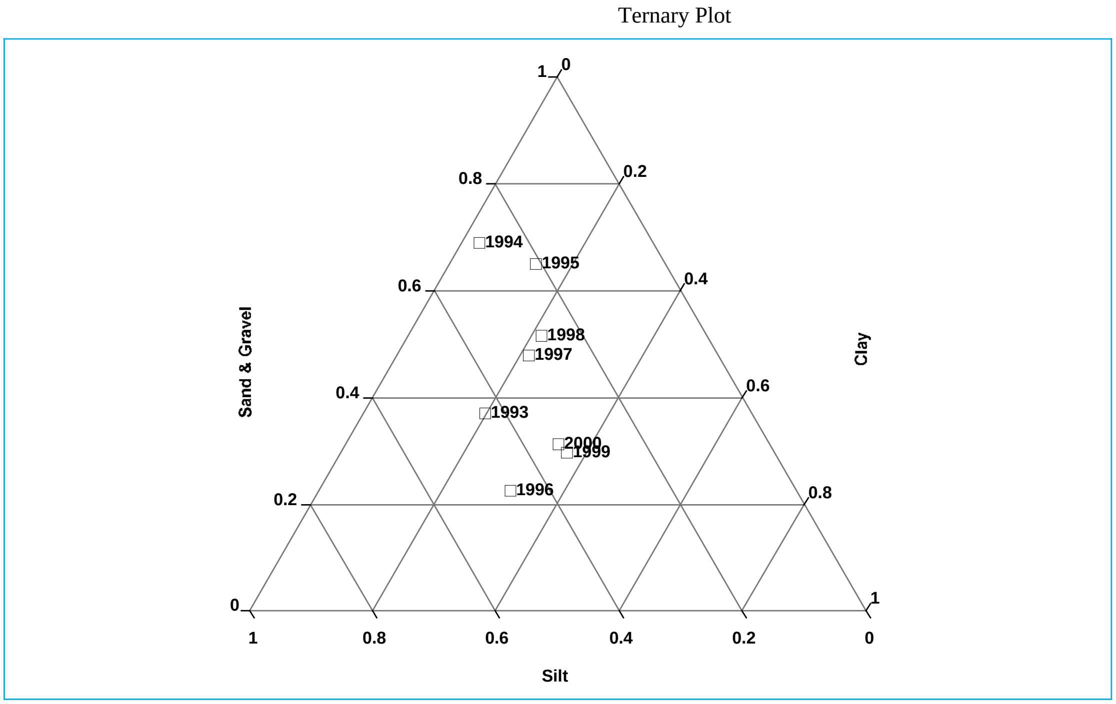
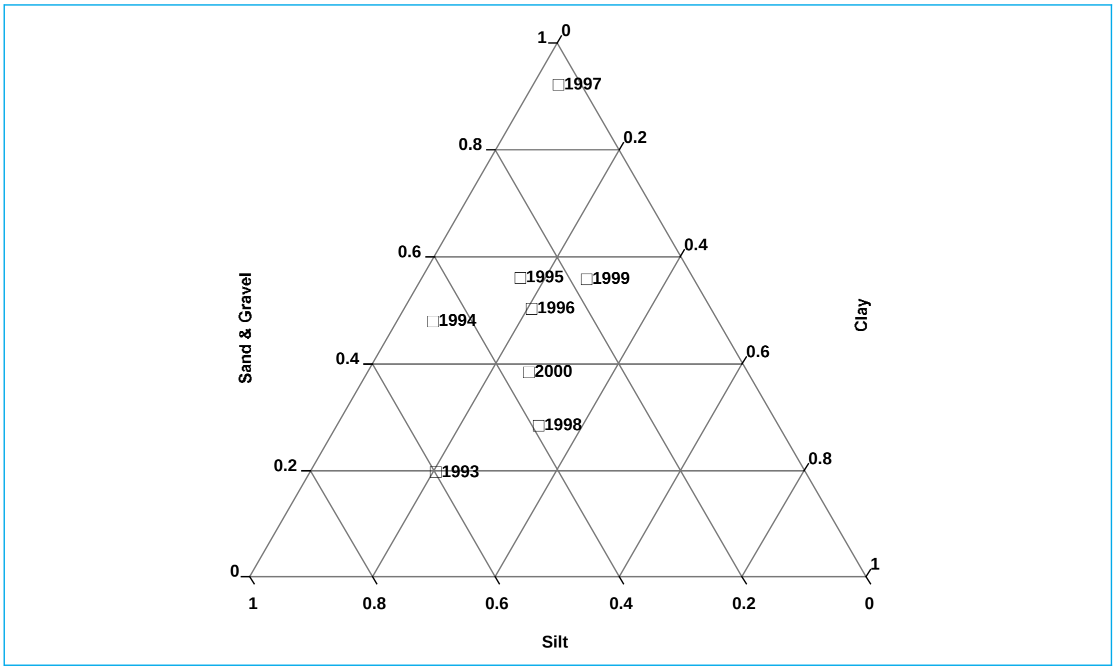


Figure C-1-3. Grain size composition from sediments collected at Traditional stations T05A (top) and T06 (bottom) in April 1993–2000.

Ternary Plot



Ternary Plot

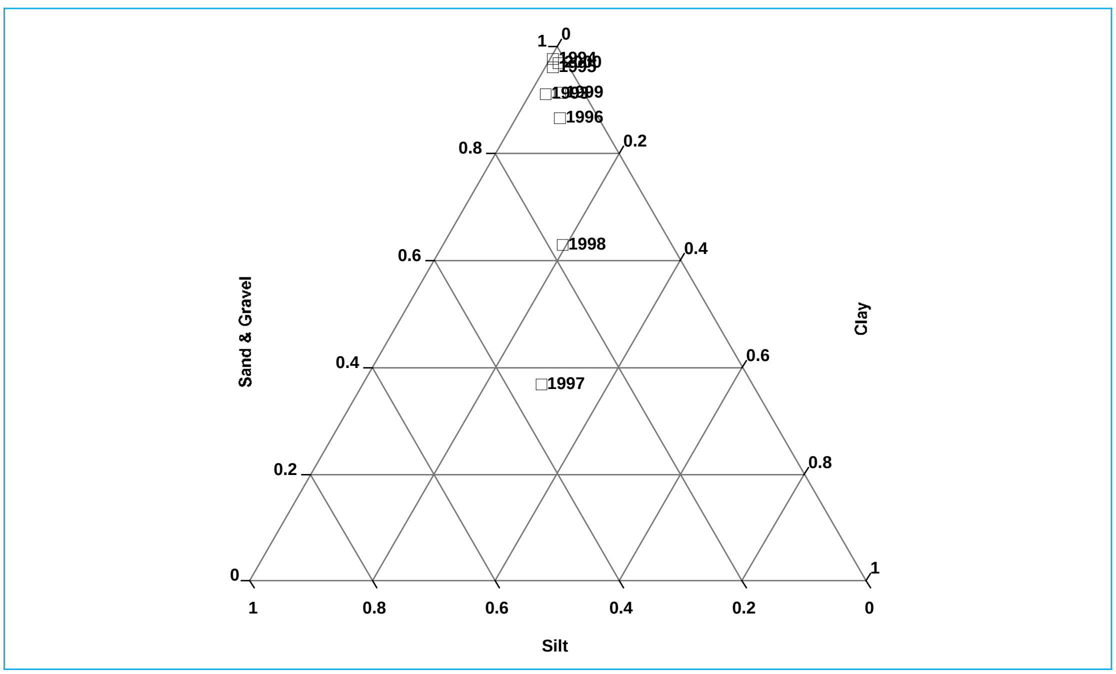
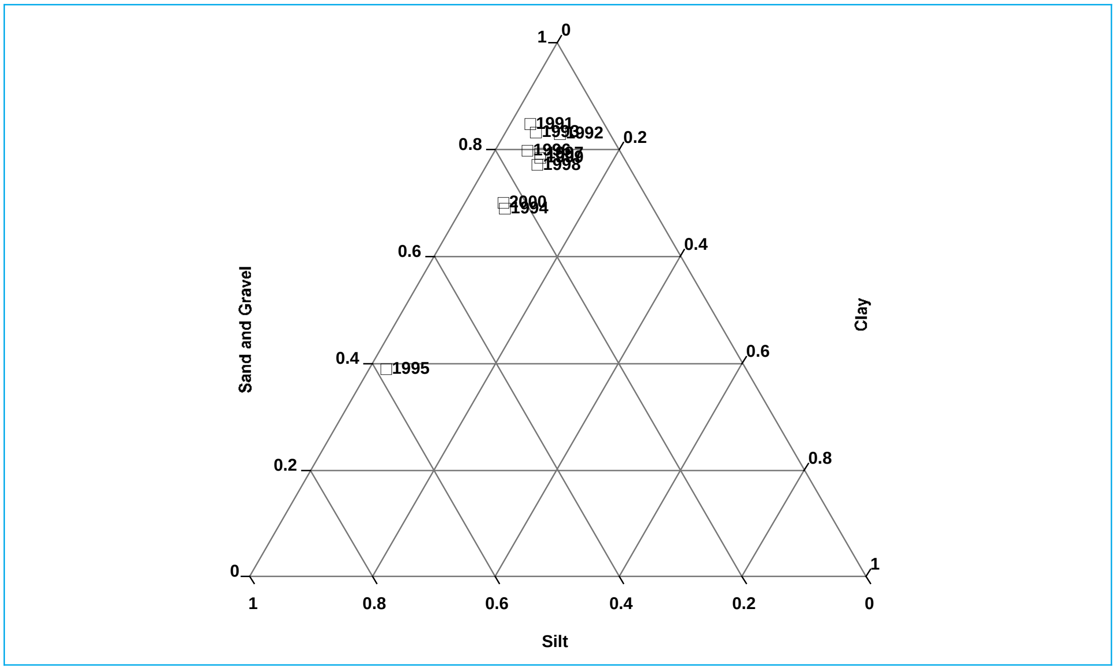


Figure C-1-4. Grain size composition from sediments collected at Traditional stations T07 (top) and T08 (bottom) in April 1993–2000.

Ternary Plot



Ternary Plot

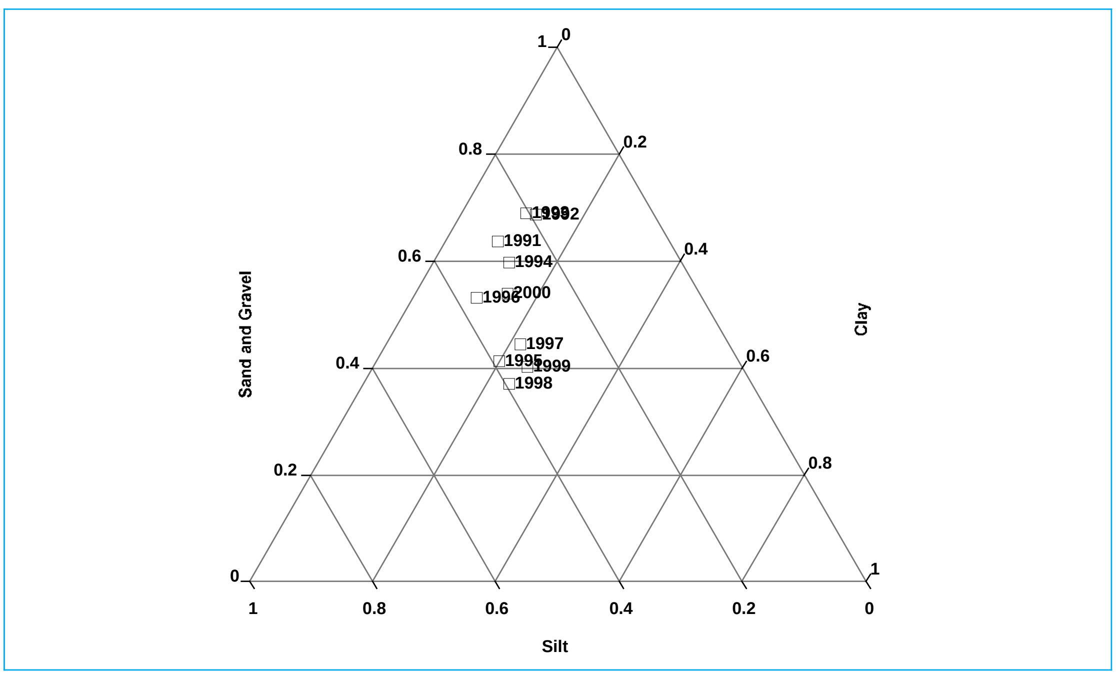
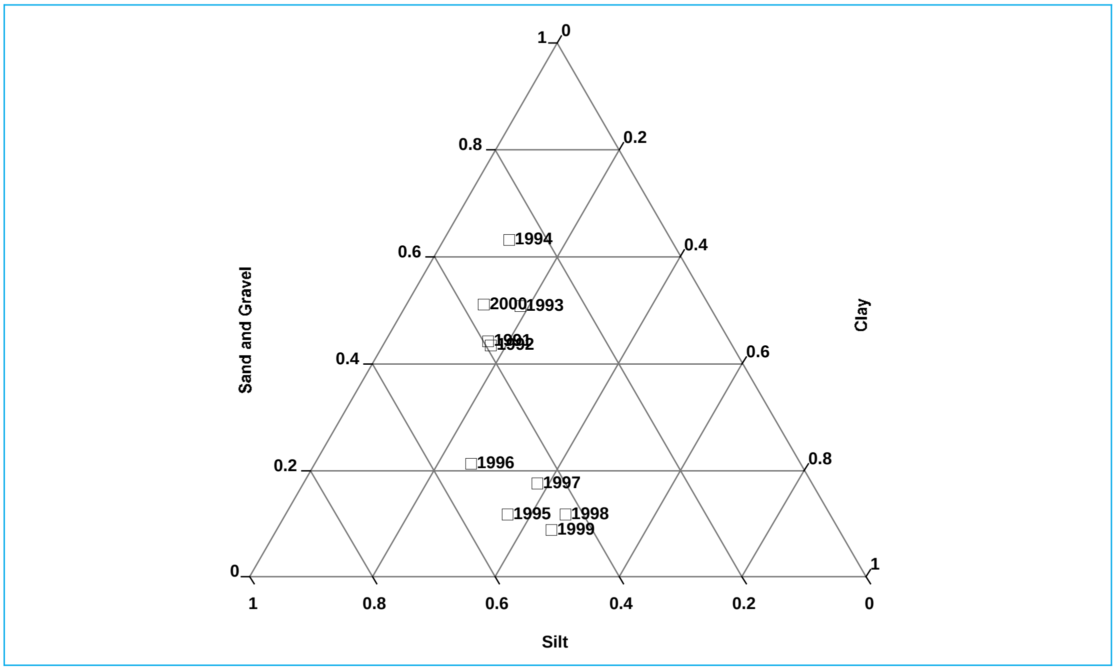


Figure C-1-5. Grain size composition from sediments collected at Traditional stations T01 (top) and T02 (bottom) in September 1991 and August 1992–2000.

Ternary Plot



Ternary Plot

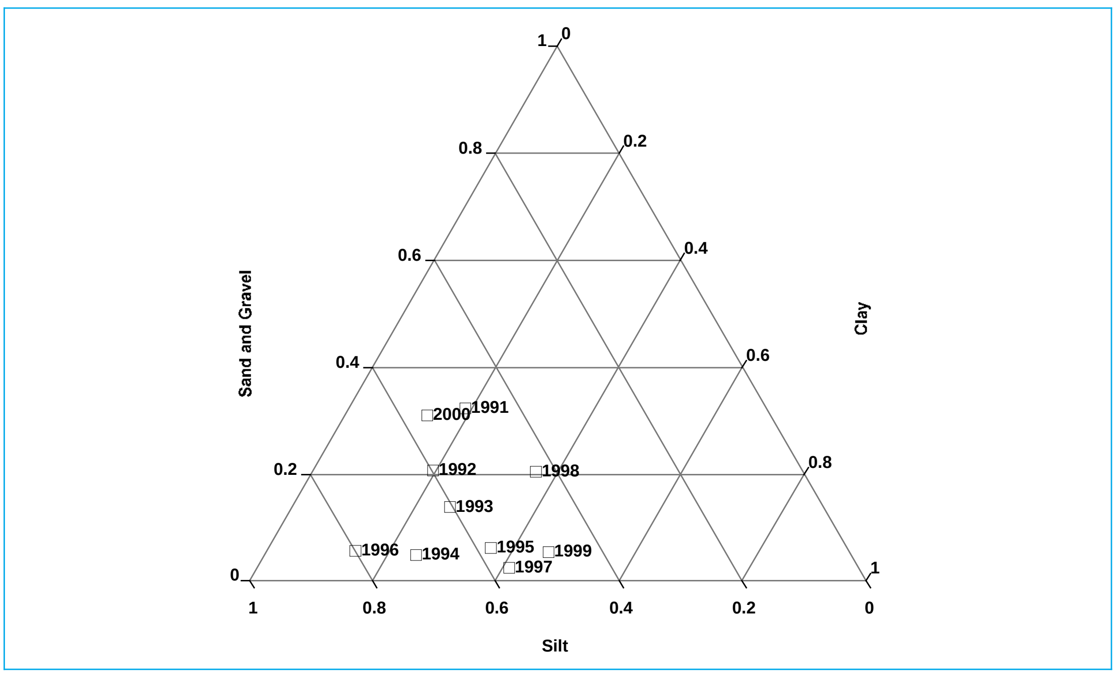
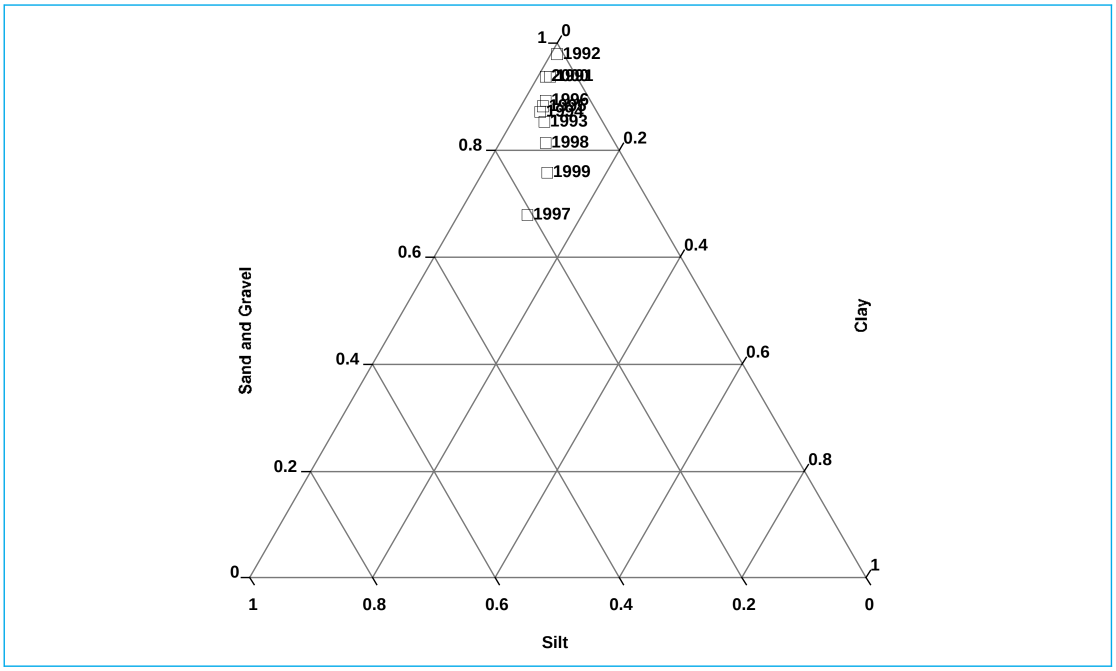


Figure C-1-6. Grain size composition from sediments collected at Traditional stations T03 (top) and T04 (bottom) in September 1991 and August 1992–2000.

Ternary Plot



Ternary Plot

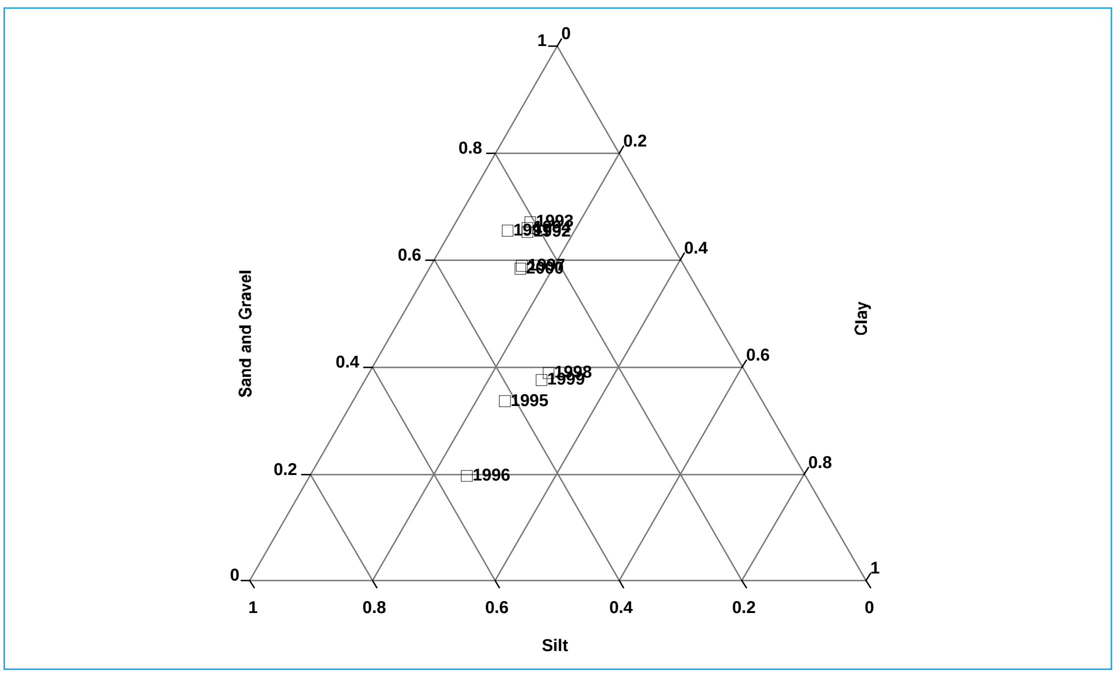
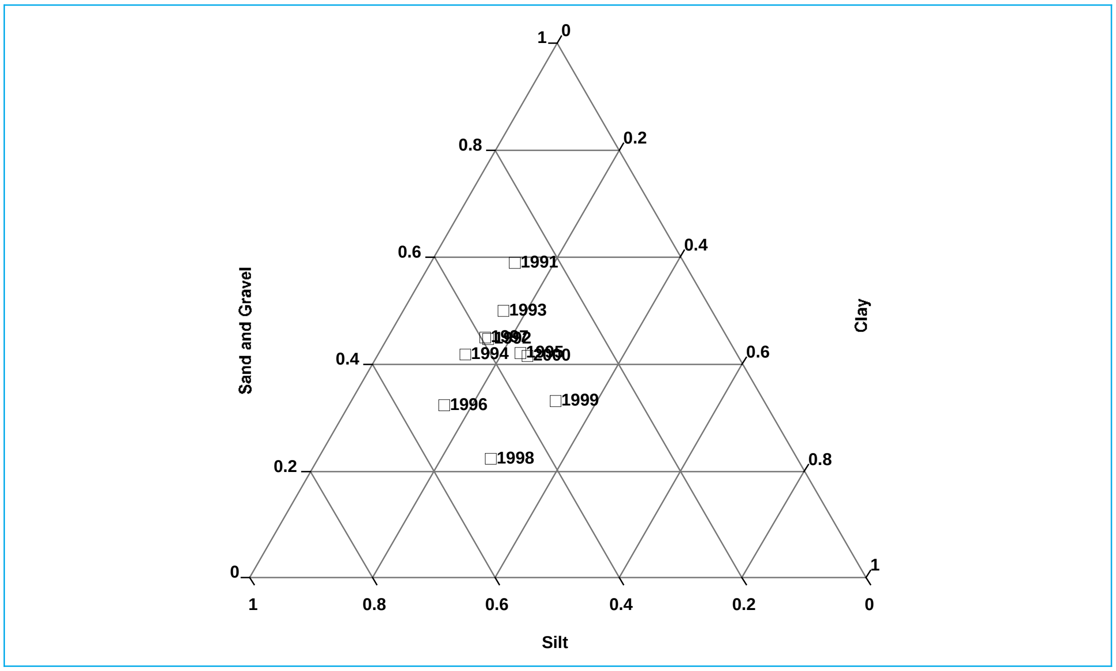


Figure C-1-7. Grain size composition from sediments collected at Traditional stations T05A (top) and T06 (bottom) in September 1991 and August 1992–2000.

