The Maine Department of Marine Resource's Finfish Aquaculture Monitoring Program (FAMP) 1992-1995

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Executive Summary

The State of Maine Aquaculture Application/Monitoring Program was created in 1991 by Public Law 381 after extensive study on the part of the legislature and considerable public input on the potential environmental effects of finfish aquaculture. This program is now referred to as the "unified" application and monitoring program.

The new application/monitoring process went into effect in the Spring of 1992. Accordingly, the Aquaculture Coordinator at the Maine Department of Marine Resources is the focal point for submission of all application and monitoring information. The Aquaculture Coordinator then assumes responsibility for disseminating relevant information to the other state and federal agencies involved.

The Aquaculture Monitoring Program consisted of eight parts:

- Monthly confidential production reporting by lease-holders,
- Semi-monthly dissolved oxygen monitoring in July, August and September,
- Annual dissolved oxygen water column profiles in August,
- Spring and Fall video recordings of the bottom beneath and adjacent to the cages,
- Biennial Fall sediment reduction-oxidation (redox) discontinuity (RPD) layer depth determinations,
- Biennial Fall total organic carbon content analyses of the bottom surface layer,
- Biennial Fall sediment grain size analyses, or granulometry, and
- Biennial Fall benthic macrofauna community analyses.

This report presents summaries and analyses of the currently available video and benthic monitoring results developed since the program was initiated in the Spring of 1992. This includes four Spring video surveys, four Fall video surveys and three years of completed benthic monitoring surveys. Also included are the results of the "Recovery" project conducted at Connors Aquaculture's Broad cove site from 1993 through 1994 and analyses of the collected data which have been used to modify the monitoring program. For ease of presentation this report is separated into sections dealing with each specific component of the monitoring program.

Briefly, water quality monitoring of dissolved oxygen saturation in 1994 and 1995 show that only slight depression in dissolved oxygen saturation immediately adjacent to cage structure and recovery to ambient levels usally occurs within 100 meters. Violations of the Maine Department of Environmental Protection's 85% dissolved oxygen standard occur very infrequently and only in immediate proximity to cages. The conclusion, therefore, is that dissolved oxygen depression or depletion associated with cage culture operations is not a major environmental concern in Maine.

Video monitoring remains an effective and relatively inexpensive means of quickly assessing short-term affects at cage sites. Recent improvements in filming and presentation of results should enhance the usefulness of this assessment tool.

Analyses of individual benthic parametric results show only weak relationships between the parameter results and distance or proximity to cage. Analyses of inter-parametric results similarly show little relationship between parameters. The lack of clear relationships points out the complexity of the interaction between cage operations and the surrounding environment and supports the previous suggestion that husbandry practices profoundly affect the degree of environmental impact and that site-by-site review is the appropriate approach to both monitoring and management.

Comparisons of results from sites where two sampling rounds have been completed for the years 1992 and 1994 indicate that the environmental affects of cage sulture operations have remained stable or, in certain cases even improved, during the period. Production during the same period, however, also remained stable or declined. Comparison of the 1993 and 1995 monitoring results should yield considerable information in view of the surge in production which occurred in 1995.

Results of a study on the length of time required for previously degraded bottoms to recover indicate that substantial recovery occurs in as short a time as 18 months. Dragging of the study area as part of commercial fishing activity may have contributed to the rapid recovery, suggesting dragging as a possible mitigation measure on bottoms affected by culture operations.

Additional efforts on improving the effectiveness and efficiency of the monitoring program have resulted in significant cost reductions for specific benthic analyses.

In summary, since the Finfish Aquaculture Monitoring Program began in the Spring of 1992, environmental degradation resulting from finfish culture operations, as measured by water quality and benthic monitoring, has remained stable or improved at most sites. During this period at least three sites have been identified where degradation caused sufficient concern to require mitigation. In each of these cases mitigation measures were implemented voluntarily by the operators, avoiding severe degradation of the sites.

Based on all of the results to-date, it seems reasonable to conclude that the Finfish Aquaculture Monitoring Program is effectively safe-guarding against excessive environmental degradation as a result of finfish aquaculture operations and that, in the vast majority of cases, the finfish aquaculture industry is acting responsibly in the management of their operations.

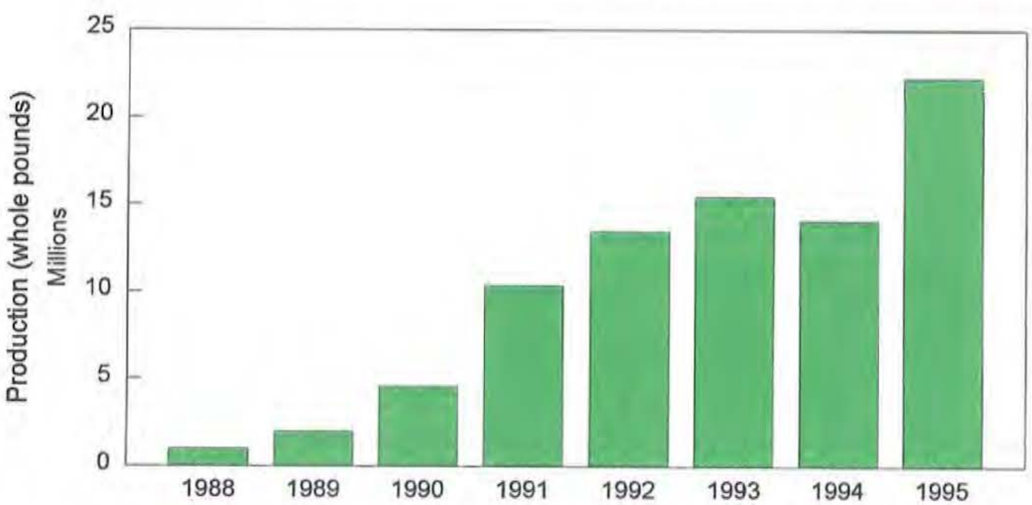
1. Introduction

This report briefly summarizes the results of the first four years of the semiannual aquaculture underwater video monitoring and the first three years of benthic sediment and macrofauna analyses. Analysis of the fourth year, Fall 1995, benthic sampling is currently in progress. This report also includes the conclusions developed from these results, some of which have been used to modify the program.

2. Background

Farm production of Atlantic salmon, *Salmo salar,* began in Maine in the early to mid 70's at a single site in Blue Hill. After several years of trials, however, the site was eventually abandoned. Another site was established in 1983, but production remained low and development of the finfish culture industry remained static through 1985. In 1986 a second site was added, tripling the number of cages in operation, and rainbow trout, *Onchorynchus mykiss*, was added as a cultured species.. Production reached the 1 million pound level in 1988 and continued to double annually through 1991. In 1992 and 1993 production increased slowly, and even declined in 1994. However, in 1995 production surged by 8 million pounds and total whole fish production exceeded 22 million pounds (Figure 2.1.).

Figure 2.1.
Maine finfish aquaculture production 1988-95



As reported in the *Preliminary Report on the Maine Department of Marine Resource's Finfish Aquaculture Monitoring Program (FAMP)*, (Heinig, MER Assessment Corp., 1994), hereafter refered to as the *Preliminary Report*, prior to 1988, the site application process was cumbersome and few, if any, monitoring requirements were placed on finfish growers. Beginning in 1988 certain growers were required to provide various monitoring results to several different agencies, including the U.S. Environmental Protection Agency (EPA), Army Corps of Engineers (ACOE), and the Maine Department of Environmental Protection (DEP), but the monitoring requirements were poorly coordinated and differed from site to site. The rapid growth of the industry during the 1987-1989 period caused some to question the adequacy of the application and monitoring processes. In response to this, legislation was submitted in 1990 to address these concerns. As written, however, the bill called for such stringent monitoring requirements that, had it passed in its original form, the industry would have been crippled. After extensive study on the part of the legislature and considerable public input, a compromise was struck in 1991 which resulted in Public Law 381 and what is now termed the "unified" application and monitoring program.

The new application/monitoring process went into effect in the Spring of 1992. Accordingly, the Aquaculture Coordinator at the Maine Department of Marine Resources is the focal point for submission of all application and monitoring information. The Aquaculture Coordinator then assumes responsibility for disseminating relevant information to the other state and federal agencies involved.

The Finfish Aquaculture Monitoring Program (FAMP) focuses on benthic impacts and includes video recording of the bottom beneath and adjacent to the cages, sediment analyses for redox discontinuity layer depth, total organic carbon content of the bottom surface layer, sediment granulometry, and benthic macrofauna community analysis. Video recordings are conducted semi-annually in the Spring and Fall while benthic analyses are carried out biennially on a rotating basis so that each site is sampled every other year. The program also includes dissolved oxygen monitoring through water column profiles conducted in September of each year. The original oxygen monitoring procedure was modified in 1994 and the modifications and monitoring results are discussed here. The monthly production reporting by lease holders, as confidential information, is compiled and analyzed separately and is consequently not discussed here.

3. Program Review

The following is a detailed description of each of the monitoring program's environmental assessment components with a summary of the results obtained to-date. A copy of the Finfish Aquaculture Monitoring Program (FAMP) guidelines is included as Appendix I. Due to the volume of data collected over the past four-year period, only summaries of the data are presented here to support the conclusions pertaining to the relevance of the components to the program and recommended modifications to the overall program.

3.1. Water Quality Survey

The original dissolved oxygen monitoring requirements of the Finfish Aquaculture Monitoring Program specified that dissolved oxygen was to be analyzed by the individual operators of each aquaculture site every two weeks between July 1 and September 30 of each year. In addition, an annual dissolved oxygen profile was to be done at three specified locations around each site during the month of August using the same techniques used for the semi-monthly analyses. The semi-monthly monitoring was intended to evaluate short-term affects on dissolved oxygen while the annual profiling during the month of anticipated peak production was intended to describe the broader, longer-term water column affects.

Data collected during 1992, the first year of the program's implementation, was both sporadic and of questionable quality. Compliance with the program requirements improved in 1993 as did the quality of the data. Analysis of the results from individual sites showed that, in general, affects on dissolved oxygen were negligible. However, due to the large numbers of individuals collecting the information and the differences in techniques employed at different sites, the data was of limited value in comparing results between sites.

In view of the high variability of results and the consequent inability to compare data between sites, the DMR chose to adopt a standard protocol and incorporate dissolved oxygen profiling into the scope of work of the Fall portion of the 1994-95 FAMP and again for the Fall portion of the 1995-96 FAMP. These modifications to the Program have allowed the DMR to achieved two objectives: 1) the standardization of the sampling protocols, and 2) standardization of field procedures and observations by having a single entity apply the protocol at all sites.

3.1.1. Sampling Protocol

According to the FAMP, dissolved oxygen profiles are to be taken at three specific distances from the finfish cage structures: 1) at 100 meters, or ~300 feet, upcurrent of the structure, 2) within 5 meters, or ~15 feet, downcurrent of the structure, and 3) 100 meters, or ~300 feet downcurrent of the structure.

All sampling is carried out using the Maine Department of Marine Resources' Sea-Bird Electronics, Inc. model SBE 19 SEACAT Profiler, Serial No. SBE 192369-254. The SBE 19 is equipped with a pump, a Senso-Metrics Sp 91FFS pressure sensor (S/N 8M187), a temperature-conductivity sensor (S/N 254), a Beckman dissolved oxygen sensor (S/N 0-10-13), and an Innovative pH sensor.