Ternary Plot



Ternary Plot

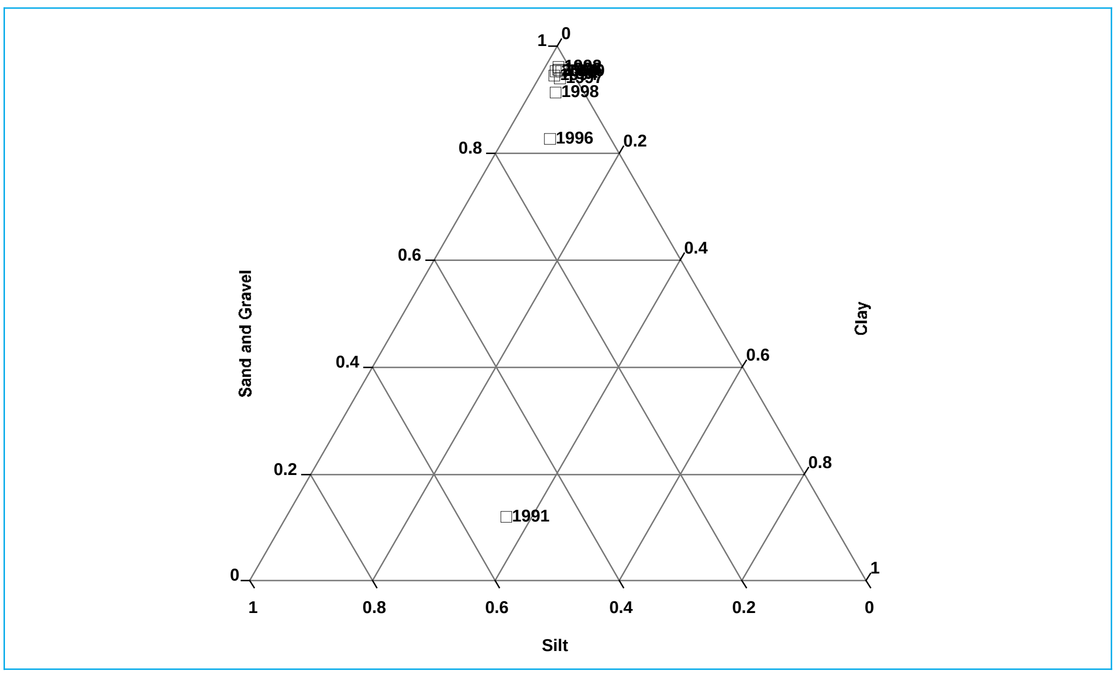


Figure C-1-8. Grain size composition from sediments collected at Traditional stations T07 (top) and T08 (bottom) in September 1991 and August 1992–2000.

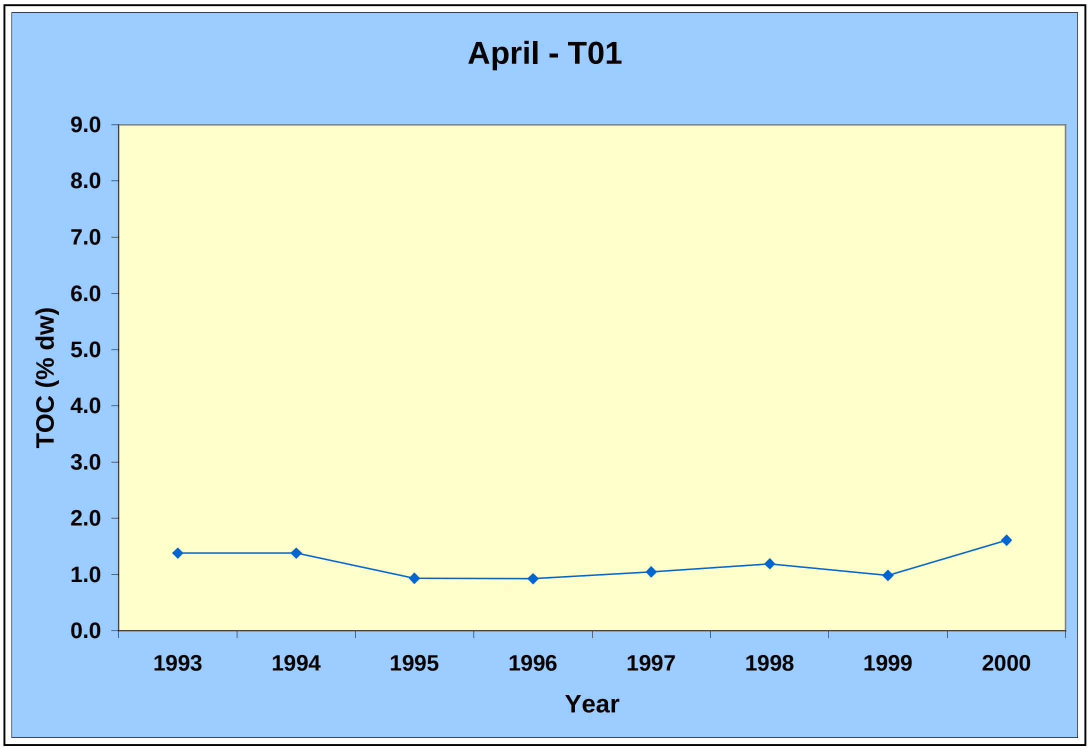


Figure C-1-9. Total organic carbon content in sediments collected at Station T01 in April 1993–2000.

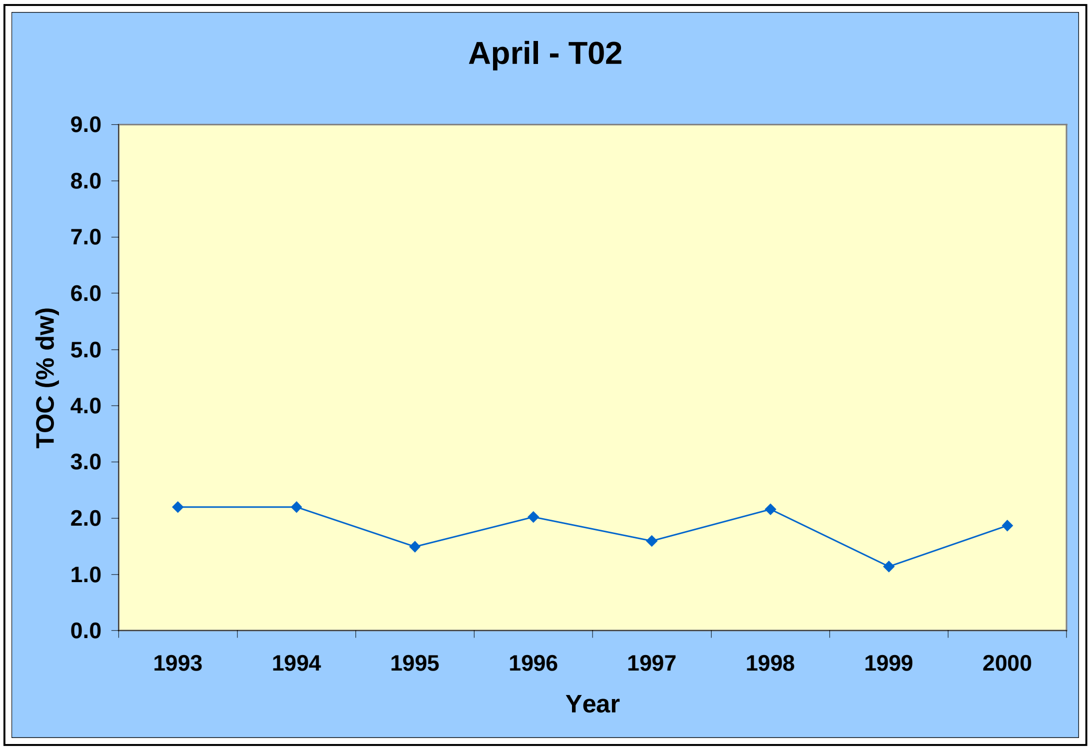


Figure C-1-10. Total organic carbon content in sediments collected at Station T02 in April 1993–2000.

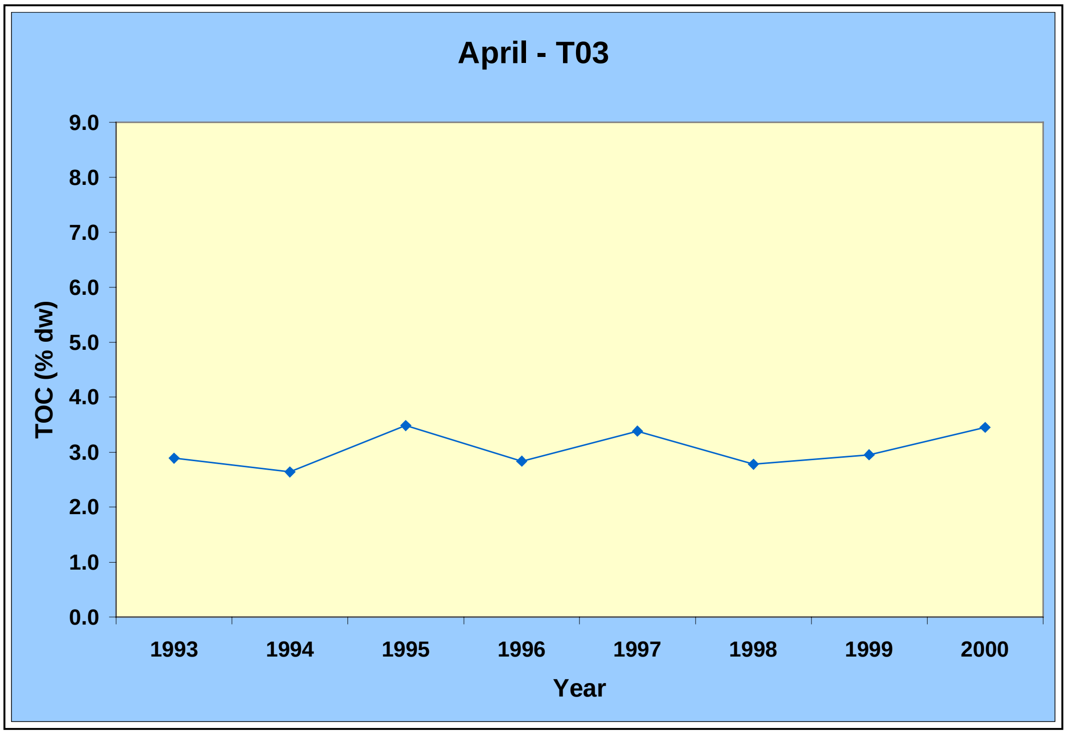


Figure C-1-11. Total organic carbon content in sediments collected at Station T03 in April 1993–2000.

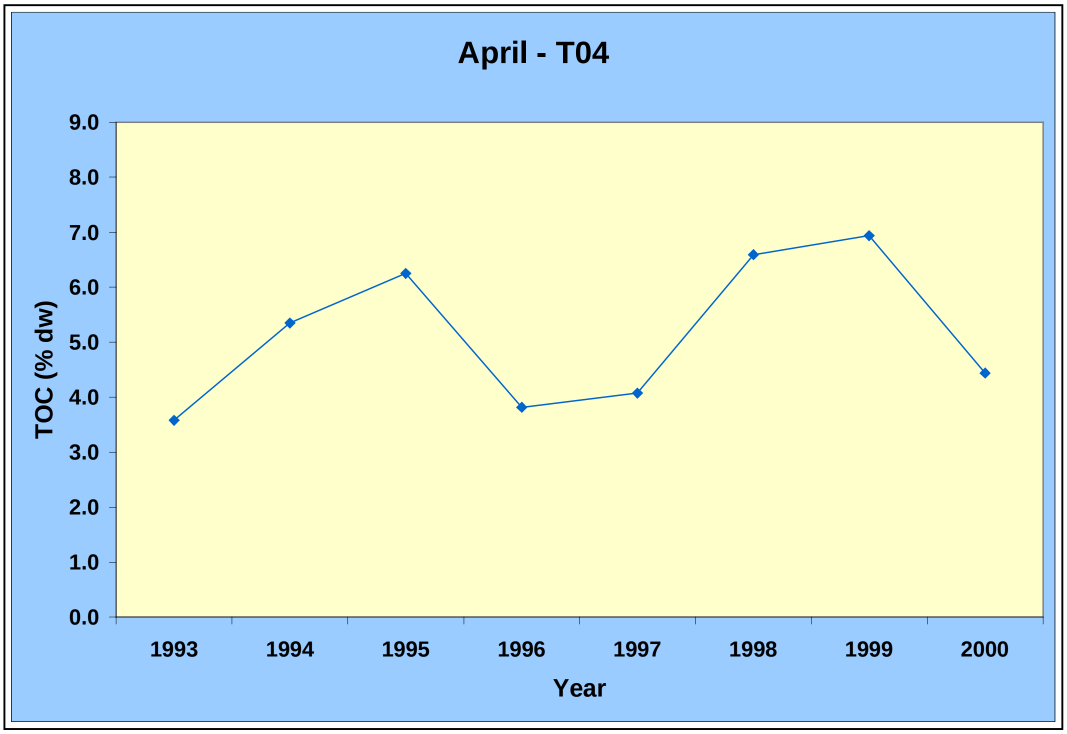


Figure C-1-12. Total organic carbon content in sediments collected at Station T04 in April 1993–2000.

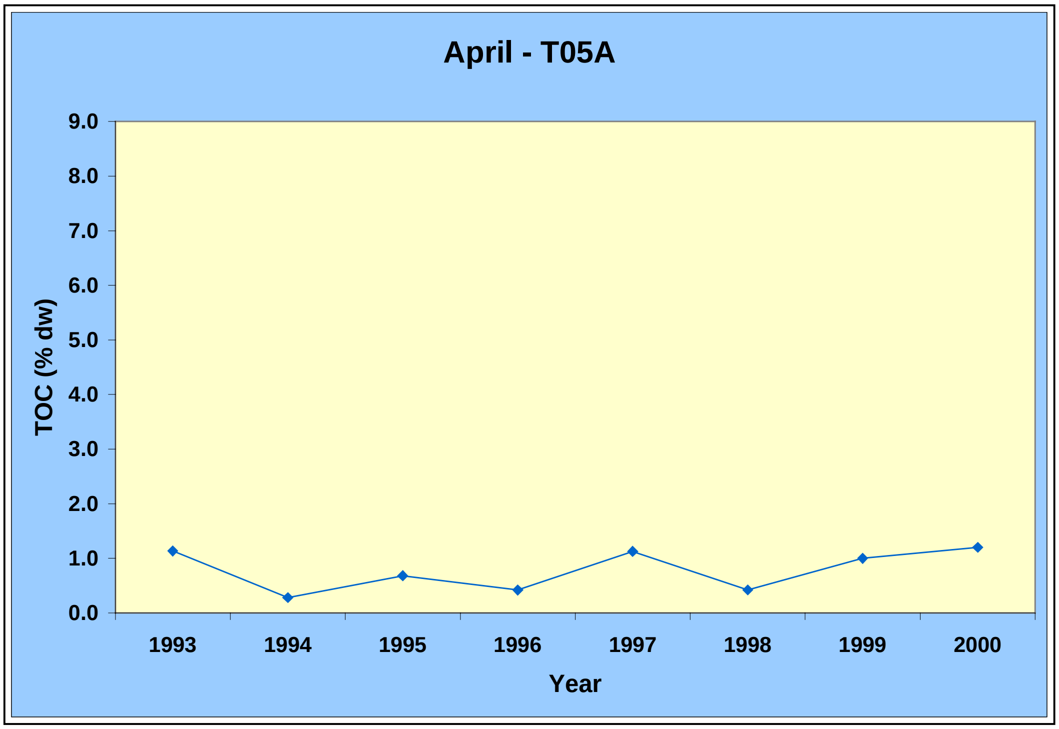


Figure C-1-13. Total organic carbon content in sediments collected at Station T05A in April 1993–2000.

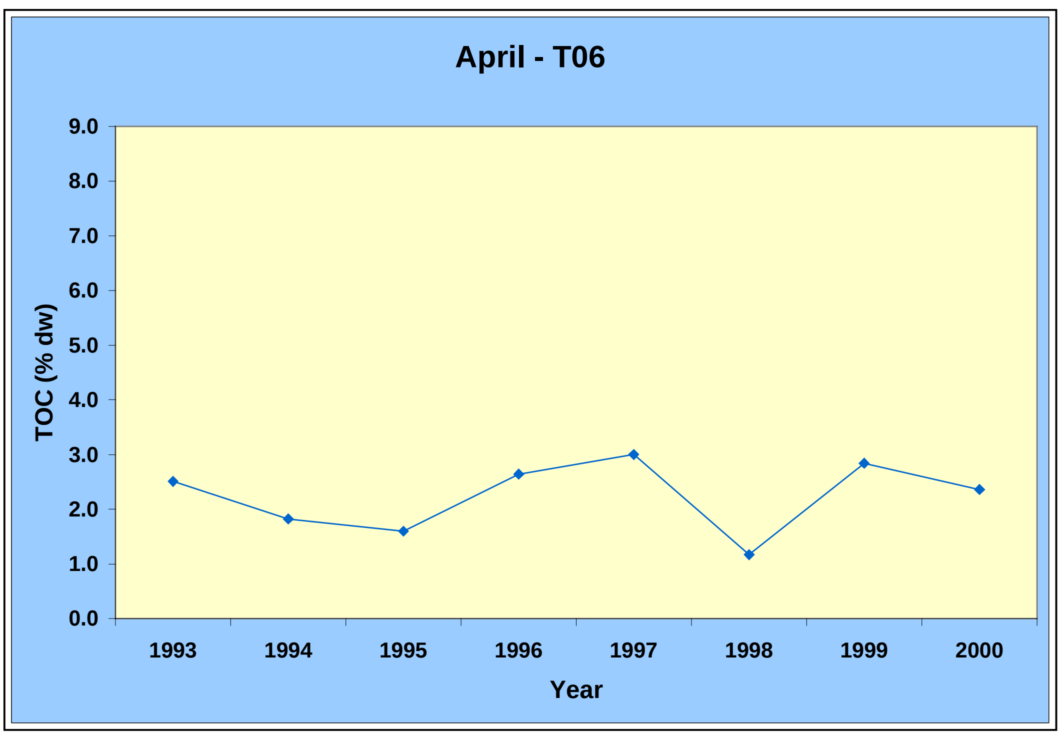


Figure C-1-14. Total organic carbon content in sediments collected at Station T06 in April 1993–2000.

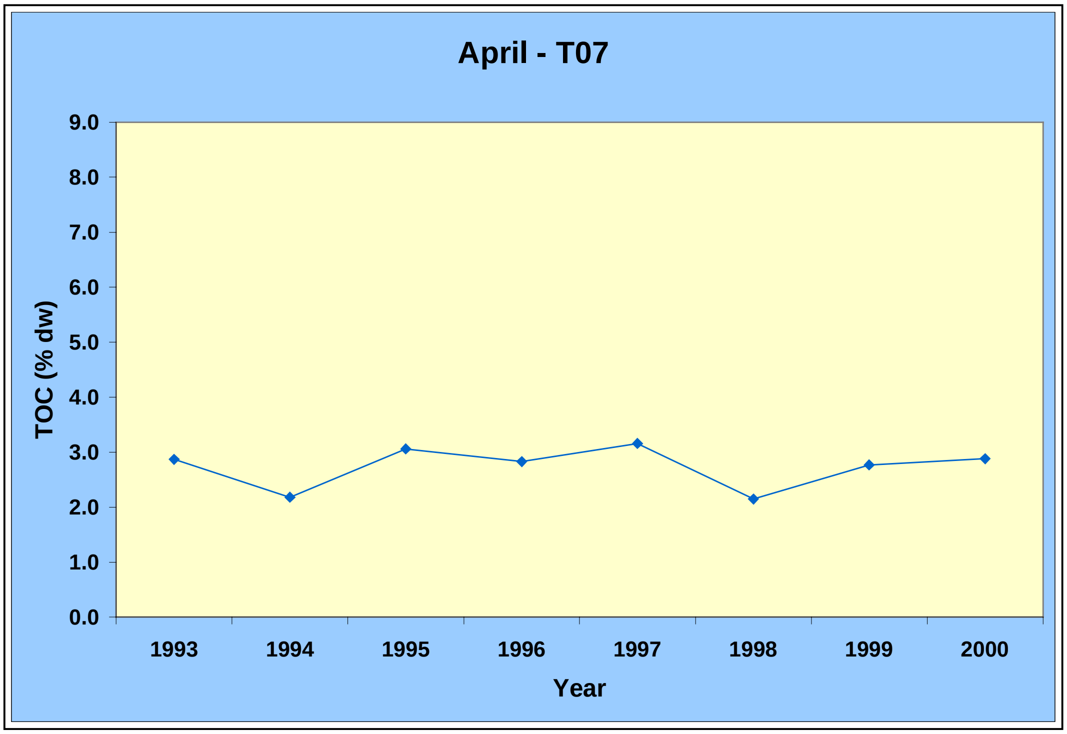


Figure C-1-15. Total organic carbon content in sediments collected at Station T07 in April 1993–2000.