3.1.2. Results

The detailed, site-by-site results of the 1994 and 1995 dissolved oxygen profiling are presented in *Maine Department of Marine Resources 1994-95 Finfish Aquaculture Monitoring Program, Task III. Annual Fall 1994 Water Quality Survey,* (MER Assessment Corp., 1994) and *Maine Department of Marine Resources 1995-96 Finfish Aquaculture Monitoring Program, Task III. Annual Fall 1995 Water Quality Survey,* (Heinig, MER Assessment Corp., 1995)

Dissolved oxygen concentrations in the vicinity of finfish culture operations in Maine in September 1994 ranged, for the most part, (~96%), from slightly super-saturated to slightly below full saturation, with a small percentage, (~4%), falling below the Department of Environmental Protection's 85% saturation standard. Table 3.1., below, summarizes the dissolved oxygen saturation results of the 1994 profiling.

Table 3.1.
Categorization of 1994 dissolved oxygen saturation minima

No. of Stations	D.O. Saturation	Percent of Total
211	95-100%	86.8
18	90-94%	7.4
5	85-89%	2.1
6	80-84%	2.5
3	<80%	1.2
243		**100.0**

Dissolved oxygen concentrations in the vicinity of finfish culture operations, as well as at ambient control stations, in Maine in 1995 were generally below full saturation and consistently lower than those obtained in the study conducted in 1994. Table 3.2., below, summarizes the dissolved oxygen saturation results of the 1995 profiling:

Table 3.2.
Categorization of 1995 dissolved oxygen saturation minima

No. of Stations	D.O. Saturation	Percent of Total
6	95-100%	2.0
98	90-94%	33.1
173	85-89%	58.5
17	80-84%	5.7
2	<80%	0.7
296		**100.0**

Despite the generally lower saturations observed in 1995, these results show that the vast majority of sites (~94%), represented by 277 of the 296 samples, meet or exceed the current Maine Department of Environmental Protection's minimum standard of 85% dissolved oxygen saturation for Class SB waters.

As already stated, the dissolved oxygen saturations observed both upcurrent and downcurrent of cage systems in 1995 were considerably lower than those observed during the 1994 sampling. Interestingly, low dissolved oxygen saturations were observed elsewhere along the Maine coast during the Fall of 1995 (Kelley and Libby, 1996). Given the annual variations in ambient dissolved oxygen concentrations, another approach to determining the affect of cage culture operations on ambient dissolved oxygen levels is to compare upcurrent and downcurrent values at individual sites and to calculate the amount of oxygen saturation depression that occurs from one side to the other. Table 3.3. and 3.4. on the following pages show comparisons of the mean D.O. saturation minima observed at the three distances from each of the cage systems at each of the active sites in 1994 and 1995, respectively. Results of the samplings at the Control stations are not included in the mean, maximum, or minimum calculations, but are shown at the bottom of each Table as references

Table 3.3.
Comparison of the mean D.O. saturation minima observed at the three distances from the cage systems at each of the active sites in 1994

Site	100m UP*	5m DN*	100m DN*	Diff. 100U-5D	Diff. 100U-100D
ECFF SB	106.0	103.5	104.0	2.5	2.0
BPFI BE	103.0	100.3	100.0	2.7	3.0
NESC GN	104.0	102.5	101.5	1.5	2.5
HANK CL	103.0	100.0	99.5	3.0	3.5
HARS JK	96.5	95.7	99.0	0.8	-2.5
AAQF JK2 1	99.5	99.0	99.3	0.5	0.2
NBFI JC	99.5	100.0	99.5	-0.5	0.0
ISSI PC	98.5	99.3	99.5	-0.8	-1.0
TIFI TW	100.0	95.3	98.3	4.7	1.7
CONA DC	102.5	96.8	98.0	5.7	4.5
MESI SH	104.5	98.0	99.0	6.5	5.5
CONA BC	100.3	93.9	99.8	6.4	0.5
CONA CP	103.0	97.0	98.5	6.0	4.5
RISC RN	101.3	97.8	97.8	3.5	3.5
ECFF TE	99.5	84.0	96.0	15.5	3.5
SFML JB3	97.3	85.0	95.5	12.3	1.8
STEV LU	98.5	98.5	99.0	0.0	-0.5
ASMI II Steel	101.0	97.0	103.0	4.0	-2.0
ASMI II Polar	108.0	105.0	106.0	3.0	2.0
ASMI LI	107.0	103.5	103.0	3.5	4.0
RLLT SI	102.0	99.0	102.0	3.0	0.0
IACO TC	102.5	100.0	105.5	2.5	-3.0
TISF HI	105.2	104.0	104.5	1.2	0.7
ASMI CI	105.0	97.1	99.0	7.9	6.0
MCNC CH	93.0	86.5	92.5	6.5	0.5
MCNB HC	104.0	82.0	100.0	22.0	4.0
Mean	**101.7**	**97.0**	**100.0**	**4.8**	**1.7**
Max	**108.0**	**105.0**	**106.0**	**22.0**	**6.0**
Min	**93.0**	**82.0**	**92.5**	**-0.8**	**-3.0**
CONTROL 1	99.5	-----	-----	-----	-----
CONTROL 2	101.5	-----	-----	-----	-----
CONTROL 3	101.0	-----	-----	-----	-----

*Where more than one value is available for a sampling distance, all values are averaged to provide an overall value for each distance.