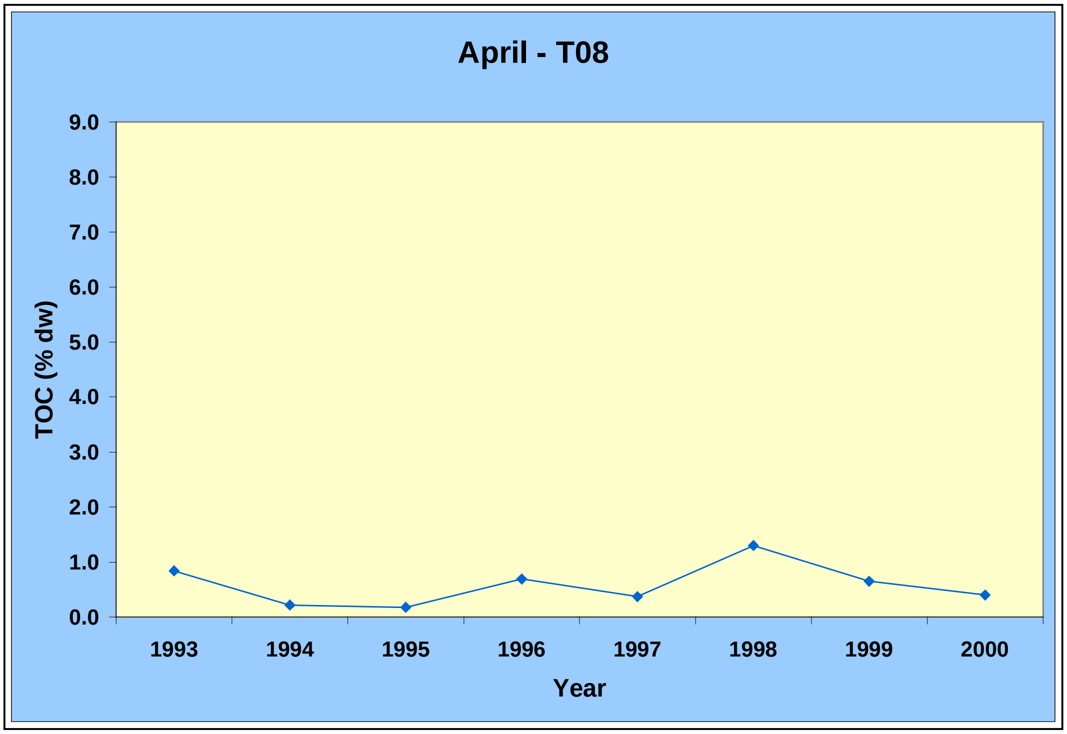


Figure C-1-16. Total organic carbon content in sediments collected at Station T08 in April 1993–2000.

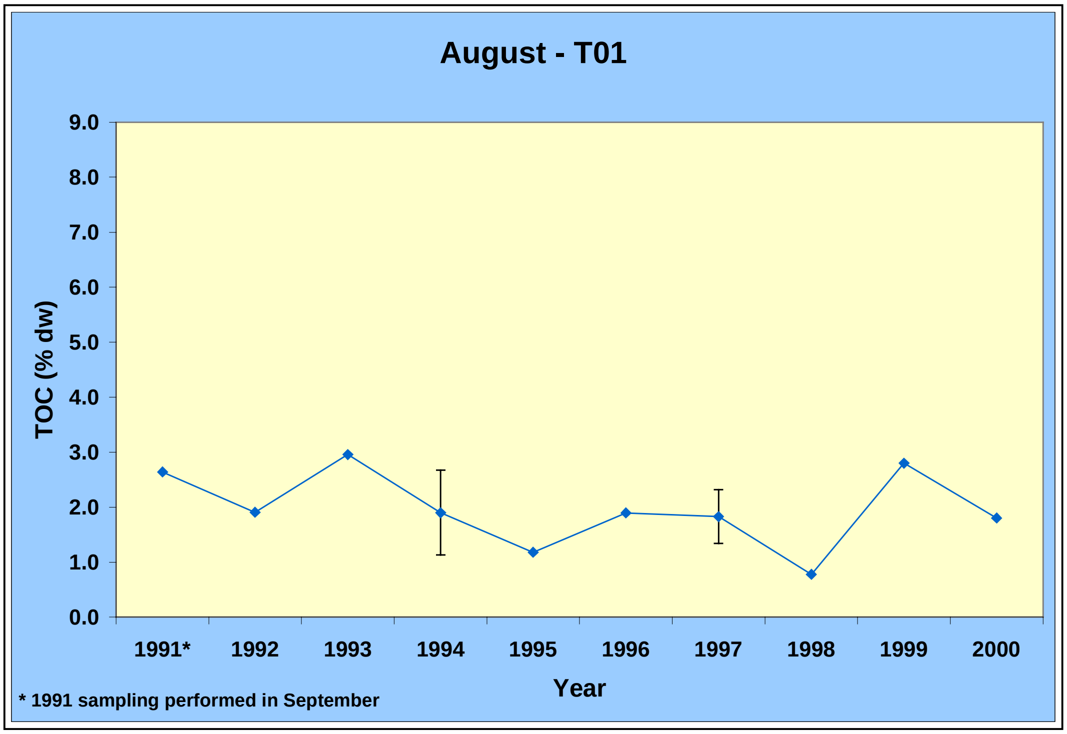


Figure C-1-17. Total organic carbon content in sediments collected at Station T01 in September 1991 and August 1992–2000. Error bars depict standard deviation of replicate analyses.

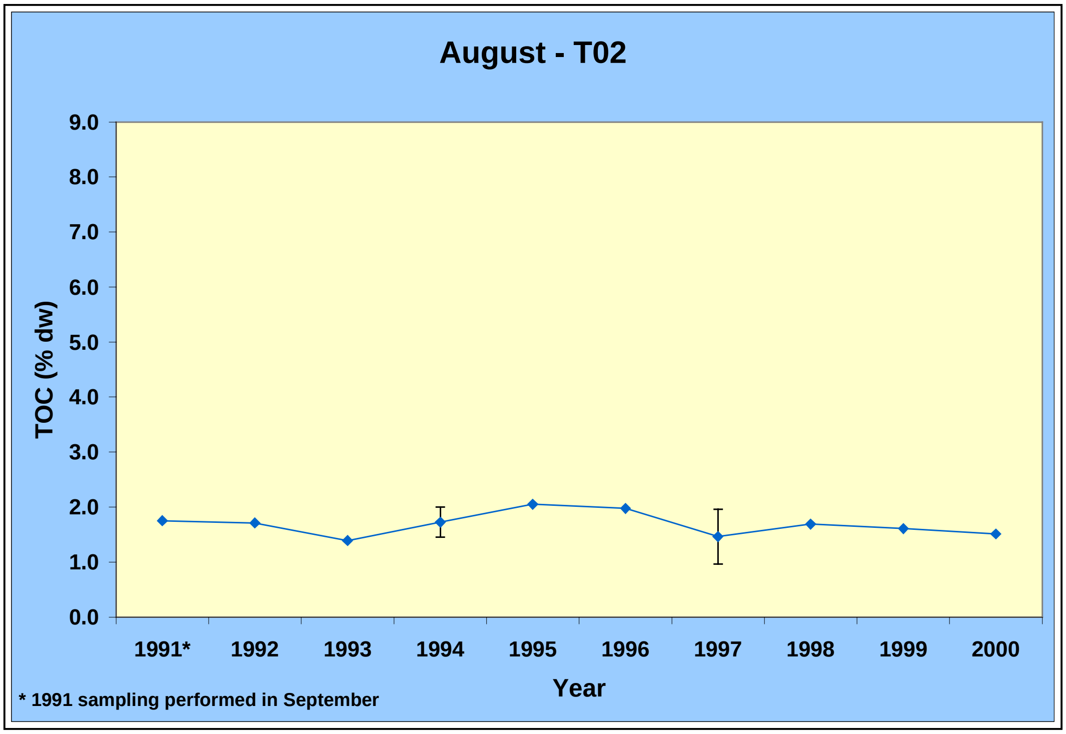


Figure C-1-18. Total organic carbon content in sediments collected at Station T02 in September 1991 and August 1992–2000. Error bars depict standard deviation of replicate analyses.

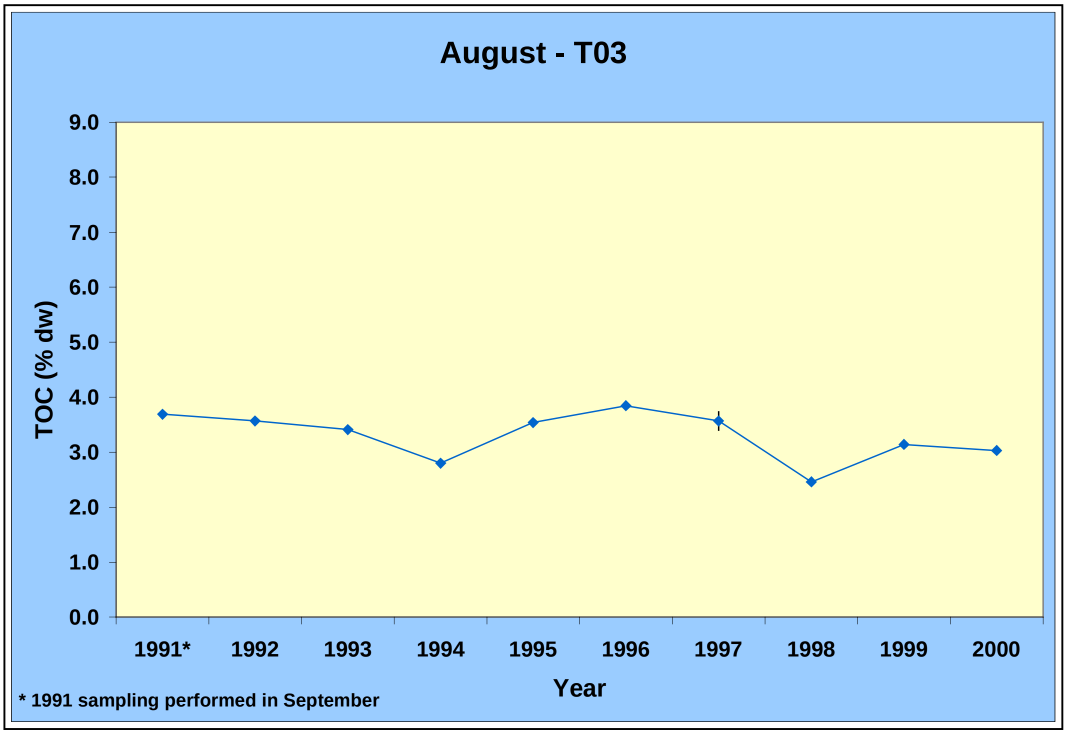


Figure C-1-19. Total organic carbon content in sediments collected at Station T03 in September 1991 and August 1992–2000.

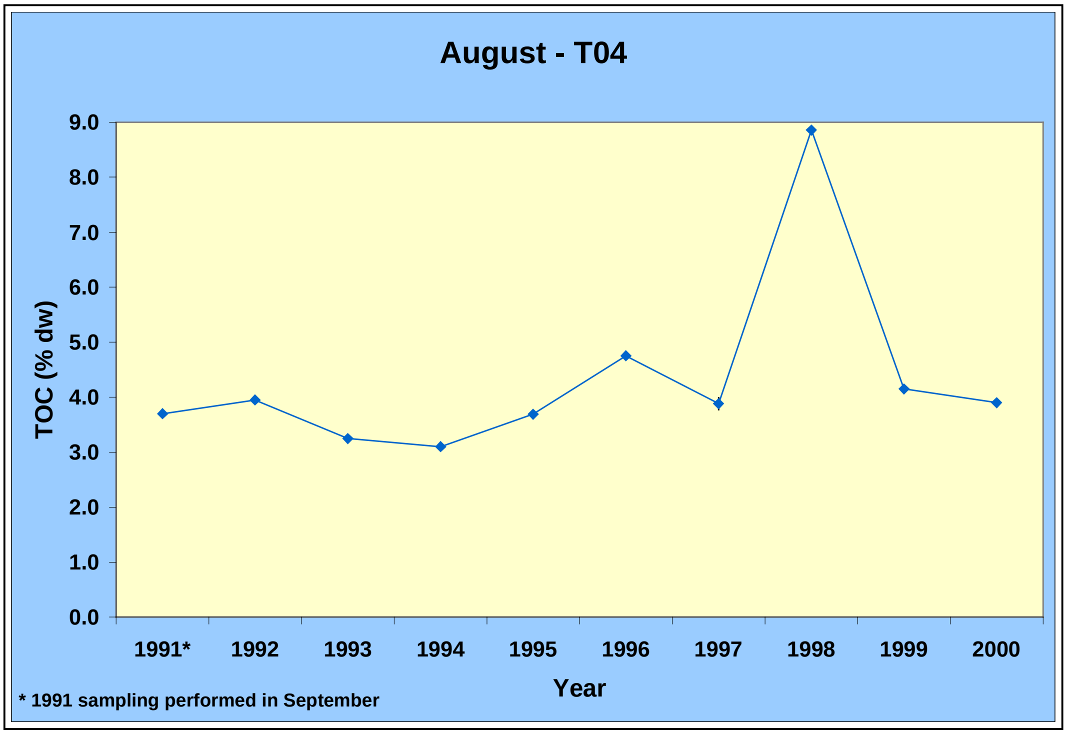


Figure C-1-20. Total organic carbon content in sediments collected at Station T04 in September 1991 and August 1992–2000.

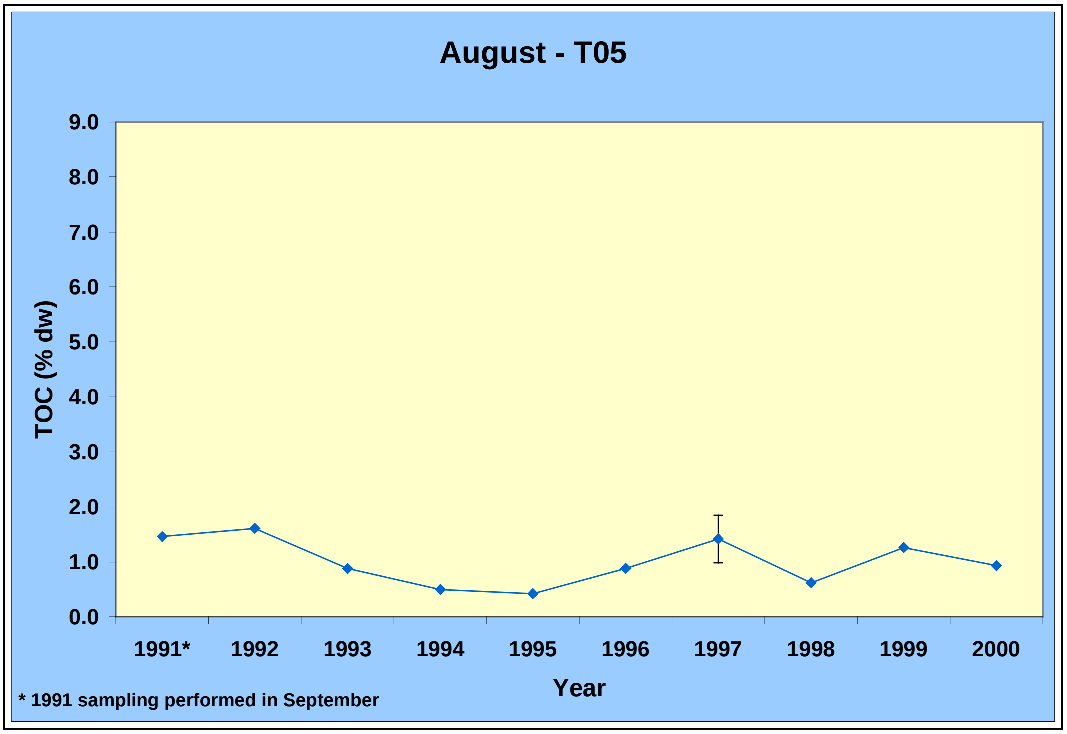


Figure C-1-21. Total organic carbon content in sediments collected at Station T05 in September 1991 and August 1992–2000. Error bars depict standard deviation of duplicate analyses.

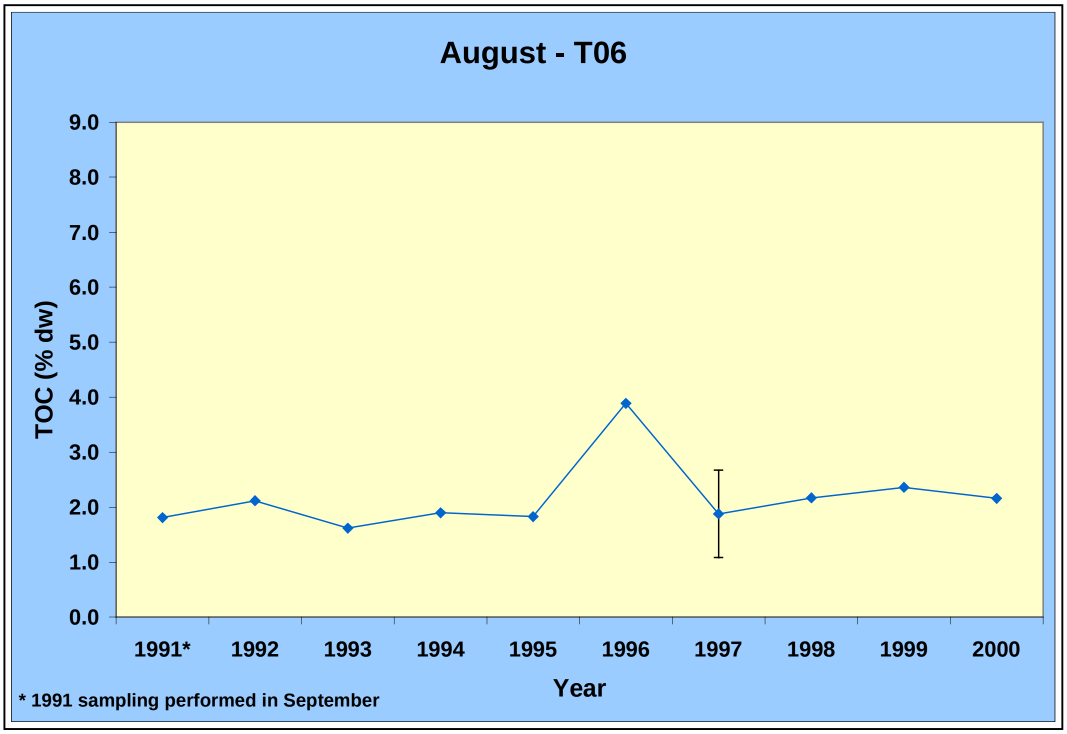


Figure C-1-22. Total organic carbon content in sediments collected at Station T06 in September 1991 and August 1992–2000. Error bars depict standard deviation of duplicate analyses.

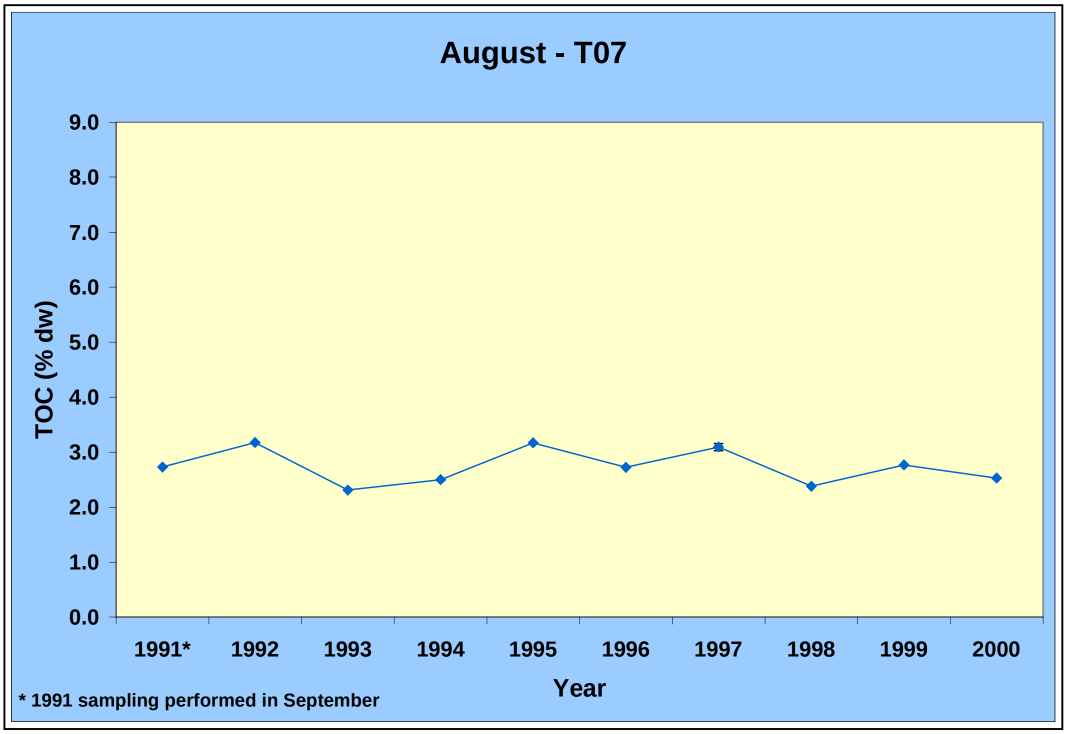


Figure C-1-23. Total organic carbon content in sediments collected at Station T07 in September 1991 and August 1992–2000.

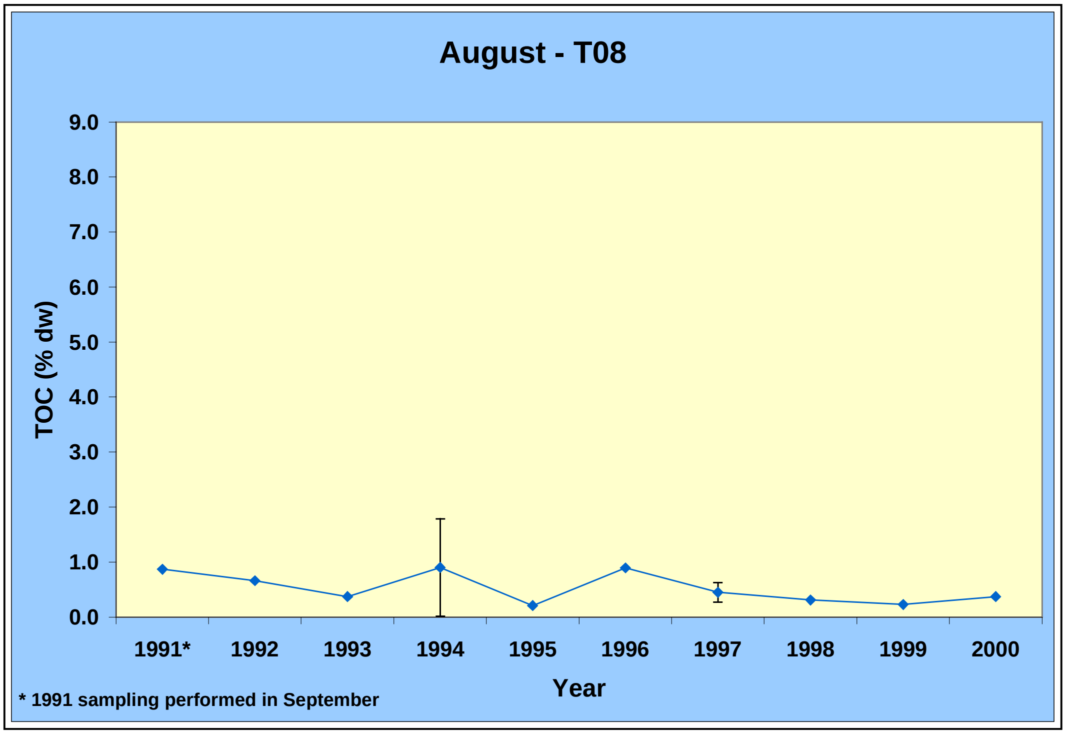


Figure C-1-24. Total organic carbon content in sediments collected at Station T08 in September 1991 and August 1992–2000. Error bars depict standard deviation of duplicate analyses.