Table 3.4.
Comparison of the mean D.O. saturation minima observed at the three distances from the cage systems at each of the active sites in 1995

Site	100m UP*	5m DN*	100m DN*	Diff. 100U-5D	Diff. 100U-100D
CONA SB	88.0	85.7	87.0	2.3	1.0
BPFI BE	89.3	87.8	88.5	1.5	0.8
DESC GN	89.0	87.0	86.0	2.0	3.0
HANK CL	87.0	88.5	89.0	-1.5	-2.0
TIFI CC	89.5	88.0	88.0	1.5	1.5
HARS JK	92.0	89.5	91.5	2.5	0.5
AAQF JK2 1	88.0	88.0	86.0	0.0	2.0
AAQF JK2 2	89.5	88.0	88.0	1.5	1.5
MAFI PC	89.0	88.0	88.5	1.0	0.5
TIFI TW	88.0	85.5	88.3	2.5	-0.3
CONA DC	92.0	87.3	89.8	4.7	2.2
MESI SH	87.5	86.0	88.5	1.5	-1.0
CONA BC	88.3	85.2	88.0	3.1	0.3
CONA CP	92.0	88.0	91.0	4.0	1.0
SFML RN	89.0	84.8	87.5	4.3	1.5
ECFF TE	90.0	85.5	88.5	4.5	1.5
SFML JB3	92.5	87.5	92.5	5.0	0.0
STEV LU	90.0	90.5	91.0	-0.5	-1.0
ASMI II Steel	94.0	92.0	89.5	2.0	4.5
ASMI II Polar	92.5	87.5	89.5	5.0	3.0
MCNI CW	92.0	90.0	89.0	2.0	3.0
ASMI LI	89.0	87.5	89.0	1.5	0.0
RLLT SI	94.0	91.0	90.0	3.0	4.0
ASMI FI	91.5	89.0	89.5	2.5	2.0
IACO HS	92.5	84.0	92.0	8.5	0.5
IACO TC	90.5	84.5	90.5	6.0	0.0
TISF HI	91.0	86.8	90.0	4.2	1.0
ASMI CI	91.3	84.6	86.5	6.7	4.8
MCNC CN	88.0	88.0	89.5	0.0	-1.5
MCNC CH	84.0	85.5	87.5	-1.5	-3.5
Mean	**90.0**	**87.4**	**89.0**	**2.7**	**1.0**
Max	**94.0**	**92.0**	**92.5**	**8.5**	**4.8**
Min	**84.0**	**84.0**	**86.0**	**-1.5**	**-3.5**
CONTROL 1	88.0	----	----	----	----
CONTROL 2	87.0	----	----	----	----

*Where more than one value is available for a sampling distance, all values are averaged to provide an overall value for each distance.

It is important to note that, in each year, profile oxygen saturation minima below 85% were observed almost exclusively within 5m of the cage systems, either at pen-net depth or close to the bottom. The mean difference between the 100m upcurrent saturation minima and the 5m downcurrent saturation minima across all sites is shown to be 4.8 and 2.7 percentage points in 1994 and 1995, respectively. The mean difference between the 100m upcurrent and 100m downcurrent saturation minima is only 1.7 and 1.0 percentage point in 1994 and 1995, respectively. In 1994 the upper and lower values for the differences for the 100m upcurrent versus 5m downcurrent and 100m upcurrent versus 100m downcurrent range from 22.0 to -0.8 and 6.0 to -3.0, respectively. In 1995 the upper and lower values for the differences for the 100m upcurrent versus 5m downcurrent and 100m upcurrent versus 100m downcurrent range from 8.5 to -1.5 and 4.8 to -3.5, respectively. The negative values for the lower end of the range indicate that, on occasion, the saturation minima at the downcurrent stations is higher than at the upcurrent stations. Although this may initially appear to be contradictory, downcurrent stations are occasionally affected by mixing of adjacent non-pen-affected waters, thus increasing the dissolved oxygen concentrations.

The data from both years of sampling show that dissolved oxygen concentration recovery occurs rapidly within a relatively short distance of the cage structures. In all cases, D.O. saturation 100 meters downcurrent of the cage structures is the same or only slightly below upcurrent values, even in cases where D.O. depression adjacent to the cage structure is significant.

All of these results suggest that depression (hypoxia) or depletion (anoxia) of dissolved oxygen *within the water column* as a result of cage culture operations is not a major environmental concern in Maine waters. This conclusion, however, must not be confused with depression or depletion of benthic sediment oxygen, both of which are frequently observed immediately beneath cage systems. Further, maintaining elevated dissolved oxygen concentrations in ambient waters, particularly bottom waters, may have a profound influence on the degree of impact an operation can have on the benthic environment immediately beneath and adjacent to the cage system(s).

3.2. Video Monitoring

Video monitoring is carried out semi-annually in the Spring and Fall of each year. The purpose of the underwater video recording is to provide those unable to dive beneath the cages with visual images of conditions adjacent to and beneath cages systems, as well as provide an objective, rapid, albeit superficial, means of documenting and evaluating changes in conditions beneath and adjacent to cage systems. This component of the monitoring program represents an instantaneous representation of shorter-term effects and changes.

3.2.1. Procedure

Transect lines, consisting of 60 meter (~200 ft) ropes, are marked in 10m alternating black and white sections, with the exception of the first and last 10m which are marked as two 5m sections, the last five of which are marked in alternating 1m black and white increments. One 60m transect line is deployed at each end of the cage system to allow measurement of distance from the cage edge along the bottom. The line is weighted at each end with yellow window weights to provide highly visible starting and ending points. The line is deployed by allowing one end-weight to drop to the bottom immediately adjacent to the cage edge. The remaining line is payed out from a boat running parallel to the predominant current direction until the line becomes taught, at which point the end-weight is allowed to drop to the bottom.

The diver survey and video recording are begun 60m from the cage(s) on the upcurrent side allowing the diver to flow with the current. Once the diver reaches the end of the transect line at the pen edge the survey continues either adjacent to or directly beneath the cage(s) until the second transect line is found at the opposite end of the system where the survey continues along the transect line to a distance 60m downcurrent of the cage(s). The video recording is taken with an underwater video camera package. Where necessary, additional lighting is provided by a 50 watt video light. The video recording is started at the end-weight and runs continuously throughout the dive, with the exception of certain instances when the diver becomes disoriented and considerable time is required to relocate the transect lines. In such cases the camera is turned off to conserve video tape and ensure sufficient tape for completion of pertinent video recording of the bottom.

3.3.2. Results

As noted in the previous *Preliminary Report*, video recording has proven to be a relatively inexpensive and rapid, yet highly effective means of documenting and visually representing conditions beneath and adjacent to cage systems. It is, however, subject to individual interpretation and proper interpretation requires experience as well as some familiarity with the specific sites filmed.

Several recommendations to improve the quality of video recordings were outlined in the January, 1994 *Preliminary Report*. Based on these recommendations filming is now carried out using artificial light throughout the entire dive instead of solely beneath the cage systems. Further, single light sources are used on the approach to and departure from the cage systems, but dual lights are used during filming beneath the cages. This change has not significantly increased the resolution of the film, but has increased the spatial coverage during filming by increasing the illuminated area.

The most significant and important change that has taken place in the video survey is the way in which results are presented. Initially, the video survey reporting format required the development of a narrative to accompany each video. As brief text summaries of the visual images, these narratives were intended primarily to assist inexperienced viewers in properly identifying organisms and objects while the videos were being watched. However, without the video image the usefulness of the narrative was very limited. Furthermore, a review of previously recorded information required either a replay of the video itself or a recollection of the video images while reviewing the narrative.

Beginning in the Spring of 1995, the video narratives were replaced by graphic representations of key video observations recorded along the transects. These graphics allow the presentation of considerable information in a clear and concise way. First, the location and direction of dive transects are clearly defined. Second, times taken from the time stamp on the video recording are used as time-distance markers along the dive path. Third, although it is difficult to precisely identify a specific image with a specific location along the transect, these locations can be estimated based on the video tape time stamp and the diver's estimated swim rate. Fourth, particularly important observations, such as gassing, nets on bottom, etc., can be highlighted, thus immediately focussing attention on the most critical observations.

Individual iconic symbols have been developed using CorelDRAW 3® graphic software to represent the most commonly observed organisms, benthic conditions, and pen operation-related debris. Figure 3.3. shows the legend developed to assist the reader in identifying the individual iconic symbols. Figures 3.4. and 3.5. show example graphic representations of the Spring 1995 and Fall 1995 dives along one of the cage systems in Cobscook Bay. This side-by-side presentation of sequential video graphic representations demonstrates the ease with which comparisons can be made between current and previous observations.

CorelDRAW 3® Is a registered trademark of Corel Corporation.