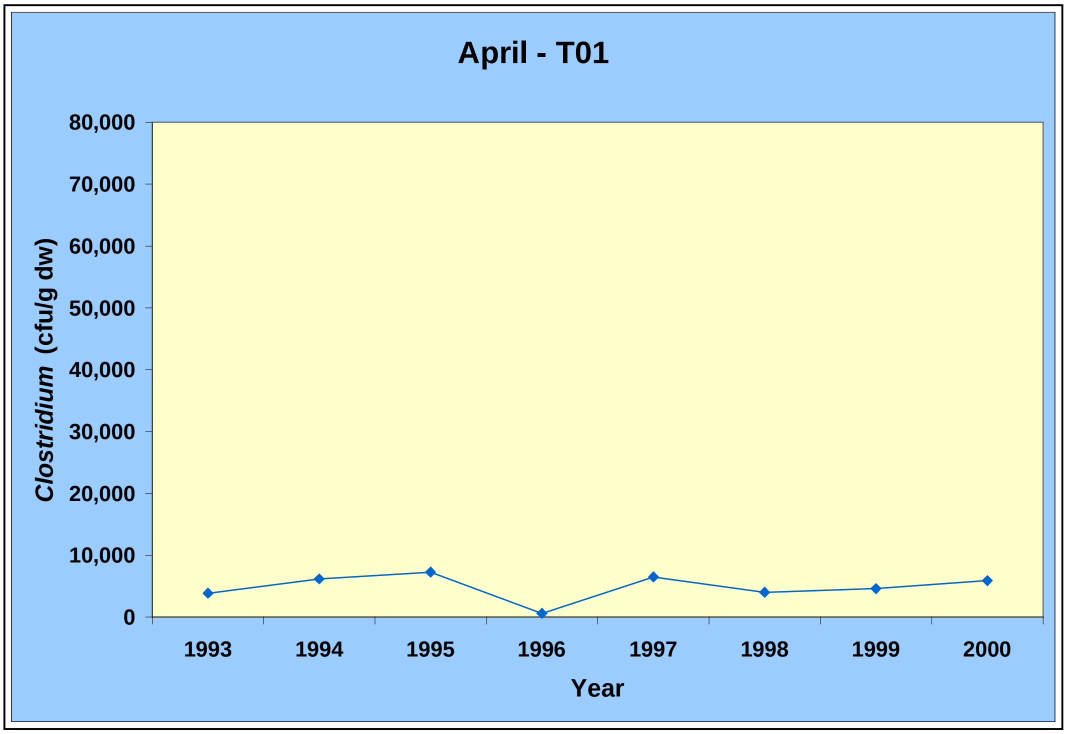


Figure C-1-25. *Clostridium perfringens* concentrations in sediments collected at Station T01 in April 1993–2000.

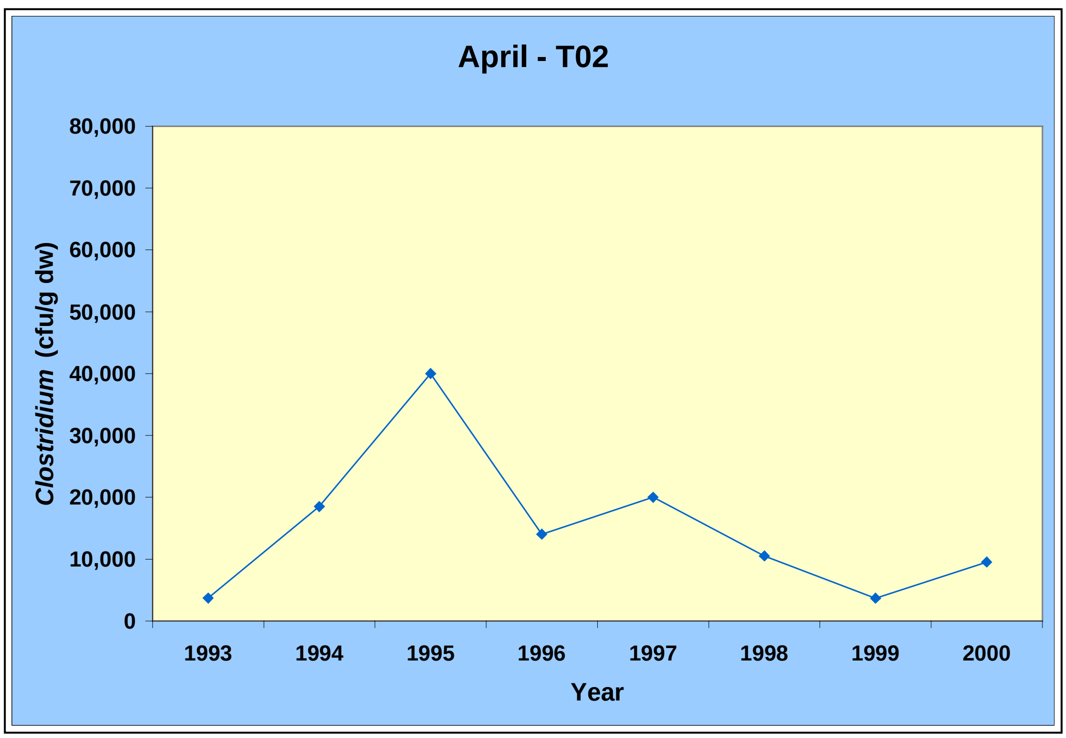


Figure C-1-26. *Clostridium perfringens* concentrations in sediments collected at Station T02 in April 1993–2000.

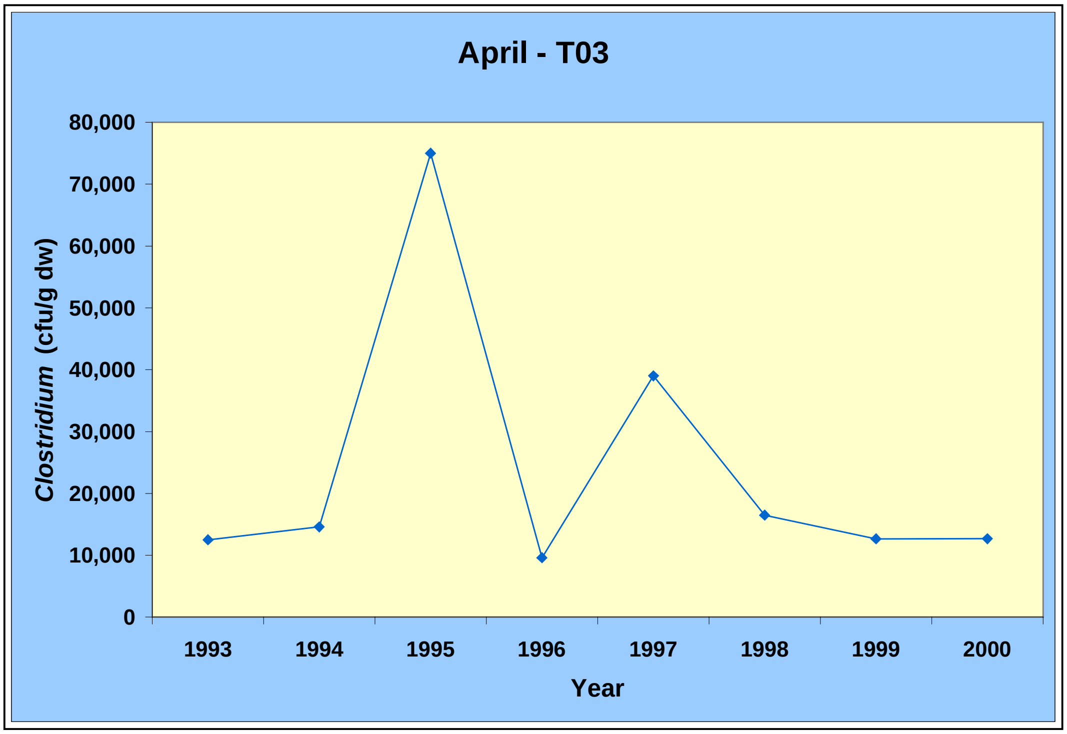


Figure C-1-27. ***Clostridium perfringens*** **concentrations in sediments collected at Station T03 in April 1993–2000.**

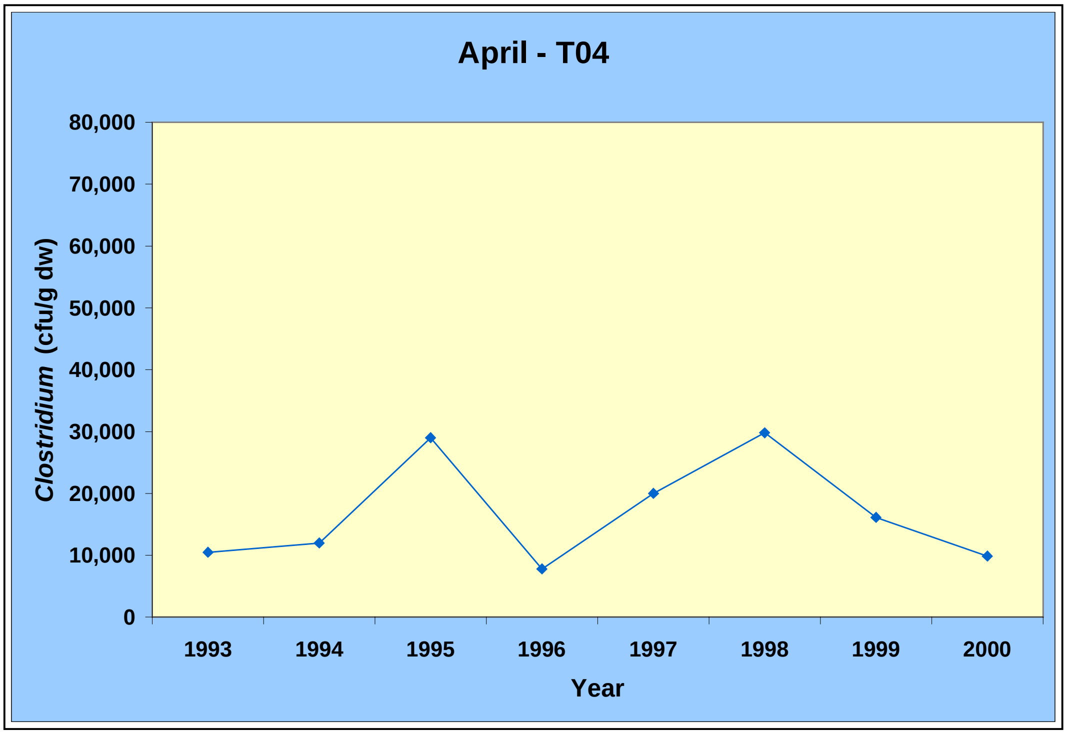


Figure C-1-28. ***Clostridium perfringens*** **concentrations in sediments collected at Station T04 in April 1993–2000.**

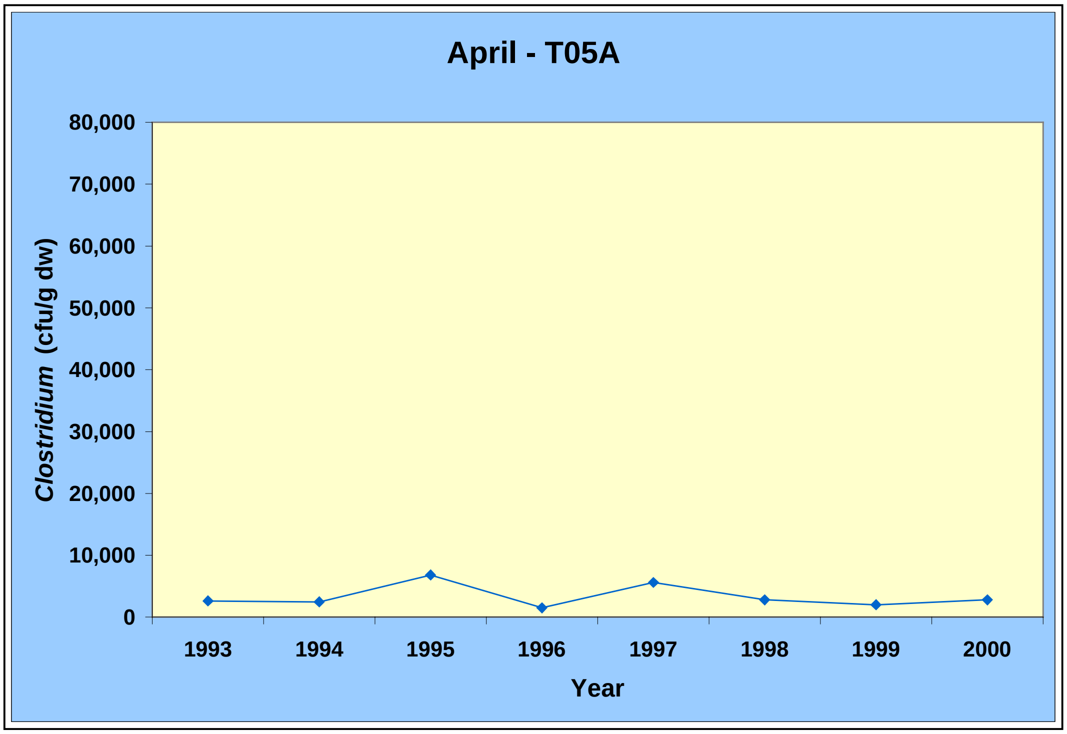


Figure C-1-29. ***Clostridium perfringens*** **concentrations in sediments collected at Station T05A in April 1993–2000.**

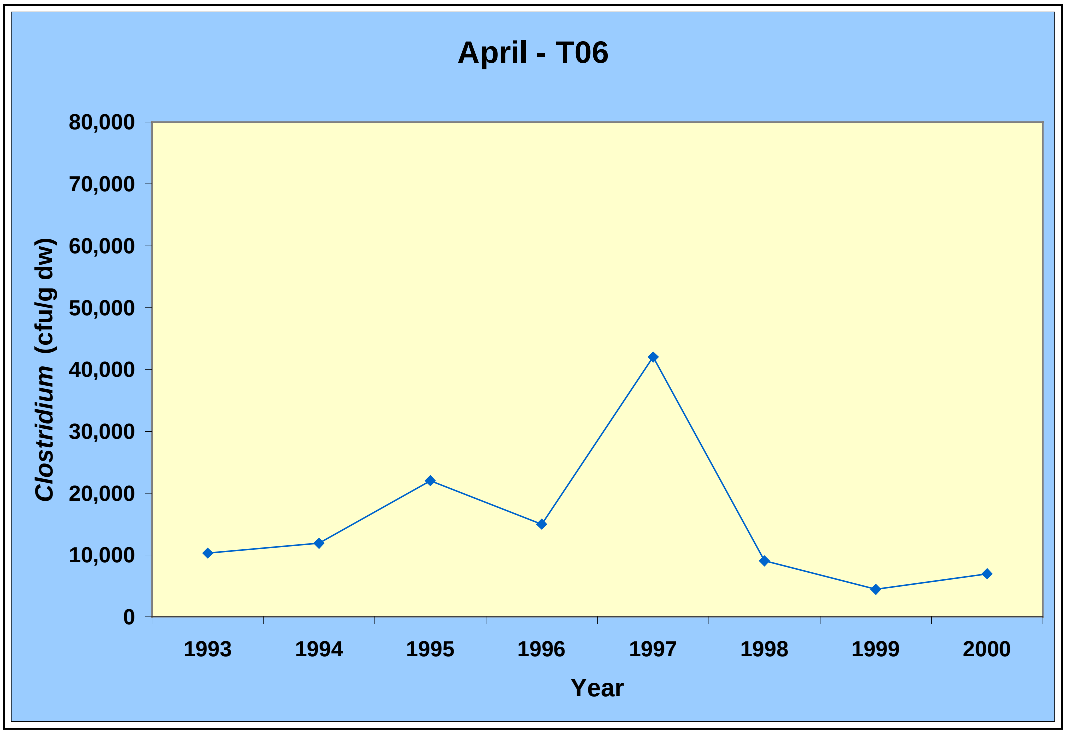


Figure C-1-30. ***Clostridium perfringens*** **concentrations in sediments collected at Station T06 in April 1993–2000.**

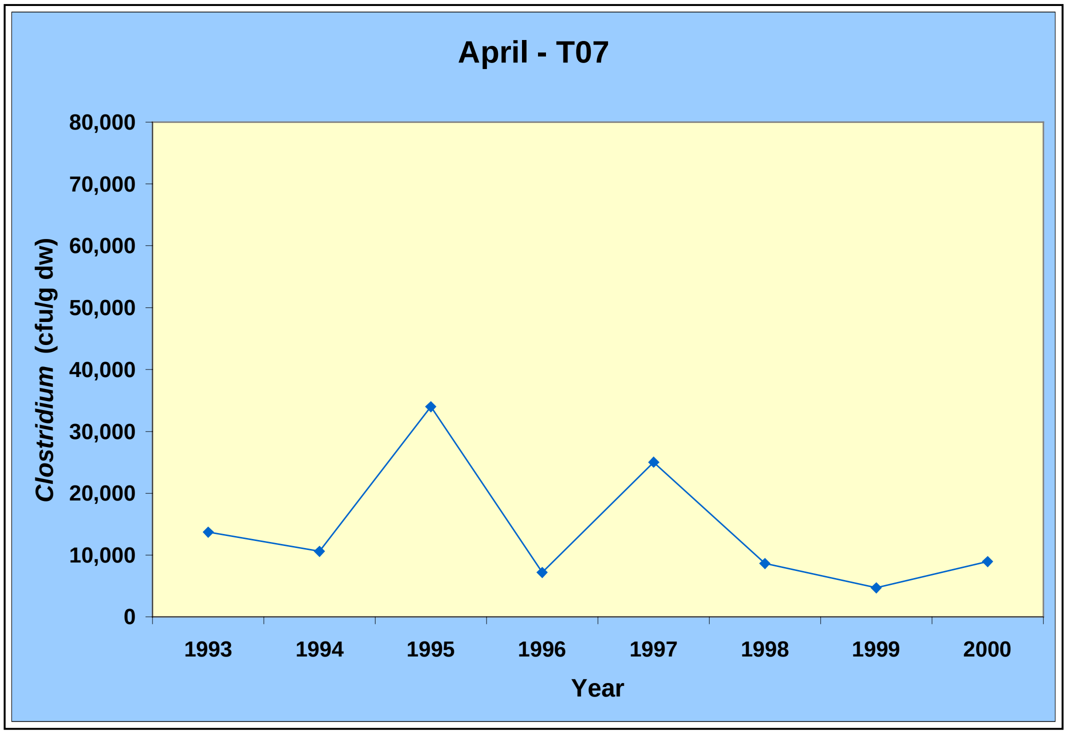


Figure C-1-31. *Clostridium perfringens* concentrations in sediments collected at Station T07 in April 1993–2000.

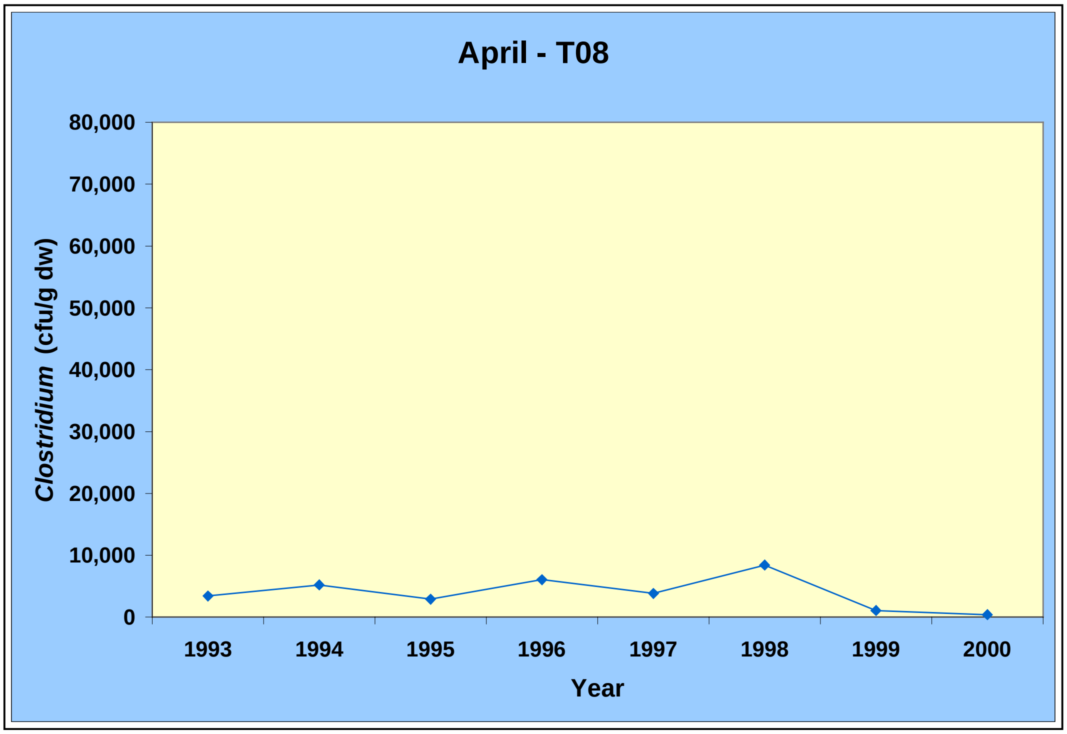


Figure C-1-32. *Clostridium perfringens* concentrations in sediments collected at Station T08 in April 1993–2000.