Figure 3.3.
Legend of video graphic representation iconic symbols

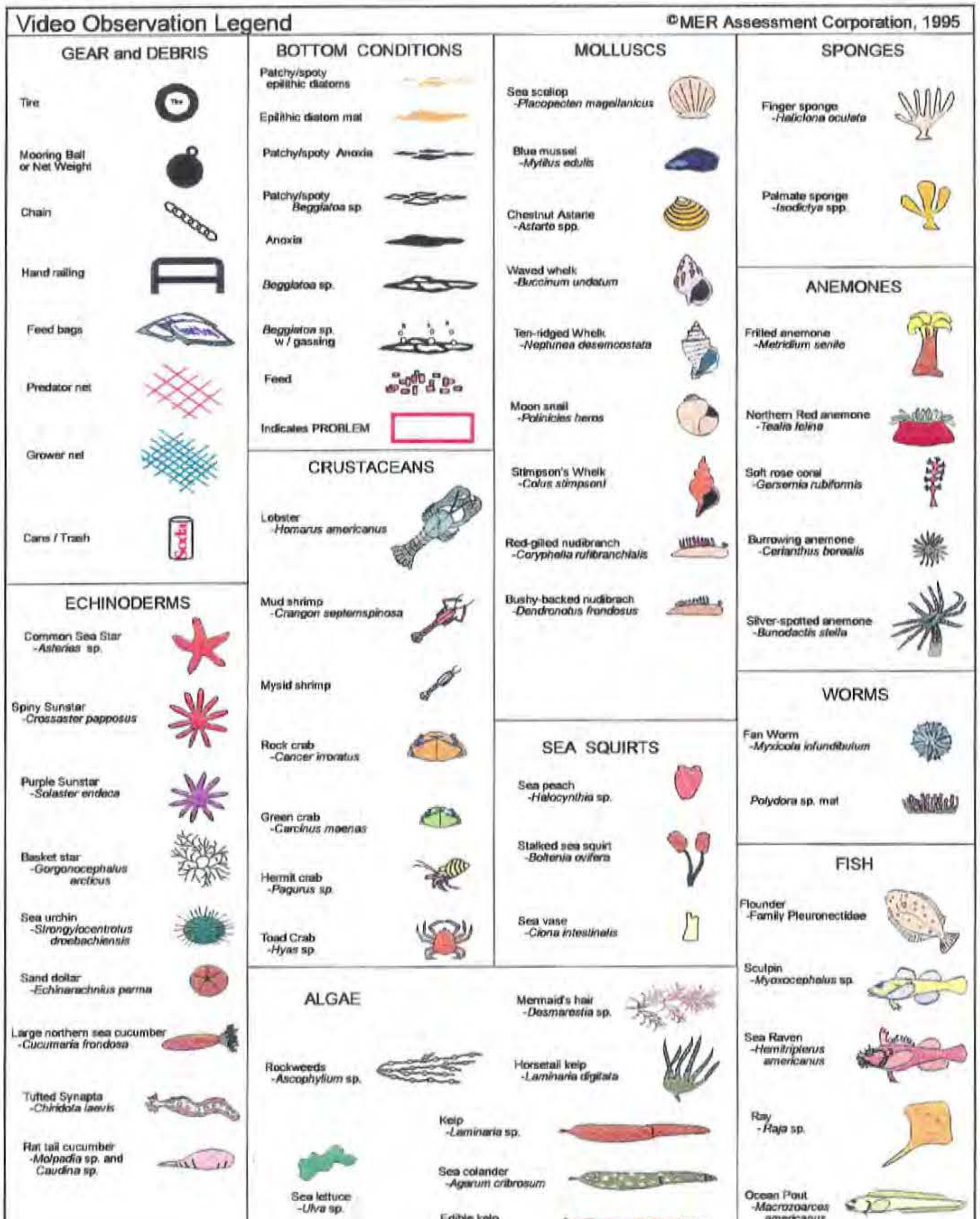


Figure 3.4.
Example graphic representation of video observations at a RISC RN, Cobscook Bay site in Spring 1995

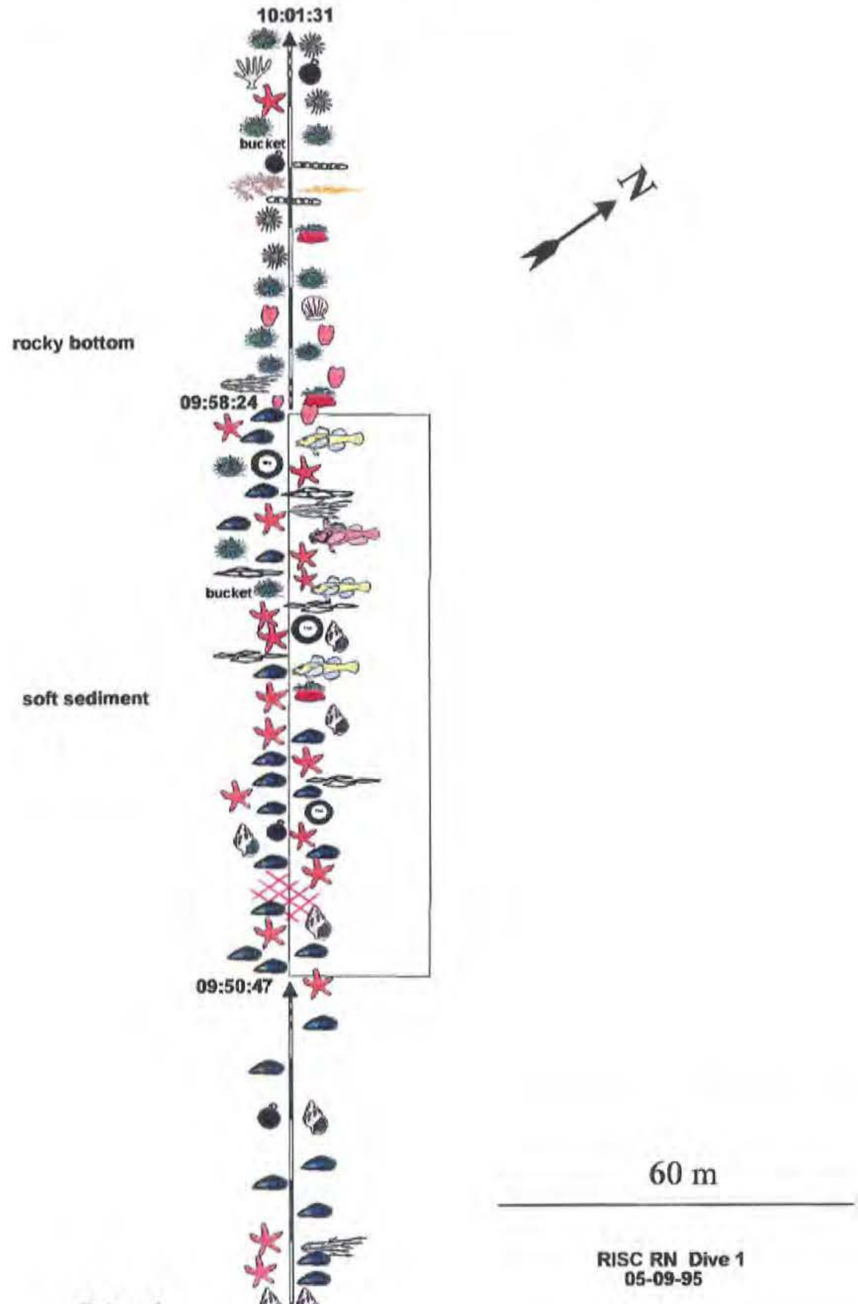
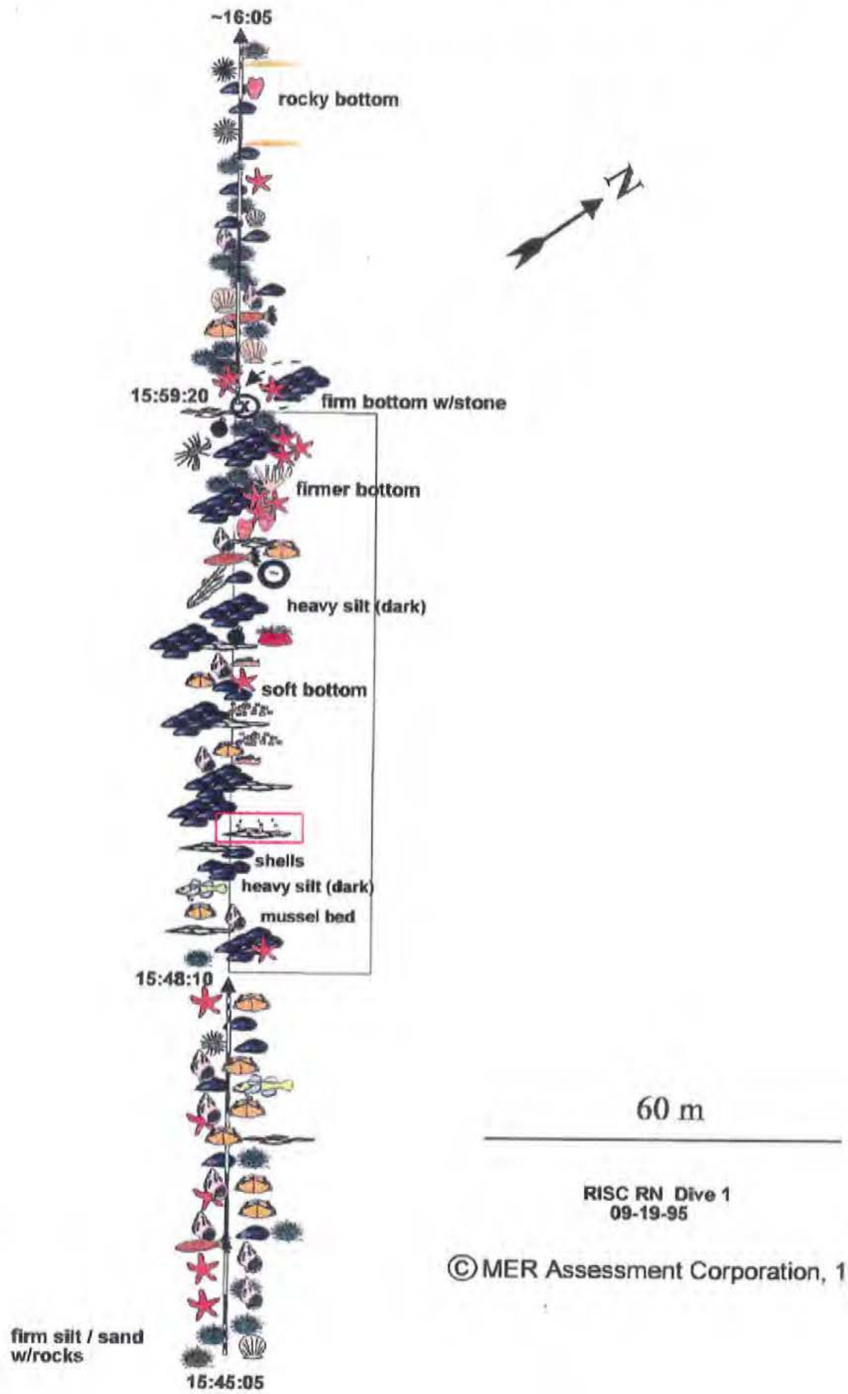


Figure 3.5.
Example graphic representation of video observations at the same RISC RN, Cobscook Bay site in Fall 1995



Since video recording of sites began in Spring 1992 changes in the conditions beneath and adjacent to cage systems have ranged from increased deterioration to significant improvement. In general, there has been a net improvement in conditions beneath and adjacent to cage systems in Maine. This trend toward improvement may be attributable to several factors, but the two most important are probably the shift from moist feed to dry feed and the increased intensity and duration of dragging activity associated with the scallop and urchin fisheries in the vicinity of cage systems, particularly in the Cobscook Bay area.

The increased structural integrity of the dry feed pellets appears to have reduced the amount of non-intercepted feed reaching the bottom, thus reducing the carbon load to the bottom. As will be discussed later, this suggestion appears to be further supported by the benthic infauna analyses. The increased dragging activity in the vicinity of the cages acts to resuspend, and consequently dissipate, any organic material accumulating on the bottom and, in certain areas, may enhance oxygen penetration into the sediment.

Although the general trend is towards improvement in benthic conditions, some observations indicate significant changes, some of which clearly indicate deterioration. The most obvious of these is the increased number of both predator and grower nets found beneath cage systems. In some cases the nets are associated with numerous cage parts and are the result of a catastrophic event which resulted in the destruction of a cage system. The shoreward system at HANK CL, Cooper's Ledge, Lubec is an example. At other sites, however, the nets appear to have been dropped to the bottom to remove fouling organisms. The temporary lowering of nets to the bottom for "biological" cleaning is a common practice, but in some cases, repeated dives have identified nets in the same location indicating that nets are being left on bottom for prolonged periods of time. Further, mussels, *Mytilus edulis*, fouling these nets have migrated to the surface of the net and begun to thrive on the bottom rather than being preyed upon, thus significantly altering the benthic community beneath the cage systems. Whether the replacement of a polychaete-based infaunal community by an epibenthic bivalve-based community is beneficial or detrimental may be debatable, but there is no doubt that it represents a significant change.

At certain sites, repeated dives over time indicate an expansion of the affected zone beyond the immediate vicinity of the cage system, evidenced principally by the increased frequency and size of bacterial-mold, *Beggiatoa* sp., spots or mats at increasing distance from the cage systems. This expansion of affect is seen primarily at sites supporting intensively-operated, multiple cage systems such as at Broad Cove, Eastport and Cross Island, Cutler, suggesting a cumulative affect. However, similar expansions has been observed at smaller sites where slow current velocities predominate.

3.3. Benthic Monitoring

Benthic monitoring is carried out adjacent, beneath, and on occasion, at some distance from, each cage system once every other year. The purpose of the benthic monitoring is to detect and document any changes which take place in the sediment composition and macrofaunal community structure on the sites as a result of the cage system operations. This component of the monitoring program seeks to track the longer-term effects and changes related to cage culture operations.