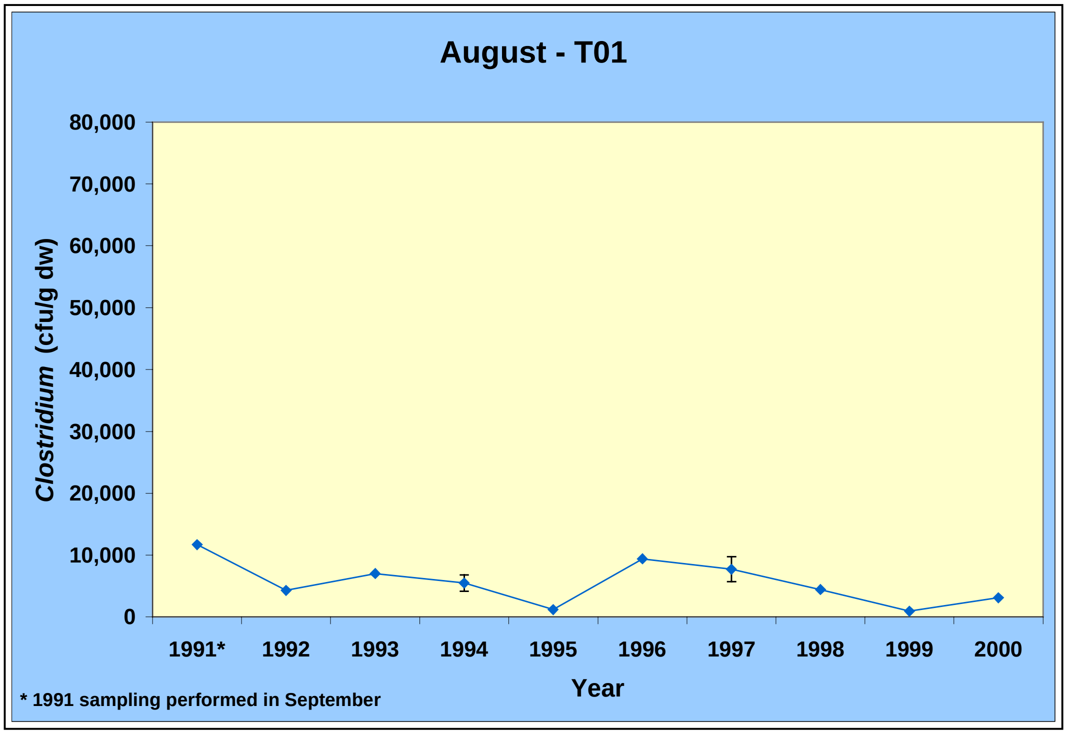


Figure C-1-33. ***Clostridium perfringens*** **concentrations in sediments collected at Station T01 in September 1991 and August 1992–2000. Error bars depict standard deviation of replicate analyses.**

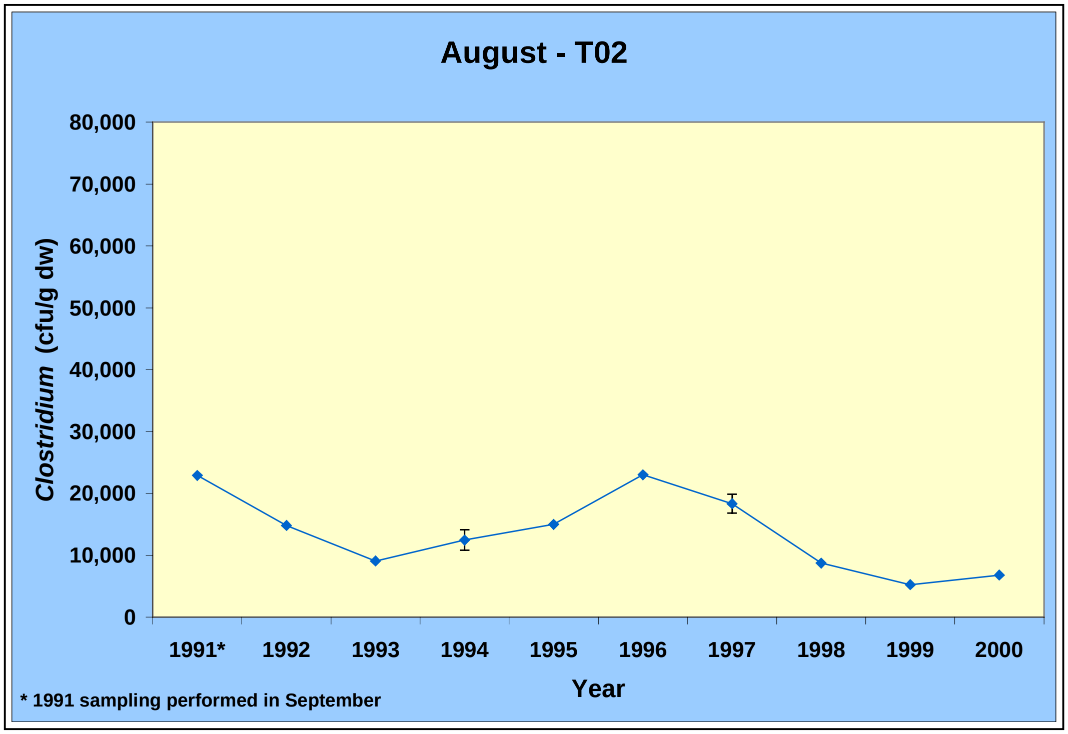


Figure C-1-34. ***Clostridium perfringens*** **concentrations in sediments collected at Station T02 in September 1991 and August 1992–2000. Error bars depict standard deviation of replicate analyses.**

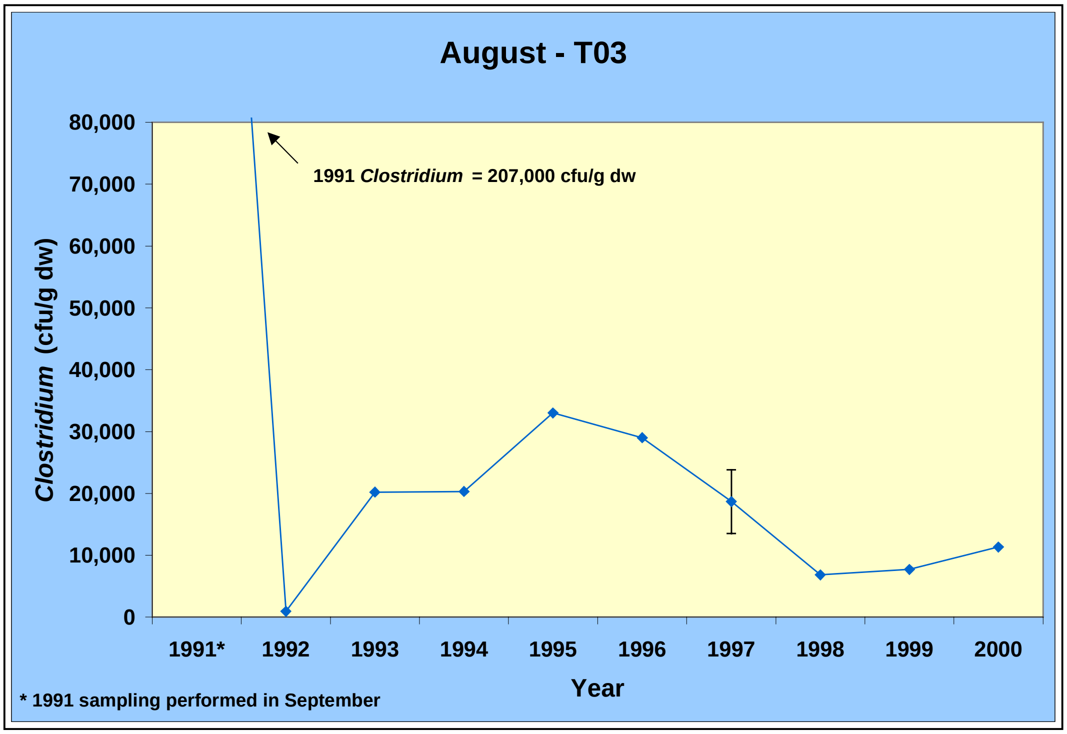


Figure C-1-35. *Clostridium perfringens* concentrations in sediments collected at Station T03 in September 1991 and August 1992–2000. Error bars depict standard deviation of replicate analyses.

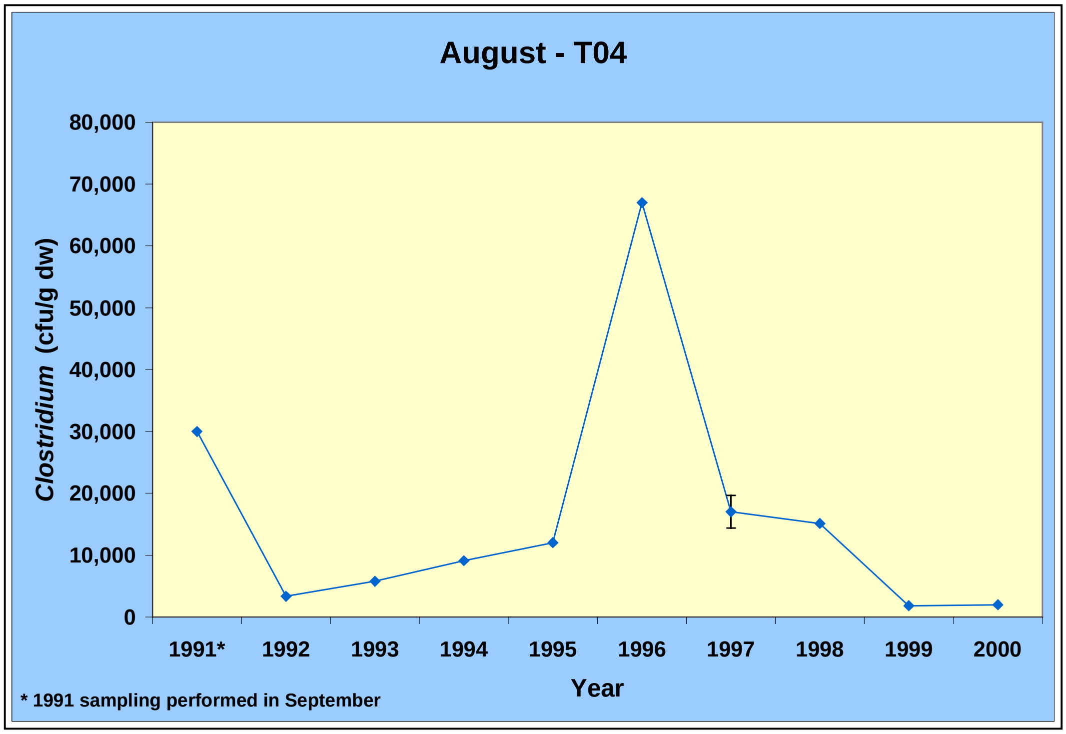


Figure C-1-36. *Clostridium perfringens* concentrations in sediments collected at Station T04 in September 1991 and August 1992–2000. Error bars depict standard deviation of replicate analyses.

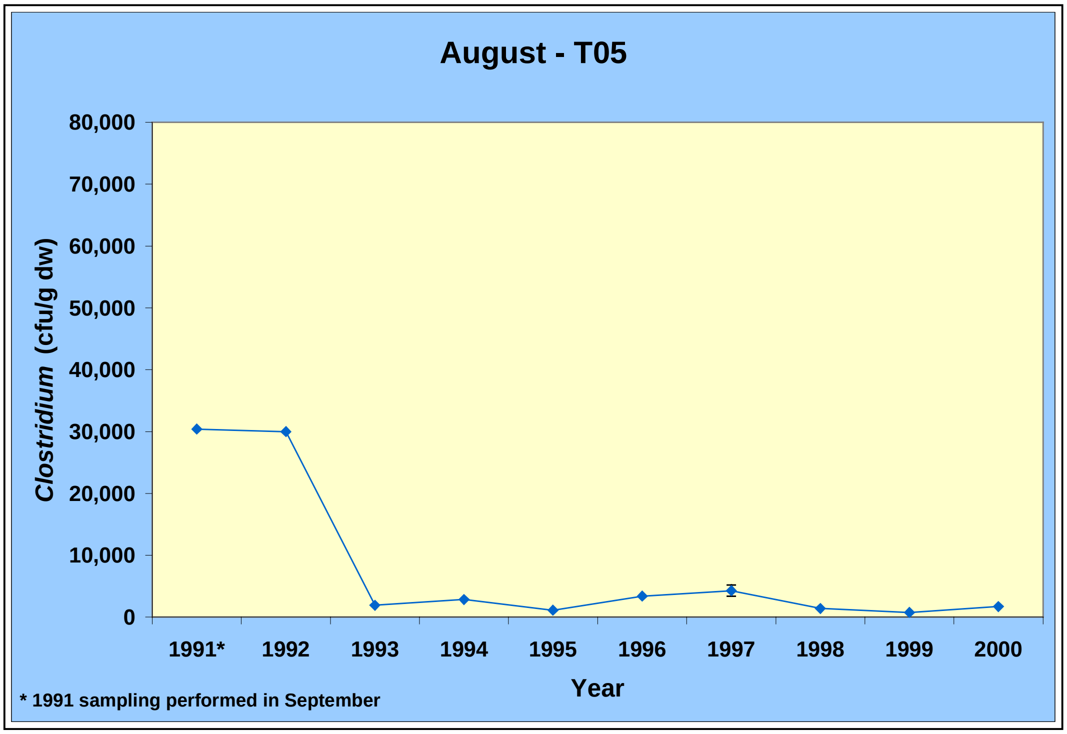


Figure C-1-37. ***Clostridium perfringens*** **concentrations in sediments collected at Station T02 in September 1991 and August 1992–2000. Error bars depict standard deviation of replicate analyses.**

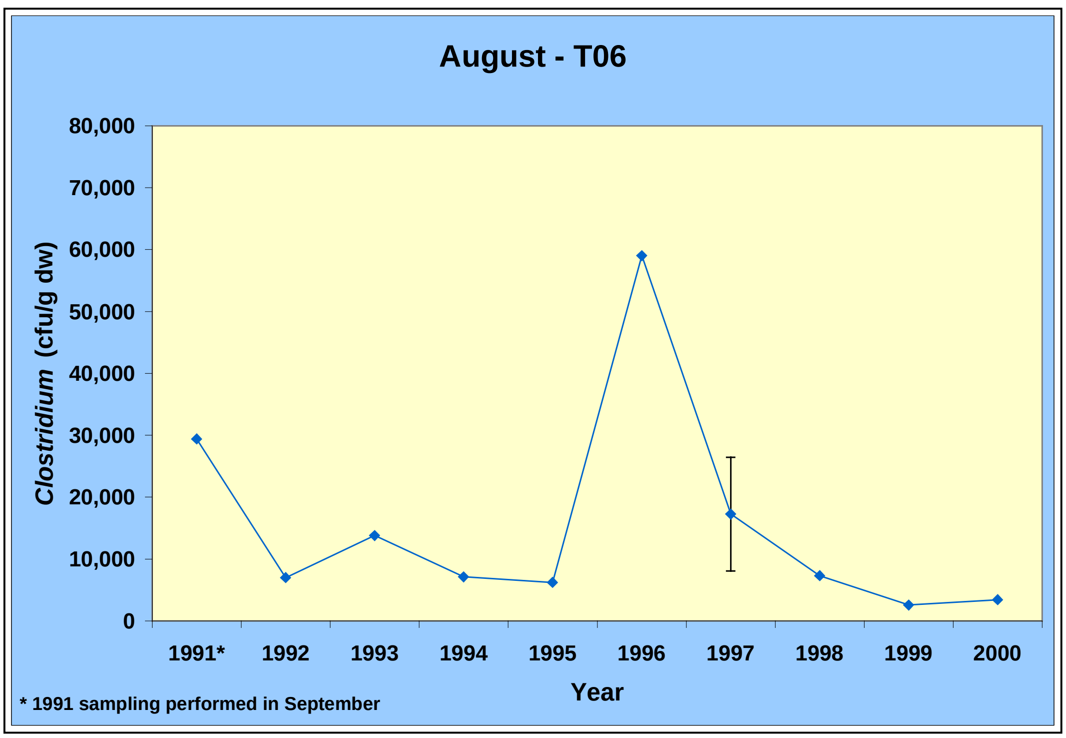


Figure C-1-38. ***Clostridium perfringens*** **concentrations in sediments collected at Station T06 in September 1991 and August 1992–2000. Error bars depict standard deviation of replicate analyses.**

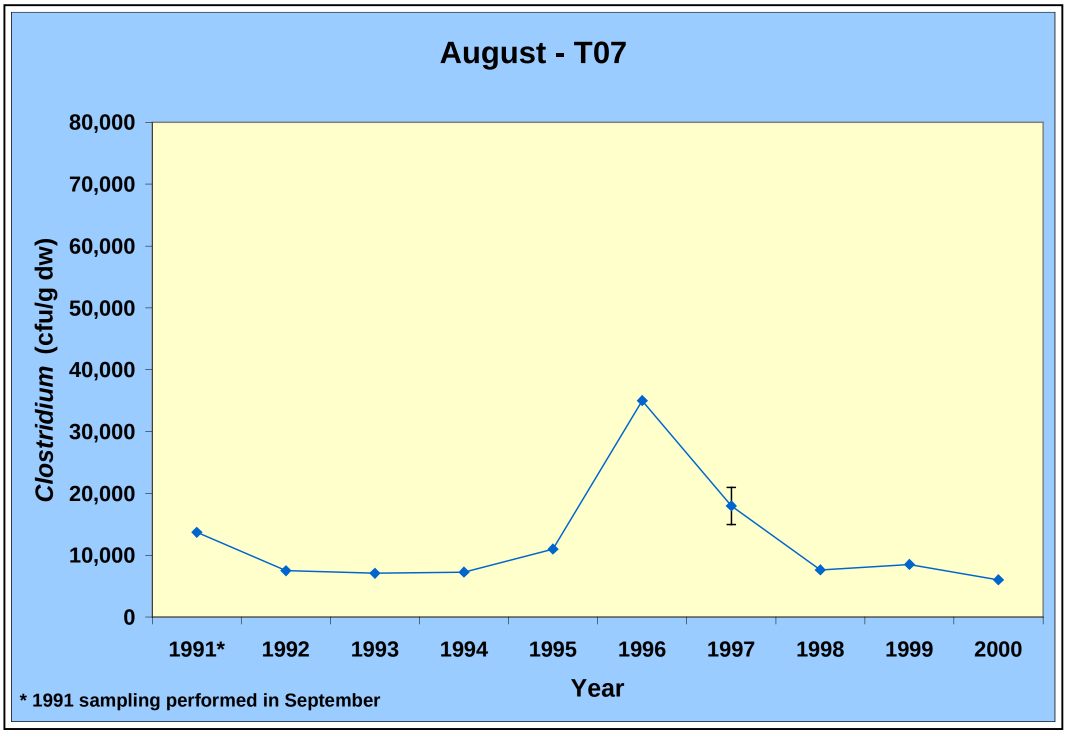


Figure C-1-39. ***Clostridium perfringens*** **concentrations in sediments collected at Station T07 in September 1991 and August 1992–2000. Error bars depict standard deviation of replicate analyses.**

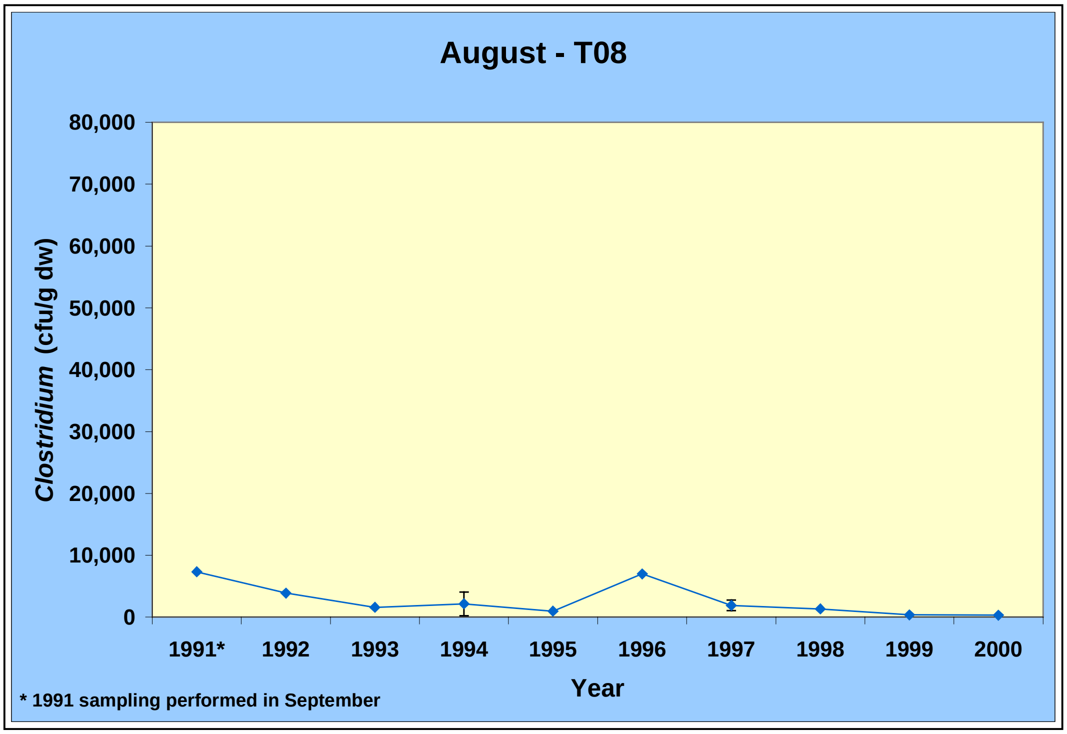


Figure C-1-40. ***Clostridium perfringens*** **concentrations in sediments collected at Station T08 in September 1991 and August 1992–2000. Error bars depict standard deviation of replicate analyses.**

APPENDIX C–2

Grain size, TOC, and *Clostridium perfringens* Data from Sediments Collected at Traditional stations in April 1993–2000.
(Results reported on dry weight basis to three significant figures)

Table C-2-1. Grain size, TOC, *Clostridium perfringens* data from sediments collected at Traditional stations in April 1993 to 2000.

Parameter	Year	T01	T02	T03	T04	T05A	T06	T07	T08
Gravel (pct)	1993	3.17	0	0	0	0.404	0	0	11.4
	1994	3.7	0.7	0.2	0	0.4	5.4	8.9	5
	1995	18.1	1.5	0	0	0.2	3.9	19.5	2.9
	1996	1.8	0.7	12.8	0	0.3	0.3	23.2	0.2
	1997	9	0.9	0	0.3	0	0	1.4	4.3
	1998	3.9	0	2.6	0	0.1	0.1	5.7	0.2
	1999	3.9	3.6	1.5	0	0.6	0.8	28.2	0.4
	2000	10.7	2.9	0.2	4.1	0	0	9.2	0.3
Grand Station Mean		6.78	1.29	2.16	0.55	0.251	1.31	12	3.09
Stdev		5.51	1.32	4.4	1.44	0.214	2.12	10.4	3.9
CV		81.2	102	203	262	85.5	161	86.6	126
Sand (pct)	1993	90.5	38.6	38.4	16.4	62.4	37.1	19.6	79.8
	1994	77.8	69.6	52	28	74.3	63.5	39.1	92.9
	1995	68.5	45.2	9.7	8.8	84	61.1	36.7	93.3
	1996	71.4	37.1	34.8	9.5	85.3	22.4	27	86.6
	1997	68.7	46.1	17.9	4.9	56	47.8	90.9	32.4
	1998	74	16.4	34.9	2.8	79.1	51.4	22.7	62.6
	1999	67.8	56.1	30.6	30.6	73	28.8	27.5	91.1
	2000	65.3	39.5	14.2	7.2	66.6	31.2	29.3	96.6
Grand Station Mean		73	43.6	29.1	13.5	72.6	42.9	36.6	79.4
Stdev		8.1	15.4	14.2	10.5	10.4	15.3	22.9	21.9
CV		11.1	35.4	48.7	77.9	14.3	35.7	62.5	27.6
Gravel + Sand (pct)	1993	93.7	38.6	38.4	16.4	62.8	37.1	19.6	91.2
	1994	81.5	70.3	52.2	28	74.7	68.9	48	97.9
	1995	86.6	46.7	9.7	8.8	84.2	65	56.2	96.2
	1996	73.2	37.8	47.6	9.5	85.6	22.7	50.2	86.8
	1997	77.7	47	17.9	5.2	56	47.8	92.3	36.7
	1998	77.9	16.4	37.5	2.8	79.2	51.5	28.4	62.8
	1999	71.7	59.7	32.1	30.6	73.6	29.6	55.7	91.5
	2000	76	42.4	14.4	11.3	66.6	31.2	38.5	96.9
Grand Station Mean		79.8	44.9	31.2	14.1	72.8	44.2	48.6	82.5
Stdev		7.31	15.9	15.7	10.2	10.4	16.9	21.9	21.7
CV		9.16	35.6	50.3	72.8	14.3	38.3	45.1	26.3
Silt (pct)	1993	5.99	48.2	41	64.3	31.1	43.2	59.9	6.14
	1994	13.7	18.9	43.8	63.1	22.2	28.1	46.1	1.8
	1995	9.4	33.3	50.1	54.9	9.7	20.8	27.9	2.6
	1996	16.4	39.1	31.7	59.6	9.6	46.1	29.1	6.2
	1997	13.9	32.1	44.7	57.8	27.5	30.6	3.6	34.1
	1998	13.2	45.4	30.2	58.5	14.2	26.7	38.8	17.6
	1999	17.4	20.1	35	32	15.7	33.5	17.3	3.7

Parameter	Year	T01	T02	T03	T04	T05A	T06	T07	T08
	2000	15.3	35.2	41	51	21	34.1	35.3	1.2
Grand Station Mean		13.2	34	39.7	55.2	18.9	32.9	32.2	9.17
Stdev		3.77	10.6	6.86	10.3	7.94	8.41	17.2	11.3
CV		28.6	31.1	17.3	18.6	42.1	25.6	53.4	124
Clay (pct)	1993	0.267	13.2	20.6	19.3	6.15	19.7	20.5	2.66
	1994	4.7	10.9	4	8.9	3.1	3	6	0.3
	1995	4	20	40.2	36.3	6.1	14.2	16	1.2
	1996	10.3	23.1	20.7	31	4.8	31.2	20.7	7
	1997	8.3	20.9	37.4	37	16.4	21.6	4.2	29.2
	1998	8.8	38.2	32.3	38.7	6.6	21.8	32.8	19.5
	1999	10.9	20.3	32.9	37.4	10.7	36.9	27	4.77
	2000	8.7	22.3	44.6	37.8	12.4	34.7	26.2	1.9
Grand Station Mean		7	21.1	29.1	30.8	8.28	22.9	19.2	8.32
Stdev		3.66	8.15	13.3	10.9	4.47	11.3	10.1	10.4
CV		52.3	38.6	45.6	35.5	54	49.2	52.4	126
Fines (pct)	1993	6.25	61.4	61.6	83.6	37.2	62.9	80.4	8.81
	1994	18.4	29.8	47.8	72	25.3	31.1	52.1	2.1
	1995	13.4	53.3	90.3	91.2	15.8	35	43.9	3.8
	1996	26.7	62.2	52.4	90.6	14.4	77.3	49.8	13.2
	1997	22.2	53	82.1	94.8	43.9	52.2	7.8	63.3
	1998	22	83.6	62.5	97.2	20.8	48.5	71.6	37.1
	1999	28.3	40.4	67.9	69.4	26.4	70.4	44.3	8.47
	2000	24	57.5	85.6	88.8	33.4	68.8	61.5	3.1
Grand Station Mean		20.2	55.2	68.8	86	27.2	55.8	51.4	17.5
Stdev		7.3	15.9	15.7	10.3	10.4	16.9	21.9	21.7
CV		36.2	28.8	22.8	11.9	38.3	30.3	42.6	124
TOC (pct)	1993	1.38	2.2	2.89	3.58	1.14	2.51	2.87	0.84
	1994	1.38	2.2	2.64	5.35	0.28	1.82	2.18	0.22
	1995	0.93	1.49	3.49	6.25	0.68	1.6	3.06	0.18
	1996	0.926	2.02	2.84	3.81	0.419	2.64	2.83	0.69
	1997	1.05	1.59	3.38	4.07	1.13	3	3.16	0.373
	1998	1.19	2.16	2.78	6.59	0.42	1.17	2.15	1.3
	1999	0.98	1.14	2.95	6.94	1	2.84	2.77	0.65
	2000	1.61	1.87	3.45	4.44	1.2	2.36	2.88	0.4
Grand Station Mean		1.18	1.83	3.05	5.13	0.783	2.24	2.74	0.582
Stdev		0.253	0.39	0.334	1.33	0.376	0.646	0.375	0.372
CV		21.5	21.3	10.9	26	48.1	28.8	13.7	63.9
Clostridium perfringens (cfu/g dw)	1993	3870	3690	12500	10500	2610	10300	13700	3420
	1994	6180	18500	14600	12000	2460	11900	10600	5230
	1995	7300	40000	75000	29000	6800	22000	34000	2900
	1996	600	14000	9600	7800	1500	15000	7200	6050

Parameter	**Year**	**T01**	**T02**	**T03**	**T04**	**T05A**	**T06**	**T07**	**T08**
	1997	6500	20000	39000	20000	5600	42000	25000	3850
	1998	4030	10500	16500	29800	2780	9050	8640	8430
	1999	4620	3670	12600	16100	2000	4460	4720	1090
	2000	5910	9520	12700	9880	2800	6950	8980	395
Grand Station Mean		4880	15000	24100	16900	3320	15200	14100	3920
Stdev		2120	11800	22600	8620	1860	12100	10100	2630
CV		43.4	78.5	93.8	51	56	79.4	71.8	67

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APPENDIX C–3

Grain size, TOC, and *Clostridium perfringens* Data from Sediments Collected at Traditional stations in September 1991 and August 1992–2000.
(Results reported on dry weight basis to three significant figures)

Table C-3-1. Grain size, TOC, *Clostridium perfringen*s data from sediments collected at Traditional stations in September 1991 and August 1992 to 2000.

Parameter	Year	T01	T02	T03	T04	T05A	T06	T07	T08
Gravel (pct)	1991	1.26	0.155	0	0	0.294	0.0841	1.75	0
	1992	65.3	21.3	0	0	92.5	0.4	4.5	2.9
	1993	8.03	3.14	0.489	0	0	0.212	10.3	1.9
	1994	8.15	2.08	6.2	0	0.3	1.4	3	3.1
	1995	6.7	0	0	0.6	0.5	2.5	24.3	0.4
	1996	12.4	0	0.9	0	0.2	0	5.1	0
	1997	15.1	0.0667	0.233	0.6	0.167	2	15.8	0.533
	1998	1.1	0.1	0.5	0	0	0.6	0.5	1
	1999	25.1	0.4	0	3.8	0.167	0.12	9.6	2.4
	2000	2.5	0.1	1.7	1.5	0.3	0.2	11	0.6
Grand Station Mean		14.6	2.73	1	0.65	9.44	0.752	8.58	1.28
Stdev		19.3	6.61	1.9	1.21	29.2	0.894	7.31	1.19
CV		132	242	190	186	309	119	85.1	92.7
Sand (pct)	1991	83.6	63.6	44.1	32.3	93.4	65.6	57.3	12.1
	1992	17.8	47.6	43.5	20.8	5.6	64.8	40.2	93.4
	1993	75.3	66	50.3	13.9	85.3	67.1	39.7	93.7
	1994	60.8	57.7	57	4.8	87.1	64.7	38.9	91.5
	1995	32.2	41.3	11.8	5.7	87.8	31.1	17.9	95.4
	1996	67.3	53.1	20.5	5.6	89.1	19.7	27.2	82.6
	1997	64.1	44.4	17.2	2	67.7	57	29.2	93.5
	1998	76.2	37.1	11.2	20.4	81.4	38.3	21.9	90.3
	1999	53.4	39.8	8.9	1.6	75.6	37.5	23.5	93
	2000	67.5	54	49.4	29.4	93.5	58.3	30.6	94.7
Grand Station Mean		59.8	50.5	31.4	13.7	76.7	50.4	32.6	84
Stdev		20.5	10	19	11.4	26.2	17.2	11.6	25.5
CV		34.2	19.9	60.7	83.9	34.2	34.1	35.6	30.4
Gravel + Sand (pct)	1991	84.9	63.8	44.1	32.3	93.7	65.7	59	12.1
	1992	83.1	68.9	43.5	20.8	98.1	65.2	44.7	96.3
	1993	83.3	69.1	50.8	13.9	85.3	67.3	50	95.6
	1994	69	59.8	63.2	4.8	87.4	66.1	41.9	94.6
	1995	38.9	41.3	11.8	6.3	88.3	33.6	42.2	95.8
	1996	79.7	53.1	21.4	5.6	89.3	19.7	32.3	82.6
	1997	79.2	44.5	17.4	2.6	67.9	59	44.9	94.1
	1998	77.3	37.2	11.7	20.4	81.4	38.9	22.4	91.3
	1999	78.5	40.2	8.9	5.4	75.8	37.6	33.1	95.4
	2000	70	54.1	51.1	30.9	93.8	58.5	41.6	95.3
Grand Station Mean		74.4	53.2	32.4	14.3	86.1	51.2	41.2	85.3
Stdev		13.5	12	20.1	11.2	9.06	17.1	10.1	26
CV		18.2	22.6	62.1	78.2	10.5	33.5	24.6	30.5

Parameter	Year	T01	T02	T03	T04	T05A	T06	T07	T08
Silt (pct)	1991	11.9	27.8	39.1	48.6	4.24	25.1	27.3	52.2
	1992	8	19.1	39	59.8	1	22.2	38.8	1.7
	1993	11.7	20.4	30.7	60.4	9.43	20.6	33.7	1.9
	1994	24	28	26.2	70.4	9.1	21.8	43.8	3.08
	1995	58.3	38.6	52	57.7	8.1	41.6	34.9	1.8
	1996	14.9	36.5	53.4	79.8	7.2	54.7	52.1	9.7
	1997	13.2	33.6	44.5	56.4	20.8	26.3	39.1	2.57
	1998	14.6	39.1	42.7	43.3	11.2	32	49.6	4.4
	1999	13.4	34.6	46.4	48.6	13.7	33.7	33.7	1.6
	2000	23.7	31	36.3	55.5	4.9	26.7	34	2.6
Grand Station Mean		19.4	30.9	41	58.1	8.97	30.5	38.7	8.15
Stdev		14.6	7.04	8.66	10.7	5.52	10.7	7.75	15.7
CV		75.3	22.8	21.1	18.5	61.6	35	20	192
Clay (pct)	1991	3.2	8.46	16.8	19.1	2.07	9.21	13.6	35.7
	1992	9	12.1	17.5	19.4	0.9	12.6	16.5	2
	1993	5.05	10.4	18.6	25.6	5.24	12.1	16.2	2.51
	1994	7.03	12.3	10.6	24.8	3.6	12	14.3	2.33
	1995	2.8	20	36.2	36	3.6	24.8	22.9	2.4
	1996	5.4	10.4	25.3	14.6	3.5	25.6	15.6	7.6
	1997	7.53	21.9	38	41	11.3	14.8	16	3.4
	1998	8.1	23.7	45.6	36.3	7.4	29.2	28	4.2
	1999	8.1	25.2	44.7	46	10.5	28.7	33.3	3
	2000	6.3	14.9	12.7	13.5	1.4	14.8	24.4	2.1
Grand Station Mean		6.25	15.9	26.6	27.6	4.95	18.4	20.1	6.52
Stdev		2.11	6.18	13.4	11.5	3.66	7.75	6.7	10.4
CV		33.7	38.8	50.2	41.5	73.8	42.1	33.3	159
Fines (pct)	1991	15.1	36.2	55.9	67.7	6.32	34.3	41	87.9
	1992	17	31.2	56.5	79.2	1.9	34.8	55.3	3.7
	1993	16.7	30.9	49.2	86.1	14.7	32.7	50	4.42
	1994	31.1	40.2	36.8	95.2	12.7	33.8	58.1	5.4
	1995	61.1	58.6	88.2	93.7	11.7	66.4	57.8	4.2
	1996	20.3	46.9	78.7	94.4	10.7	80.3	67.7	17.3
	1997	20.7	55.5	82.6	97.4	32.1	41.1	55.1	5.97
	1998	22.7	62.8	88.3	79.6	18.6	61.2	77.6	8.6
	1999	21.5	59.8	91.1	94.6	24.2	62.4	67	4.6
	2000	30	45.9	49	69	6.3	41.5	58.4	4.7
Grand Station Mean		25.6	46.8	67.6	85.7	13.9	48.8	58.8	14.7
Stdev		13.5	12	20.1	11.2	9.05	17.1	10.1	26
CV		52.8	25.6	29.8	13.1	65	35.1	17.2	177
TOC (pct)	1991	2.64	1.75	3.69	3.7	1.46	1.81	2.73	0.87
	1992	1.91	1.71	3.57	3.95	1.61	2.12	3.18	0.66
	1993	2.96	1.39	3.41	3.25	0.88	1.62	2.31	0.37

Parameter	Year	T01	T02	T03	T04	T05A	T06	T07	T08
	1994	1.9	1.73	2.8	3.1	0.5	1.9	2.5	0.9
	1995	1.18	2.05	3.54	3.69	0.42	1.83	3.17	0.21
	1996	1.9	1.98	3.84	4.75	0.884	3.89	2.73	0.893
	1997	1.83	1.46	3.57	3.88	1.42	1.88	3.09	0.45
	1998	0.78	1.69	2.46	8.86	0.62	2.17	2.38	0.31
	1999	2.8	1.61	3.14	4.15	1.26	2.36	2.77	0.23
	2000	1.8	1.51	3.03	3.9	0.93	2.16	2.53	0.37
Grand Station Mean		1.97	1.69	3.31	4.32	0.998	2.17	2.74	0.526
Stdev		0.685	0.21	0.437	1.66	0.42	0.641	0.319	0.279
CV		34.8	12.5	13.2	38.4	42.1	29.5	11.7	53
Clostridium perfringens (cfu/g dw)	1991	11700	22900	207000	30000	30400	29400	13700	7330
	1992	4300	14800	938	3330	30000	7000	7500	3890
	1993	7030	9090	20200	5750	1910	13800	7100	1580
	1994	5490	12500	20300	9080	2840	7110	7290	2160
	1995	1200	15000	33000	12000	1100	6200	11000	955
	1996	9400	23000	29000	67000	3400	59000	35000	7000
	1997	7720	18300	18700	17000	4300	17200	18000	1900
	1998	4450	8720	6840	15100	1400	7280	7650	1320
	1999	920	5260	7720	1800	750	2560	8520	350
	2000	3130	6820	11300	1960	1700	3430	6040	330
Grand Station Mean		5530	13600	35500	16300	7780	15300	12200	2680
Stdev		3470	6340	61100	19800	11900	17300	8830	2570
CV		62.8	46.5	172	121	153	113	72.5	96

APPENDIX D-1

Taxonomic Responsibilities for Boston Harbor Identifications April/August 2000 Survey

Table D-1-1. Station and major group identified by each taxonomist April & August 2000 Harbor macrobenthic samples.

Station	Major Taxonomic Group				
	Polychaeta	Oligochaeta	Mollusca	Arthropoda	Miscellaneous
T01	Tim Morris & Nancy Mountford	Russ Winchell	Nancy Mountford	Tim Morris	Tim Morris
T02	Tim Morris & Nancy Mountford	Russ Winchell	Nancy Mountford	Tim Morris	Tim Morris
T03	Tim Morris & Nancy Mountford	Russ Winchell	Nancy Mountford	Tim Morris	Tim Morris
T04	Tim Morris & Nancy Mountford	Russ Winchell	Nancy Mountford	Tim Morris	Tim Morris
T05A	Tim Morris & Nancy Mountford	Russ Winchell	Nancy Mountford	Tim Morris	Tim Morris
T06	Tim Morris & Nancy Mountford	Russ Winchell	Nancy Mountford	Tim Morris	Tim Morris
T07	Tim Morris & Nancy Mountford	Russ Winchell	Nancy Mountford	Tim Morris	Tim Morris
T08	Tim Morris & Nancy Mountford	Russ Winchell	Nancy Mountford	Tim Morris	Tim Morris

APPENDIX D-2

Data Analysis Treatments for the 2000 Boston Harbor Benthic Report

A. Export to R. Diaz/R. Kropp

1. Create an export that includes all surveys and all Traditional stations (remember R06 in April 1992 is a Traditional Station).
2. Please create separate 2000 and 1991–2000 files.
3. Please list taxa in rows and samples in columns. For the 1991–2000 data, please list the samples sequentially from 1991 to 2000. The file should be in Excel or a format importable into Excel.
4. Exclude the following taxa from the export:

CODE	DESCR
3701SPP	HYDROZOA SPP.
5001430412	POLYDORA WEBSTERI
510205SPP	ACMAEIDAE SPP.
5103100108	LITTORINA LITTOREA
5103640204	CREPIDULA FORNICATA
5103640207	CREPIDULA PLANA
51036402SPP	CREPIDULA SPP.
5507010101	MYTILUS EDULIS
5507010601	MODIOLUS MODIOLUS
550701SPP	MYTILIDAE SPP.
6130SPP	CIRRIPEDIA SPP.
6134020104	BALANUS CRENATUS
6134020114	BALANUS IMPROVISUS
61340201SPP	BALANUS SPP.
6151SPP	MYSIDACEA SPP.
6153010802	HETEROMYSIS FORMOSA
6153011508	NEOMYSIS AMERICANA
6161050101	LIMNORIA LIGNORUM
6179220103	CRANGON SEPTEMSPINOSA
6183060226	PAGURUS ACADIANUS
6183060230	PAGURUS LONGICARPUS
61830602SPP	PAGURUS SPP.
618306SPP	PAGURIDAE SPP.
6481SPP	DIPTERA SPP.

5. For these analyses only, merge to following taxa:

CODE	DESCR	CODE	DESCR
50010601TECT	Pholoe tecta	5001060101	Pholoe minuta
5001500305	Tharyx acutus	50015003SPP	Tharyx spp.
50017013SPP	Fabricia	50017013STEL	Fabricia stellaris stellaris
55200201SPP	Pandora	5520020107	Pandora gouldiana
5520050206	Lyonsia hyalina	5520050201	Lyonsia arenosa
6169020108	Ampelisca abdita	61690201SPP	Ampelisca spp.
6169020109	Ampelisca vadorum	61690201SPP	Ampelisca spp.
61690604SPP	Microdeutopus	6169060402	Microdeutopus anomalus
61691507SPP	Unciola	6169150703	Unciola irrorata
61692107SPP	Gammarus	6169210713	Gammarus lawrencianus

6. Treat the following taxa as good species

CODE	DESCR
3901SPP	Turbellaria spp.
43030205SPP	Micrura spp.
43060502SPP	Proneurotes spp.
50015003SPP	Tharyx spp.
50015005SPP	Dodecaceria spp.
61690201SPP	Ampelisca spp.

B. Calculations for Export to R. Kropp only

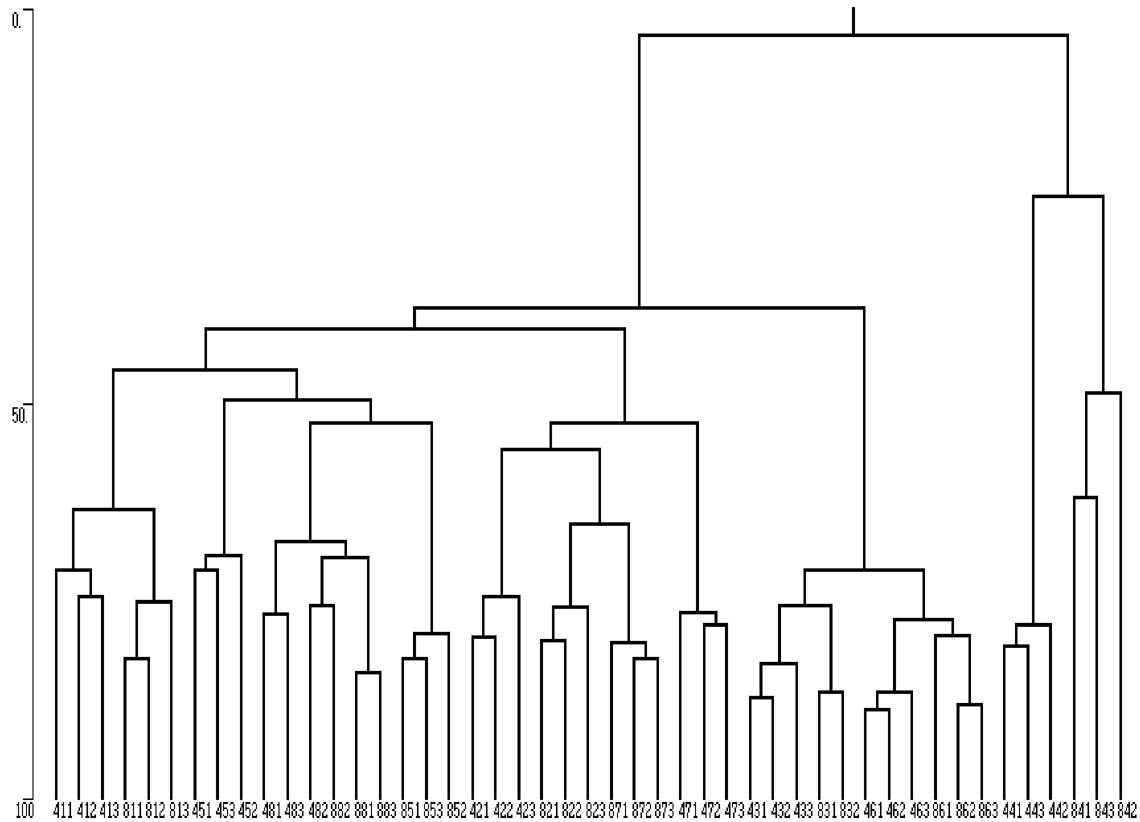
1. Calculate <u>total abundance</u> for each 2000 and 1991–2000 sample. This calculation should be based on <u>all</u> taxa whether identified to species or not (i.e., includes “good” and “bad” species).
2. Calculate dominance per station for <u>2000 data only</u>--include <u>good species only</u> taxa, provide the mean and standard deviation abundance per sample.
3. Calculate abundance (**all taxa**) and number of species (**good species only**) of major taxa for 2000 data only--<u>Annelida</u> (MWRA codes 50*), <u>Arthropoda</u> (MWRA codes 60* and 61*), <u>Mollusca</u> (MWRA codes 51*, 54*, 55*, and 56*), and <u>Other</u> (MWRA codes 37*, 39*, 43*, 72*, 73*, 74*, 77*, 81*, 82*, and 84*).
4. Provide a list of <u>all</u> taxa reported from the Harbor during 1991-2000. Include the MWRA Code, the Taxon Name, the Higher Taxon Code, the Family name, and whether or not the taxon was treated as a good species. (These items probably don’t match the database descriptors for each category. If any are unclear, call me). Here is an example of what I need to do:

MWRA Code	Taxon Name	Higher Taxon	Family	Species?
3740SPP	ANTHOZOA SPP.	CNI		No
3743010201	CERIANTHEOPSIS AMERICANUS	CNI	Cerianthidae	Yes
3758SP02	ACTINIARIA SP. 2 (BLAKE 1992)	CNI		Yes
3759010101	EDWARDSIA ELEGANS	CNI	Edwardsiidae	Yes

5. Provide these (separate 2000 and 1991–2000 results files; historical analyses can be split into two files if necessary) in a format that can be imported into Excel. Arrange results by survey, then by station within survey (for April 1992, place R06 between stations T04 and T06).

APPENDIX D-3

Bray-Curtis Dendogram



Dendrogram resulting from Bray-Curtis cluster analysis and group average sorting of 2000 Boston Harbor infaunal data. Y-axis show percent similarity; x-axis shows the sample identity where the first digit represents the month (4 = April, 8 = August), the second number is the station number, and the third number is the replicate.

APPENDIX D-4

12 Most Abundant Species

Table D-4-1. April 2000.

EVENT	SPEC_CODE	Rank	Taxon	Mean	StDev	%	Cum %	99 Rank
Station T01								
HT001	50090209SP02	1	Tubificoides sp. 2	99.3	76.16	18.2%	18.2%	
HT001	5009030301	2	Paranais litoralis	71.0	48.28	13.0%	31.2%	
HT001	50012102PETT	3	Microphthalmus pettiboneae [a]	68.3	63.22	12.5%	43.7%	5
HT001	5001430402	4	Dipolydora socialis	33.7	3.06	6.2%	49.8%	7
HT001	5515310205	5	Tellina agilis	29.3	13.61	5.4%	55.2%	
HT001	5105080202	6	Ilyanassa trivittata	21.7	11.37	4.0%	59.1%	3
HT001	5001410208	7	Aricidea catherinae	21.0	10.82	3.8%	63.0%	2
HT001	5009020403	8	Tubificoides nr. pseudogaster	17.0	13.53	3.1%	66.1%	1
HT001	50015003SPP	9	Tharyx spp.	14.3	3.51	2.6%	68.7%	
HT001	5001430448	10	Polydora cornuta	13.3	2.52	2.4%	71.2%	11
HT001	5001230707	11	Exogone hebes	13.0	7.00	2.4%	73.5%	8
HT001	5001431001	12	Spiophanes bombyx	12.3	8.50	2.3%	75.8%	
			Total	546.7				
Station T02								
HT001	50090209SP02	1	Tubificoides sp. 2	90.7	5.13	27.1%	27.1%	
HT001	50012102PETT	2	Microphthalmus pettiboneae	59.7	64.35	17.8%	44.9%	
HT001	5009020906	3	Tubificoides apectinatus	57.7	10.69	17.2%	62.2%	1
HT001	5001250104	4	Nephtys cornuta	19.3	3.79	5.8%	67.9%	3
HT001	50015003SPP	5	Tharyx spp.	16.7	3.51	5.0%	72.9%	
HT001	5001431801	6	Streblospio benedicti	13.0	7.55	3.9%	76.8%	
HT001	5001430402	7	Dipolydora socialis	11.0	5.29	3.3%	80.1%	7
HT001	5001410208	8	Aricidea catherinae	10.0	5.00	3.0%	83.1%	5
HT001	5001600101	9	Capitella capitata complex	8.3	1.53	2.5%	85.6%	10
HT001	5001600402	10	Mediomastus californiensis	5.7	0.58	1.7%	87.3%	11
HT001	50015004VIVI	11	Chaetozone vivipara	5.0	4.36	1.5%	88.7%	
HT001	43SP02	12	Nemertea sp. 2	4.7	2.52	1.4%	90.1%	6
HT001	61690201SPP	12	Ampelisca spp.	4.7	1.53	1.4%	91.5%	4
			Total	334.7				
Station T03								
HT001	61690201SPP	1	Ampelisca spp.	1341.7	259.95	32.3%	32.3%	4
HT001	5001410208	2	Aricidea catherinae	703.0	127.58	16.9%	49.2%	1
HT001	5009020403	3	Tubificoides nr. pseudogaster	533.7	87.13	12.8%	62.0%	2
HT001	5009020906	4	Tubificoides apectinatus	530.0	223.52	12.7%	74.8%	3
HT001	6169260217	5	Photis pollex	321.7	157.99	7.7%	82.5%	6
HT001	6169420702	6	Phoxocephalus holbolli	151.0	30.12	3.6%	86.1%	5
HT001	6169345201	7	Orchomenella minuta	100.7	31.97	2.4%	88.6%	
HT001	50015003SPP	8	Tharyx spp.	96.0	76.62	2.3%	90.9%	
HT001	6169060702	9	Leptocheirus pinguis	87.3	47.06	2.1%	93.0%	11
HT001	5105080202	10	Ilyanassa trivittata	41.3	17.62	1.0%	94.0%	7

EVENT	SPEC_CODE	Rank	Taxon	Mean	StDev	%	Cum %	99 Rank
HT001	6169150703	11	Unciola irrorata	39.7	3.79	1.0%	94.9%	
HT001	5001430402	12	Dipolydora socialis	35.7	11.24	0.9%	95.8%	9
			Total	4157.7				
Station T04								
HT001	5001600101	1	Capitella capitata complex	412.0	195.23	47.6%	47.6%	1
HT001	5009030301	2	Paranais litoralis	277.3	69.06	32.0%	79.6%	2
HT001	5001431801	3	Streblospio benedicti	96.3	43.98	11.1%	90.7%	
HT001	5001430448	4	Polydora cornuta	55.7	10.69	6.4%	97.1%	2
HT001	5001430704	5	Spio setosa	6.0	4.00	0.7%	97.8%	
HT001	5515310205	6	Tellina agilis	4.7	3.06	0.5%	98.3%	
HT001	61690201SPP	7	Ampelisca spp.	2.3	2.52	0.3%	98.6%	
HT001	5001130205	8	Eteone longa	2.0	2.00	0.2%	98.8%	
HT001	5001430408	9	Dipolydora quadrilobata	2.0	1.00	0.2%	99.1%	
HT001	50090209SP02	10	Tubificoides sp. 2	2.0	2.00	0.2%	99.3%	
HT001	50015003SPP	11	Tharyx spp.	1.7	1.53	0.2%	99.5%	
HT001	43SP02	12	Nemertea sp. 2	0.7	0.58	0.1%	99.6%	
HT001	5001130207	12	Eteone heteropoda	0.7	1.15	0.1%	99.7%	
HT001	5001431302	12	Pygospio elegans	0.7	1.15	0.1%	99.7%	
			Total	866.3				
Station T05A								
HT001	5515310205	1	Tellina agilis	101.3	33.23	27.4%	27.4%	
HT001	5001431001	2	Spiophanes bombyx	42.3	23.35	11.4%	38.8%	
HT001	6169210713	3	Gammarus lawrencianus	42.0	20.07	11.4%	50.2%	
HT001	5001430402	4	Dipolydora socialis	26.0	15.10	7.0%	57.2%	
HT001	5001600101	5	Capitella capitata complex	14.7	9.71	4.0%	61.2%	7
HT001	6162020703	6	Edotia triloba	14.3	3.06	3.9%	65.0%	11
HT001	5105080202	7	Ilyanassa trivittata	13.7	14.36	3.7%	68.7%	3
HT001	5009020906	8	Tubificoides apectinatus	12.7	4.16	3.4%	72.2%	1
HT001	50015003SPP	9	Tharyx spp.	10.3	5.51	2.8%	75.0%	
HT001	50015004VIVI	10	Chaetozone vivipara	10.0	7.55	2.7%	77.7%	8
HT001	61690201SPP	11	Ampelisca spp.	9.3	12.74	2.5%	80.2%	
HT001	6169260217	12	Photis pollex	8.0	1.00	2.2%	82.3%	10
			Total	370.0				
Station T06								
HT001	5009020403	1	Tubificoides nr. pseudogaster	2082.3	617.70	39.4%	39.4%	2
HT001	61690201SPP	2	Ampelisca spp.	1618.7	195.15	30.7%	70.1%	1
HT001	6169260217	3	Photis pollex	376.0	146.73	7.1%	77.2%	4
HT001	5001410208	4	Aricidea catherinae	273.0	116.76	5.2%	82.4%	7
HT001	5009020906	5	Tubificoides apectinatus	176.7	34.59	3.3%	85.7%	3
HT001	6169420702	6	Phoxocephalus holbolli	165.7	16.62	3.1%	88.9%	8
HT001	6169345201	7	Orchomenella minuta	145.7	28.22	2.8%	91.6%	
HT001	6169150703	8	Unciola irrorata	74.7	15.01	1.4%	93.0%	5
EVENT	**SPEC_CODE**	**Rank**	**Taxon**	**Mean**	**StDev**	**%**	**Cum %**	**99 Rank**
HT001	5515480102	9	Petricola pholadiformis	72.3	26.84	1.4%	94.4%	

HT001	5502020206	10	Nucula delphinodonta	48.0	13.89	0.9%	95.3%	
HT001	5515310205	11	Tellina agilis	44.3	16.50	0.8%	96.2%	
HT001	5105080202	12	Ilyanassa trivittata	34.7	11.59	0.7%	96.8%	12
			Total	5279.7				
Station T07								
HT001	5009020906	1	Tubificoides apectinatus	201.0	54.74	42.6%	42.6%	1
HT001	5001250104	2	Nephtys cornuta	112.7	49.01	23.9%	66.5%	2
HT001	5001410208	3	Aricidea catherinae	63.3	16.26	13.4%	79.9%	3
HT001	61690201SPP	4	Ampelisca spp.	30.3	8.08	6.4%	86.4%	5
HT001	50015003SPP	5	Tharyx spp.	9.3	5.13	2.0%	88.3%	
HT001	5001310140	6	Scoletoma hebes	9.0	2.65	1.9%	90.2%	6
HT001	5001430402	7	Dipolydora socialis	7.3	6.11	1.6%	91.8%	10
HT001	5009020403	7	Tubificoides nr. pseudogaster	7.3	6.66	1.6%	93.4%	4
HT001	5515310205	9	Tellina agilis	7.3	4.51	1.6%	94.9%	
HT001	5001600101	10	Capitella capitata complex	3.7	2.52	0.8%	95.7%	
HT001	5001310204	11	Ninoe nigripes	2.7	0.58	0.6%	96.3%	12
HT001	43SP02	12	Nemertea sp. 2	2.0	1.73	0.4%	96.7%	9
			Total	471.7				
Station T08								
HT001	50020501SP01	1	Polygordius sp. A	308.0	82.16	22.0%	22.0%	4
HT001	5001430402	2	Dipolydora socialis	297.0	49.00	21.2%	43.2%	12
HT001	5001431001	3	Spiophanes bombyx	219.0	88.76	15.7%	58.9%	3
HT001	5515310205	4	Tellina agilis	178.7	67.32	12.8%	71.7%	
HT001	5001410208	5	Aricidea catherinae	93.0	6.08	6.6%	78.3%	1
HT001	5502020206	6	Nucula delphinodonta	69.3	21.13	5.0%	83.3%	5
HT001	5105080202	7	Ilyanassa trivittata	42.0	20.78	3.0%	86.3%	8
HT001	5001230707	8	Exogone hebes	32.0	5.20	2.3%	88.6%	11
HT001	7700010203	9	Phoronis architecta	25.7	41.00	1.8%	90.4%	
HT001	5009020403	10	Tubificoides nr. pseudogaster	18.3	20.21	1.3%	91.7%	2
HT001	61690201SPP	11	Ampelisca spp.	17.3	14.47	1.2%	92.9%	
HT001	50012102PETT	12	Microphthalmus pettiboneae	12.3	9.07	0.9%	93.8%	
			Total	1399.0				

[a] Microphthalmus pettiboneae was previously known as M. aberrans.

Table D-4-2. August 2000.

EVENT	SPEC_CODE	Rank	Taxon	Mean	StDev	%	Cum %	99 Rank
Station T01								
HT002	50090209SP02	1	Tubificoides sp. 2	147.3	24.99	20.5%	20.5%	
HT002	5001430448	2	Polydora cornuta	138.3	48.01	19.2%	39.7%	2
HT002	50012102PETT	3	Microphthalmus pettiboneae [a]	124.3	102.65	17.3%	57.1%	3
HT002	5009020403	4	Tubificoides nr. pseudogaster	61.3	65.59	8.5%	65.6%	1
HT002	5001410208	5	Aricidea catherinae	52.0	25.53	7.2%	72.8%	5
HT002	5001431801	6	Streblospio benedicti	49.7	21.78	6.9%	79.7%	4
HT002	5515310205	7	Tellina agilis	24.7	10.02	3.4%	83.2%	10
HT002	5001230707	8	Exogone hebes	15.0	10.82	2.1%	85.3%	9
HT002	5001431001	9	Spiophanes bombyx	11.3	7.09	1.6%	86.8%	7
HT002	5105080202	10	Ilyanassa trivittata	10.7	4.93	1.5%	88.3%	6
HT002	50015003SPP	11	Tharyx spp.	9.7	3.21	1.3%	89.7%	
HT002	5001600402	12	Mediomastus californiensis	7.3	2.31	1.0%	90.7%	
HT002	61690201SPP	12	Ampelisca spp.	7.3	5.03	1.0%	91.7%	
			Total	718.7				
Station T02								
HT002	5001430448	1	Polydora cornuta	508.7	341.33	51.6%	51.6%	4
HT002	5009020906	2	Tubificoides apectinatus	92.7	58.80	9.4%	61.0%	
HT002	61690201SPP	3	Ampelisca spp.	85.0	109.66	8.6%	69.7%	6
HT002	5001431801	4	Streblospio benedicti	67.0	29.61	6.8%	76.5%	3
HT002	50090209SP02	5	Tubificoides sp. 2	42.3	18.15	4.3%	80.8%	
HT002	50015003SPP	6	Tharyx spp.	41.7	24.09	4.2%	85.0%	
HT002	5001410208	7	Aricidea catherinae	22.7	6.03	2.3%	87.3%	10
HT002	5001250104	8	Nephtys cornuta	21.3	16.29	2.2%	89.5%	8
HT002	50012102PETT	9	Microphthalmus pettiboneae	20.0	7.21	2.0%	91.5%	1
HT002	5001600402	10	Mediomastus californiensis	19.3	5.03	2.0%	93.5%	
HT002	6169060702	11	Leptocheirus pinguis	12.3	17.93	1.3%	94.7%	5
HT002	5105080202	12	Ilyanassa trivittata	7.0	3.61	0.7%	95.4%	11
			Total	985.0				
Station T03								
HT002	61690201SPP	1	Ampelisca spp.	3064.5	191.63	29.3%	29.3%	1
HT002	5009020906	2	Tubificoides apectinatus	1662.0	39.60	15.9%	45.3%	5
HT002	5001430448	3	Polydora cornuta	1382.5	142.13	13.2%	58.5%	7
HT002	5009020403	4	Tubificoides nr. pseudogaster	1136.0	411.54	10.9%	69.4%	4
HT002	5001410208	5	Aricidea catherinae	742.0	135.76	7.1%	76.5%	2
HT002	6169420702	6	Phoxocephalus holbolli	698.5	23.33	6.7%	83.2%	
HT002	50015003SPP	7	Tharyx spp.	377.0	31.11	3.6%	86.8%	
HT002	6169345201	8	Orchomenella minuta	308.5	60.10	3.0%	89.7%	
HT002	6169150703	9	Unciola irrorata	280.0	41.01	2.7%	92.4%	9
HT002	6169060702	10	Leptocheirus pinguis	231.0	4.24	2.2%	94.6%	10
HT002	6169260217	11	Photis pollex	152.0	9.90	1.5%	96.1%	6
HT002	5105080202	12	Ilyanassa trivittata	93.5	30.41	0.9%	97.0%	11
			Total	10443.0				
EVENT	**SPEC_CODE**	**Rank**	**Taxon**	**Mean**	**StDev**	**%**	**Cum %**	**99 Rank**

Station T04								
HT002	5001431801	1	Streblospio benedicti	111.3	138.54	86.3%	86.3%	1
HT002	50090209SP02	2	Tubificoides sp. 2	11.3	13.80	8.8%	95.1%	
HT002	5105080202	3	Ilyanassa trivittata	3.3	3.51	2.6%	97.7%	2
HT002	50015003SPP	4	Tharyx spp.	0.7	1.15	0.5%	98.2%	
HT002	5515250301	4	Mulinia lateralis	0.7	1.15	0.5%	98.7%	9
HT002	5515310205	4	Tellina agilis	0.7	1.15	0.5%	99.2%	
HT002	50020501SP01	7	Polygordius sp. A	0.3	0.58	0.3%	99.5%	
HT002	5515290301	7	Ensis directus	0.3	0.58	0.3%	99.7%	3
HT002	61690201SPP	7	Ampelisca spp.	0.3	0.58	0.3%	100.0%	4
			Total	129.0				
Station T05A								
HT002	5001431001	1	Spiophanes bombyx	314.0	126.12	53.1%	53.1%	3
HT002	5515310205	2	Tellina agilis	57.7	10.79	9.7%	62.8%	11
HT002	5105080202	3	Ilyanassa trivittata	51.3	11.93	8.7%	71.5%	9
HT002	50015003SPP	4	Tharyx spp.	40.3	14.01	6.8%	78.3%	
HT002	6169150703	5	Unciola irrorata	35.7	22.01	6.0%	84.3%	7
HT002	5001430448	6	Polydora cornuta	23.0	16.70	3.9%	88.2%	1
HT002	50012102PETT	7	Microphthalmus pettiboneae	14.0	11.53	2.4%	90.6%	
HT002	5009020906	8	Tubificoides apectinatus	12.0	3.46	2.0%	92.6%	2
HT002	5001410208	9	Aricidea catherinae	9.3	3.06	1.6%	94.2%	
HT002	50020501SP01	10	Polygordius sp. A	6.3	6.66	1.1%	95.3%	5
HT002	6169260217	11	Photis pollex	4.3	4.04	0.7%	96.0%	
HT002	5001431801	12	Streblospio benedicti	3.7	0.58	0.6%	96.6%	
			Total	591.7				
Station T06								
HT002	61690201SPP	1	Ampelisca spp.	3671.7	1644.81	46.8%	46.8%	1
HT002	5009020403	2	Tubificoides nr. pseudogaster	1494.7	479.39	19.0%	65.8%	2
HT002	5001430448	3	Polydora cornuta	622.7	343.40	7.9%	73.7%	3
HT002	6169420702	4	Phoxocephalus holbolli	505.0	237.76	6.4%	80.2%	5
HT002	5009020906	5	Tubificoides apectinatus	310.3	122.51	4.0%	84.1%	7
HT002	6169260217	6	Photis pollex	294.7	174.43	3.8%	87.9%	8
HT002	5001410208	7	Aricidea catherinae	292.3	99.04	3.7%	91.6%	6
HT002	6169150202	8	Crassicorophium bonelli	245.3	173.90	3.1%	94.7%	
HT002	6169345201	9	Orchomenella minuta	111.0	86.71	1.4%	96.1%	
HT002	6169150703	10	Unciola irrorata	59.0	51.39	0.8%	96.9%	4
HT002	5105080202	11	Ilyanassa trivittata	56.7	31.34	0.7%	97.6%	
HT002	5502020206	12	Nucula delphinodonta	31.3	8.33	0.4%	98.0%	11
			Total	7852.3				
Station T07								
HT002	5009020906	1	Tubificoides apectinatus	432.0	233.66	41.9%	41.9%	1
HT002	5001410208	2	Aricidea catherinae	186.0	78.85	18.1%	60.0%	4
HT002	5001430448	3	Polydora cornuta	98.0	67.95	9.5%	69.5%	2
HT002	50012102PETT	4	Microphthalmus pettiboneae	69.0	44.54	6.7%	76.2%	6
EVENT	**SPEC_CODE**	**Rank**	**Taxon**	**Mean**	**StDev**	**%**	**Cum %**	**99 Rank**
HT002	5001431801	5	Streblospio benedicti	67.0	23.00	6.5%	82.7%	8
HT002	50015003SPP	6	Tharyx spp.	60.3	27.01	5.9%	88.5%	
HT002	5001250104	7	Nephtys cornuta	39.7	17.95	3.8%	92.4%	3

HT002	5001310140	8	Scoletoma hebes	18.7	10.02	1.8%	94.2%	7
HT002	61690201SPP	9	Ampelisca spp.	11.7	8.14	1.1%	95.3%	5
HT002	5009020403	10	Tubificoides nr. pseudogaster	7.3	0.58	0.7%	96.1%	9
HT002	5001600402	11	Mediomastus californiensis	6.7	1.53	0.6%	96.7%	
HT002	5515310205	12	Tellina agilis	6.0	4.36	0.6%	97.3%	
			Total	1030.3				
Station T08								
HT002	5001431001	1	Spiophanes bombyx	523.7	301.65	32.1%	32.1%	2
HT002	61690201SPP	2	Ampelisca spp.	303.7	253.90	18.6%	50.8%	
HT002	50020501SP01	3	Polygordius sp. A	290.7	91.18	17.8%	68.6%	1
HT002	5001230707	4	Exogone hebes	107.3	48.54	6.6%	75.2%	6
HT002	5515310205	5	Tellina agilis	66.0	18.19	4.1%	79.3%	4
HT002	5105080202	6	Ilyanassa trivittata	58.3	15.63	3.6%	82.9%	7
HT002	5001410208	7	Aricidea catherinae	54.3	11.72	3.3%	86.2%	3
HT002	5502020206	8	Nucula delphinodonta	34.7	14.01	2.1%	88.3%	5
HT002	5009020403	9	Tubificoides nr. pseudogaster	20.3	18.50	1.2%	89.6%	
HT002	5001430402	10	Dipolydora socialis	17.3	13.50	1.1%	90.6%	
HT002	5520050201	11	Lyonsia arenosa	16.7	12.74	1.0%	91.7%	
HT002	6169260217	12	Photis pollex	12.0	8.54	0.7%	92.4%	8
			Total	1629.0				

[a] Microphthalmus pettiboneae was previously known as M. aberrans.

APPENDIX D-5

List of Taxa Included in the Analyses of 1991–2000 Boston Harbor Data

MWRA Code	Taxon Name	Higher Taxon	Family	Good_Bad
3740SPP	Anthozoa spp.	CNI		B
3743010201	Ceriantheopsis americanus	CNI	Cerianthidae	G
3758SP02	Actiniaria sp. 2	CNI		G
3758SPP	Actiniaria spp.	CNI		B
3759010101	Edwardsia elegans	CNI	Edwardsiidae	G
3901SPP	Turbellaria spp.	PLA		G
4302010104	Tubulanus pellucidus	NEM	Tubulanidae	G
4303020209	Cerebratulus lacteus	NEM	Lineidae	G
43030202SPP	Cerebratulus spp.	NEM	Lineidae	B
43030205SPP	Micrura spp.	NEM	Lineidae	G
4306050101	Amphiporus angulatus	NEM	Amphiporidae	G
4306050115	Amphiporus cruentatus	NEM	Amphiporidae	G
43060501SP02	Amphiporus sp. 1	NEM	Amphiporidae	G
43060501SPP	Amphiporus spp.	NEM	Amphiporidae	B
43060502SPP	Proneurotes spp.	NEM	Amphiporidae	G
4306060216	Tetrastemma vittatum	NEM	Tetrastemmatidae	G
43060602SPP	Tetrastemma spp.	NEM	Tetrastemmatidae	B
43SP02	Nemertea sp. 2	NEM		G
43SP04	Nemertea sp. D	NEM		G
43SP05	Nemertea sp. 5	NEM		G
43SP12	Nemertea sp. 12	NEM		G
43SP13	Nemertea sp. 13	NEM		G
43SPP	Nemertea spp.	NEM		B
5001020601	Gattyana amondseni	POL	Polynoidae	G
5001020603	Gattyana cirrosa	POL	Polynoidae	G
5001020803	Harmothoe extenuata	POL	Polynoidae	G
5001020806	Harmothoe imbricata	POL	Polynoidae	G
5001021103	Lepidonotus squamatus	POL	Polynoidae	G
50010211SPP	Lepidonotus spp.	POL	Polynoidae	B
5001022001	Hartmania moorei	POL	Polynoidae	G
5001022103	Enipo torelli	POL	Polynoidae	G
500102HARSPP	Harmothoinae spp.	POL	Polynoidae	B
500102SPP	Polynoidae spp.	POL	Polynoidae	B
5001060101	Pholoe minuta	POL	Pholoidae	G
5001060303	Sthenelais limicola	POL	Sigalionidae	G
500106SPP	Sigalionidae spp.	POL	Sigalionidae	B
500110SPP	Amphinomidae spp.	POL	Amphinomidae	B
5001130102	Phyllodoce groenlandica	POL	Phyllodocidae	G
5001130104	Phyllodoce mucosa	POL	Phyllodocidae	G
5001130106	Phyllodoce maculata	POL	Phyllodocidae	G
5001130204	Eteone flava	POL	Phyllodocidae	G
5001130205	Eteone longa	POL	Phyllodocidae	G
5001130207	Eteone heteropoda	POL	Phyllodocidae	G
50011302SPP	Eteone spp.	POL	Phyllodocidae	B
5001130301	Eulalia viridis	POL	Phyllodocidae	G
5001130304	Eulalia bilineata	POL	Phyllodocidae	G
5001130801	Paranaitis speciosa	POL	Phyllodocidae	G

MWRA Code	Taxon Name	Higher Taxon	Family	Good_Bad
50011308SPP	Paranaitis spp.	POL	Phyllodocidae	B
5001131101	Eumida sanguinea	POL	Phyllodocidae	G
5001131410	Phyllodoce arenae	POL	Phyllodocidae	G
50011314SPP	Phyllodoce spp.	POL	Phyllodocidae	B
500113SPP	Phyllodocidae spp.	POL	Phyllodocidae	B
50012102PETT	Microphthalmus pettiboneae	POL	Hesionidae	G
50012102SPP	Microphthalmus spp.	POL	Hesionidae	B
500121SPP	Hesionidae spp.	POL	Hesionidae	B
5001230101	Proceraea cornuta	POL	Syllidae	G
5001230111	Autolytus fasciatus	POL	Syllidae	G
50012302SPP	Pionosyllis spp.	POL	Syllidae	B
5001230306	Syllis cornuta	POL	Syllidae	G
5001230501	Typosyllis alternata	POL	Syllidae	G
50012305SP01	Typosyllis sp. 1	POL	Syllidae	G
50012305SPP	Typosyllis spp.	POL	Syllidae	B
5001230706	Exogone verugera	POL	Syllidae	G
5001230707	Exogone hebes	POL	Syllidae	G
5001230709	Exogone arenosa	POL	Syllidae	G
50012307SPP	Exogone spp.	POL	Syllidae	B
5001230817	Sphaerosyllis longicauda	POL	Syllidae	G
50012308SPP	Sphaerosyllis spp.	POL	Syllidae	B
5001230903	Brania wellfleetensis	POL	Syllidae	G
5001231503	Syllides longocirrata	POL	Syllidae	G
5001231701	Parapionosyllis longicirrata	POL	Syllidae	G
500123SPP	Syllidae spp.	POL	Syllidae	B
5001240302	Neanthes virens	POL	Nereidae	G
5001240404	Nereis procera	POL	Nereidae	G
5001240406	Nereis zonata	POL	Nereidae	G
5001240411	Nereis diversicolor	POL	Nereidae	G
50012404SPP	Nereis spp.	POL	Nereidae	B
500124SPP	Nereididae spp.	POL	Nereidae	B
5001250102	Nephtys ciliata	POL	Nephtyidae	G
5001250103	Nephtys caeca	POL	Nephtyidae	G
5001250104	Nephtys cornuta	POL	Nephtyidae	G
5001250109	Nephtys longosetosa	POL	Nephtyidae	G
5001250115	Nephtys incisa	POL	Nephtyidae	G
5001250117	Nephtys picta	POL	Nephtyidae	G
50012501SPP	Nephtys spp.	POL	Nephtyidae	B
5001250304	Aglaophamus circinata	POL	Nephtyidae	G
500125SPP	Nephtyidae spp.	POL	Nephtyidae	B
50012604SP01	Sphaerodoridium sp. A	POL	Sphaerodoridae	G
5001270105	Glycera dibranchiata	POL	Glyceridae	G
50012701SPP	Glycera spp.	POL	Glyceridae	B
500127SPP	Glyceridae spp.	POL	Glyceridae	B
5001310102	Scoletoma fragilis	POL	Lumbrineridae	G
5001310140	Scoletoma hebes	POL	Lumbrineridae	G
5001310149	Scoletoma acicularum	POL	Lumbrineridae	G

MWRA Code	Taxon Name	Higher Taxon	Family	Good_Bad
50013101SPP	Scoletoma spp.	POL	Lumbrineridae	B
5001310204	Ninoe nigripes	POL	Lumbrineridae	G
500131SPP	Lumbrineridae spp.	POL	Lumbrineridae	B
5001360202	Protodorvillea gaspeensis	POL	Dorvilleidae	G
50013604SPP	Ophryotrocha spp.	POL	Dorvilleidae	B
50013614CAEC	Parougia caeca	POL	Dorvilleidae	G
500136SP01	Dorvilleidae sp. A	POL	Dorvilleidae	G
500136SPP	Dorvilleidae spp.	POL	Dorvilleidae	B
5001400301	Scoloplos armiger	POL	Orbiniidae	G
5001400304	Leitoscoloplos robustus	POL	Orbiniidae	G
5001400305	Leitoscoloplos acutus	POL	Orbiniidae	G
50014003SPP	Scoloplos spp.	POL	Orbiniidae	B
50014016SPP	Leitoscoloplos spp.	POL	Orbiniidae	B
500140SPP	Orbiniidae spp.	POL	Orbiniidae	B
5001410208	Aricidea catherinae	POL	Paraonidae	G
5001410217	Aricidea quadrilobata	POL	Paraonidae	G
5001410302	Paraonis fulgens	POL	Paraonidae	G
5001410801	Levinsenia gracilis	POL	Paraonidae	G
5001411204	Paradoneis armatus	POL	Paraonidae	G
5001430402	Dipolydora socialis	POL	Spionidae	G
5001430404	Dipolydora caulleryi	POL	Spionidae	G
5001430408	Dipolydora quadrilobata	POL	Spionidae	G
5001430414	Dipolydora concharum	POL	Spionidae	G
5001430438	Polydora aggregata	POL	Spionidae	G
5001430448	Polydora cornuta	POL	Spionidae	G
50014304SP01	Polydora sp. 1	POL	Spionidae	G
50014304SPP	Polydora spp.	POL	Spionidae	B
5001430506	Prionospio steenstrupi	POL	Spionidae	G
5001430701	Spio filicornis	POL	Spionidae	G
5001430704	Spio setosa	POL	Spionidae	G
5001430707	Spio limicola	POL	Spionidae	G
5001430709	Spio thulini	POL	Spionidae	G
50014307SPP	Spio spp.	POL	Spionidae	B
5001431001	Spiophanes bombyx	POL	Spionidae	G
5001431302	Pygospio elegans	POL	Spionidae	G
5001431801	Streblospio benedicti	POL	Spionidae	G
5001432001	Scolelepis squamata	POL	Spionidae	G
5001432002	Scolelepis bousfieldi	POL	Spionidae	G
5001432006	Scolelepis texana	POL	Spionidae	G
50014320SPP	Scolelepis spp.	POL	Spionidae	B
500143SPP	Spionidae spp.	POL	Spionidae	B
5001450203	Trochochaeta multisetosa	POL	Trochochaetidae	G
50014502SPP	Trochochaeta spp.	POL	Trochochaetidae	B
5001500101	Cirratulus cirratus	POL	Cirratulidae	G
5001500104	Cirriformia grandis	POL	Cirratulidae	G
50015001SPP	Cirratulus spp	POL	Cirratulidae	B
50015002SP02	Caulleriella sp. B	POL	Cirratulidae	G

MWRA Code	Taxon Name	Higher Taxon	Family	Good_Bad
50015002SPP	Caulleriella spp.	POL	Cirratulidae	B
5001500301	Aphelochaeta monilaris	POL	Cirratulidae	G
5001500305CF	Tharyx cf. acutus	POL	Cirratulidae	G
5001500307	Aphelochaeta marioni	POL	Cirratulidae	G
5001500310	Monticellina dorsobranchialis	POL	Cirratulidae	G
50015003ASP01	Aphelochaeta sp. 1	POL	Cirratulidae	G
50015003ASPP	Aphelochaeta spp.	POL	Cirratulidae	B
50015003BAPT	Monticellina baptisteae	POL	Cirratulidae	G
50015003MSPP	Monticellina spp.	POL	Cirratulidae	B
50015003SPP	Tharyx spp.	POL	Cirratulidae	G
50015004BH	Chaetozone cf. setosa (Boston Harbor)	POL	Cirratulidae	G
50015004SPP	Chaetozone spp.	POL	Cirratulidae	B
50015004VIVI	Chaetozone vivipara	POL	Cirratulidae	G
50015005SPP	Dodecaceria spp.	POL	Cirratulidae	G
5001500ASPP	Cirratulus spp. or Cirriformia spp.	POL	Cirratulidae	B
500150SPP	Cirratulidae spp.	POL	Cirratulidae	B
5001520101	Cossura longocirrata	POL	Cossuridae	G
50015402SPP	Flabelligera spp.	POL	Flabelligeridae	B
5001540304	Pherusa affinis	POL	Flabelligeridae	G
5001570101	Scalibregma inflatum	POL	Scalibregmatidae	G
5001580607	Ophelina acuminata	POL	Ophellidae	G
500158SPP	Opheliidae spp.	POL	Ophellidae	B
5001600101	Capitella capitata complex	POL	Capitellidae	G
5001600201	Heteromastus filiformis	POL	Capitellidae	G
5001600402	Mediomastus californiensis	POL	Capitellidae	G
50016004SPP	Mediomastus spp.	POL	Capitellidae	B
500160SPP	Capitellidae spp.	POL	Capitellidae	B
5001620204	Arenicola marina	POL	Arenicolidae	G
50016203SPP	Branchiomaldane spp.	POL	Arenicolidae	B
5001630202	Clymenella torquata	POL	Maldanidae	G
5001630302	Maldane glebifex	POL	Maldanidae	G
50016303SPP	Maldane spp.	POL	Maldanidae	B
500163ELON	Sabaco elongatus	POL	Maldanidae	G
500163SPP	Maldanidae spp.	POL	Maldanidae	B
5001640402	Galathowenia oculata	POL	Oweniidae	G
5001650202	Sabellaria vulgaris	POL	Sabellariidae	G
5001660303	Pectinaria granulata	POL	Pectinariidae	G
50016603HYPE	Pectinaria hyperborea	POL	Pectinariidae	G
50016603SPP	Pectinaria spp.	POL	Pectinariidae	B
5001670213	Ampharete lindstroemi	POL	Ampharetidae	G
5001670214	Ampharete finmarchica	POL	Ampharetidae	G
50016702SPP	Ampharete spp.	POL	Ampharetidae	B
5001670701	Anobothrus gracilis	POL	Ampharetidae	G
5001670802	Asabellides oculata	POL	Ampharetidae	G
500167SPP	Ampharetidae spp.	POL	Ampharetidae	B
50016801SPP	Amphitritinae spp.	POL	Terebellidae	B

MWRA Code	Taxon Name	Higher Taxon	Family	Good_Bad
5001680404	Neoamphitrite figulus	POL	Terebellidae	G
5001680602	Nicolea zostericola	POL	Terebellidae	G
5001680701	Pista cristata	POL	Terebellidae	G
5001680802	Polycirrus medusa	POL	Terebellidae	G
5001680804	Polycirrus eximius	POL	Terebellidae	G
5001680805	Polycirrus cf. haematodes	POL	Terebellidae	G
50016808SP01	Polycirrus sp. A	POL	Terebellidae	G
50016808SPP	Polycirrus spp.	POL	Terebellidae	B
50016813SPP	Lanassa spp.	POL	Terebellidae	B
500168SPP	Terebellidae spp.	POL	Terebellidae	B
5001700204	Euchone incolor	POL	Sabellidae	G
50017013STEL	Fabricia stellaris stellaris	POL	Sabellidae	G
5001709SPP	Fabricinae spp.	POL	Sabellidae	B
500170SPP	Sabellidae spp.	POL	Sabellidae	B
500178CIRSPP	Cerceis spp.	POL	Spirobidae	B
50020501SP01	Polygordius sp. A	POL	Polygordiidae	G
5003SPP	Oligochaeta spp.	OLI		B
5009010301LONG	Grania postclitellochaeta longiducta	OLI	Enchytraeidae	G
500901SP01	Enchytraeidae sp. 1	OLI	Enchytraeidae	G
500901SP02	Enchytraeidae sp. 2	OLI	Enchytraeidae	G
500901SP03	Enchytraeidae sp. 3	OLI	Enchytraeidae	G
5009020202	Tubificoides benedeni	OLI	Tubificidae	G
5009020403	Tubificoides nr. pseudogaster	OLI	Tubificidae	G
5009020906	Tubificoides apectinatus	OLI	Tubificidae	G
50090209SP01	Tubificoides sp. 1	OLI	Tubificidae	G
50090209SP02	Tubificoides sp. 2	OLI	Tubificidae	G
500902SP02	Tubificidae sp. 2	OLI	Tubificidae	G
500902SPP	Tubificidae spp.	OLI	Tubificidae	B
5009030301	Paranais litoralis	OLI	Naididae	G
5103090305	Lacuna vincta	GAS	Lacunidae	G
5103760407	Polinices duplicatus	GAS	Naticidae	G
5103760409	Lunatia triseriata	GAS	Naticidae	G
51037608SPP	Lunatia spp.	GAS	Naticidae	B
5103761201	Euspira heros	GAS	Naticidae	G
510376SPP	Naticidae spp.	GAS	Naticidae	B
5105030207	Mitrella lunata	GAS	Columbellidae	G
5105080102	Nassarius vibex	GAS	Nassariidae	G
5105080201	Ilyanassa obsoleta	GAS	Nassariidae	G
5105080202	Ilyanassa trivittata	GAS	Nassariidae	G
51080101SPP	Odostomia spp.	GAS	Pyramidellidae	B
510801SPP	Pyramidellidae spp.	GAS	Pyramidellidae	B
511004SPP	Cylichnidae spp.	GAS	Cylichnidae	B
5110090101	Diaphana minuta	GAS	Diaphanidae	G
5127SPP	Nudibranchia spp.	GAS		B
5128SP01	Doridoidea sp. A	GAS		G
51SPP	Gastropoda spp.	GAS		B
5502020205	Nucula annulata	BIV	Nuculidae	G

MWRA Code	Taxon Name	Higher Taxon	Family	Good_Bad
5502020206	Nucula delphinodonta	BIV	Nuculidae	G
55020202SPP	Nucula spp.	BIV	Nuculidae	B
550202SPP	Nuculidae spp.	BIV	Nuculidae	B
5502040204	Nuculana acuta	BIV	Nuculanidae	G
5502040511	Yoldia limatula	BIV	Nuculanidae	G
5502040513	Yoldia sapotilla	BIV	Nuculanidae	G
55020405SPP	Yoldia spp.	BIV	Nuculanidae	B
550204SPP	Nuculanidae spp.	BIV	Nuculanidae	B
5507010201	Crenella decussata	BIV	Mytilidae	G
55070102SPP	Crenella spp.	BIV	Mytilidae	B
5507010401	Musculus niger	BIV	Mytilidae	G
55070104SPP	Musculus spp.	BIV	Mytilidae	B
5509090202	Anomia simplex	BIV	Anomiidae	G
5515020325	Thyasira gouldi	BIV	Thyasiridae	G
5515100110	Mysella planulata	BIV	Montacutidae	G
5515100602	Aligena elevata	BIV	Keliidae	G
5515140101	Turtonia minuta	BIV	Turtoniidae	G
5515190113	Astarte undata	BIV	Astartidae	G
55151901SPP	Astarte spp.	BIV	Astartidae	B
5515220601	Cerastoderma pinnulatum	BIV	Cardiidae	G
5515250102	Spisula solidissima	BIV	Mactridae	G
5515250301	Mulinia lateralis	BIV	Mactridae	G
5515290105	Siliqua costata	BIV	Solenidae	G
5515290301	Ensis directus	BIV	Solenidae	G
5515310116	Macoma balthica	BIV	Tellinidae	G
5515310205	Tellina agilis	BIV	Tellinidae	G
551531SPP	Tellinidae spp.	BIV	Tellinidae	B
5515390101	Arctica islandica	BIV	Arcticidae	G
5515471201	Pitar morrhuana	BIV	Veneridae	G
551547SPP	Veneridae spp.	BIV	Veneridae	B
5515480102	Petricola pholadiformis	BIV	Petricolidae	G
5517010201	Mya arenaria	BIV	Myidae	G
5517060201	Hiatella arctica	BIV	Hiatellidae	G
5520020107	Pandora gouldiana	BIV	Pandoridae	G
5520050201	Lyonsia arenosa	BIV	Lyonsiidae	G
5520070104	Periploma papyratium	BIV	Periplomatidae	G
5520080102	Asthenothaerus hemphilli	BIV	Thraciidae	G
5520080209	Thracia conradi	BIV	Thraciidae	G
55200802SPP	Thracia spp.	BIV	Thraciidae	B
5520080301	Bushia elegans	BIV	Thraciidae	G
552008SPP	Thraciidae spp.	BIV	Thraciidae	B
55SP01	Bivalvia sp. 1	BIV		G
55SPP	Bivalvia spp.	BIV		B
6001040202	Achelia spinosa	PYC	Ammotheidae	G
6001060102	Phoxichilidium femoratum	PYC	Phoxichilidiidae	G
6154010105	Lamprops quadriplicata	CUM	Lampropidae	G
6154040211	Eudorella pusilla	CUM	Leuconidae	G

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6154050121	Diastylis polita	CUM	Diastylidae	G
6154050127	Diastylis sculpta	CUM	Diastylidae	G
61540501SPP	Diastylis spp.	CUM	Diastylidae	B
615405SPP	Diastylidae spp.	CUM	Diastylidae	B
6155SPP	Tanaidacea spp.	TAN		B
6157020402	Tanaissus psammophilus	TAN	Nototanaidae	G
6158SPP	Isopoda spp.	ISO		B
6160010301	Ptilanthura tenuis	ISO	Anthuridae	G
6161011203	Politolana polita	ISO	Cirolanidae	G
61620203SPP	Idotea spp.	ISO	Idoteidae	B
6162020503	Chiridotea tuftsi	ISO	Chaetiliidae	G
61620206SPP	Erichsonella spp.	ISO	Idoteidae	B
6162020703	Edotia triloba	ISO	Idoteidae	G
61631201SPP	Munna spp.	ISO	Munnidae	B
6163120204	Pleurogonium inerme	ISO	Paramunnidae	G
61631202SPP	Pleurogonium spp.	ISO	Paramunnidae	B
6168SPP	Amphipoda spp.	AMP		B
61690201SPP	Ampelisca spp.	AMP	Ampeliscidae	G
6169040201	Cymadusa compta	AMP	Amphilochidae	G
6169060304	Lembos websteri	AMP	Aoridae	G
6169060402	Microdeutopus anomalus	AMP	Aoridae	G
6169060702	Leptocheirus pinguis	AMP	Aoridae	G
616906SPP	Aoridae spp.	AMP	Aoridae	B
6169070101	Argissa hamatipes	AMP	Argissidae	G
6169150201	Monocorophium acherusicum	AMP	Corophiidae	G
6169150202	Crassicorophium bonelli	AMP	Corophiidae	G
6169150203	Crassicorophium crassicorne	AMP	Corophiidae	G
6169150207	Monocorophium tuberculatum	AMP	Corophiidae	G
6169150211	Monocorophium insidiosum	AMP	Corophiidae	G
6169150213	Apocorophium acutum	AMP	Corophiidae	G
6169150302	Ericthonius brasiliensis	AMP	Corophiidae	G
6169150703	Unciola irrorata	AMP	Corophiidae	G
6169150801	Pseudunciola obliquua	AMP	Corophiidae	G
616915SP01	Corophiidae sp. 1	AMP	Corophiidae	G
616915SPP	Corophiidae spp.	AMP	Corophiidae	B
6169170401	Dexamine thea	AMP	Dexaminidae	G
6169201203	Pontogeneia inermis	AMP	Eusiridae	G
6169210713	Gammarus lawrencianus	AMP	Gammaridae	G
616921MESPP	Melitidae spp.	AMP	Melitidae	B
616921SPP	Gammaridae spp.	AMP	Gammaridae	B
6169260217	Photis pollex	AMP	Isaeidae	G
61692602SPP	Photis spp.	AMP	Isaeidae	B
6169260301	Protomedeia fasciata	AMP	Isaeidae	G
6169270202	Ischyrocerus anguipes	AMP	Ischyroceridae	G
61692702SPP	Ischyrocerus spp.	AMP	Ischyroceridae	B
6169270303	Jassa marmorata	AMP	Ischyroceridae	G
6169330301	Listriella barnardi	AMP	Liljeborgiidae	G

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6169345201	Orchomenella minuta	AMP	Lysianassidae	G
616937AMSP01	Ameroculodes sp. 1	AMP	Oedicerotidae	G
616937SPP	Oedicerotidae spp.	AMP	Oedicerotidae	B
6169420702	Phoxocephalus holbolli	AMP	Phoxocephalidae	G
6169421502	Rhepoxynius hudsoni	AMP	Phoxocephalidae	G
6169430503	Pleusymtes glaber	AMP	Pleustidae	G
6169440104	Dyopedos monacanthus	AMP	Podoceridae	G
6169480305	Metopella carinata	AMP	Stenothoidae	G
6169480306	Metopella angusta	AMP	Stenothoidae	G
6169480801	Proboloides holmesi	AMP	Stenothoidae	G
6169481001	Stenothoe gallensis	AMP	Stenothoidae	G
6169481002	Stenothoe minuta	AMP	Stenothoidae	G
616948SPP	Stenothoidae spp.	AMP	Stenothoidae	B
61695101SPP	Orchestia spp.	AMP	Talitridae	B
6171010703	Caprella linearis	AMP	Caprellidae	G
6171010727	Caprella penantis	AMP	Caprellidae	G
61710107SPP	Caprella spp.	AMP	Caprellidae	B
6171010801	Aeginina longicornis	AMP	Caprellidae	G
6171010901	Paracaprella tenuis	AMP	Caprellidae	G
617101SPP	Caprellidae spp.	AMP	Caprellidae	B
6184SPP	Brachyura spp.	DEC		B
6188030108	Cancer irroratus	DEC	Cancridae	G
6189010701	Carcinus maenas	DEC	Portunidae	G
7200020305	Nephasoma diaphanes	SIP	Golfingiidae	G
72SPP	Sipuncula spp.	SIP		B
7301020201	Echiurus echiurus	ECI	Echiuridae	G
7700010203	Phoronis architecta	PHO	Phoronidae	G
8104SPP	Asteroidea spp.	ECH		B
8120SPP	Ophiuroidea spp.	ECH		B
8127010611	Ophiura robusta	ECH	Ophiuridae	G
8129030202	Axiognathus squamatus	ECH	Amphiuridae	G
8136SPP	Echinoidea spp.	ECH		B
8149030201	Strongylocentrotus droebachiensis	ECH		G
8201010303	Saccoglossus bromophenolosus	HEM		G
8201SPP	Enteropneusta spp.	HEM		B
8401SPP	Ascidiacea spp.	URO		B
8406030108	Molgula manhattensis	URO	Molgulidae	G
84060301SPP	Molgula spp.	URO	Molgulidae	B
8406030501	Bostrichobranchus pilularis	URO	Molgulidae	G

Key:

AMP	Amphipoda
BIV	Bivalvia
CNI	Cnidaria
CUM	Cumacea
DEC	Decapoda
ECH	Echinodermata

GAS	Gastropoda
HEM	Hemichordata
ISO	Isopoda
NEM	Nemertea
OLI	Oligochaeta
PHO	Phoronida
PLA	Platyhelminthes
POL	Polychaeta
PYC	Pycnogonida
SIP	Sipuncula
TAN	Tanaidacea
URO	Urochordata

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