3.3.1. Procedure

3.3.1.1. Sediments

Single sediment cores for grain size analysis are taken at pre-selected stations around and under the cage systems using 4 in. diameter PVC pipe coring devices. The corers are inserted as far as possible into the bottom, or to full resistance, and the depth of insertion recorded. The contents of the corer is transferred into labeled "Zip-lock" bags for transportation to the analyzing facility. Samples for the determination of the redox discontinuity layer (RPDL) depth, depth of any unconsolidated organic material (UOM), and subsamples for Total Organic Carbon (TOC) analysis are taken with 8 in. long sections of 3/4 in. diameter clear PVC pipe. The RPDL depth and depth of the UOM are measured on-site. Once these are measured the top 2-3 cm of sediment are collected for TOC analysis and placed into plastic sample bottles. Upon return to shore these samples are placed in a standard freezer and maintained frozen until delivery to the analyzing facility. The TOC analysis is carried out according to the methods of Hedges and Stern (1984). Granulometry is carried out according to the washed sieve method.

3.3.1.2. Macrofauna

Single sediment cores for benthic macrofauna analysis are taken at pre-selected stations around and under the cage systems using 4 in. diameter PVC pipe coring devices. These are inserted to approximately the same depth as the cores for grain size analysis. Prior to the Fall of 1995, the contents of the cores was washed through a U.S. Standard No. 35 sieve (500μ mesh). Beginning with the sampling in the Fall of 1995, cores are now sieved on a U.S. Standard No. 50 sieve (1.0 mm mesh). All material retained on the screen is transferred into sample containers, and the containers filled with 10% buffered formalin. Several drops of a 1% Rose Bengal staining solution are added to each sample to assist in highlighting the organisms for sorting. After 5 days of fixing in 10% Formalin, the formalin solution is decanted from the sample containers through a 500μ mesh sieve and the formalin volume replaced with 70% ethanol to insure preservation of the organisms' integrity, particularly the bivalves and other calcareous forms.

3.3.2. Results

A detailed summary of the Fall 1992 and Fall 1993 benthic monitoring results are presented in *Maine Department of Marine Resources Fall 1992 and Fall 1993 Finfish Aquaculture Monitoring Survey: Benthic Infauna and Sediment Data Summary*, (Heinig, MER Assessment Corporation, 1995). Results of the 1994 benthic monitoring have been reported on an individual site basis. Once the 1995 benthic monitoring results are available, these will be reported along with the 1994 results in a format similar to the 1992-93 results.

For the purposes of this report, three approaches have been taken in analyzing the compiled data: 1) individual parametric; 2) inter-parametric; and 3) site-by-site approach. The individual and inter-parametric approaches focuses on individual parameters and the relationship between them. The site-by-site approach focuses on changes which have occurred in these parameters over time for those sites where two sampling cycles have been completed, i.e. 1992 and 1994.

3.3.2.1. Individual Parametric Approach

Sediments

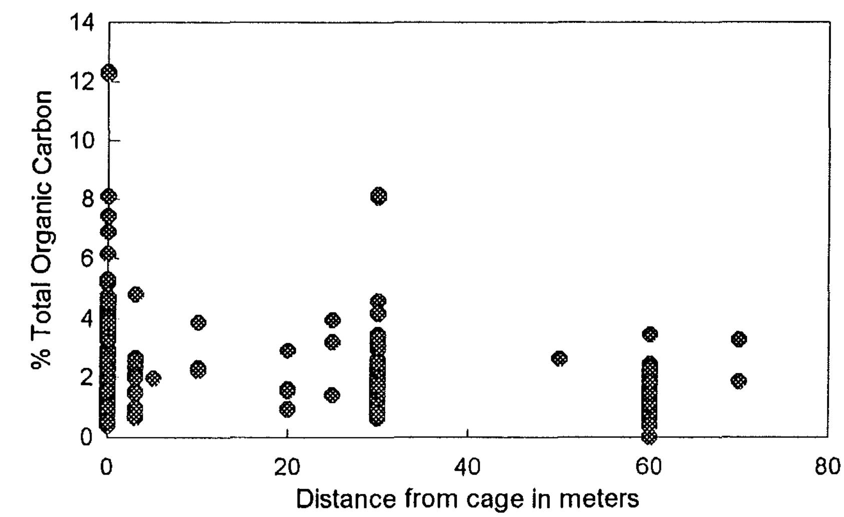
All of the parameters reviewed as part of the benthic sediment monitoring are reported quantitatively, however two are less clearly defined and are subject to interpretation.

As reported in the *Preliminary Report*, the **unconsolidated layer** usually appears as a loosely compacted to flocculent layer on the surface of an otherwise relatively compacted sediment core. The depth of the unconsolidated organic material layer is usually difficult to establish because there is rarely a discrete line of demarcation between the unconsolidated and consolidated portions of the sediment cores. Further, it is often difficult to distinguish between an unconsolidated layer of organic material and very fine, loosely compacted silt. As a rule, the depth of this loosely compacted layer is deeper directly beneath the cages than at a distance from the cages. Nevertheless, the difference between the "ambient" condition and "affected" condition is usually slight, and in many cases, undetectable.

Similarly, the **reduction-oxidation (redox) discontinuity (RPD) level**, which defines the boundary between oxic, or oxygenated sediments, and the anoxic, or oxygen depleted sediments, is often very difficult to distinguish. This is due in part to streaking of the layers along the inner surface of the corer as well as localized variations in the RPD level within the core. This difficulty, however, is limited to the areas of "limited" affect; where significant affect is encountered, i.e. directly beneath the cages, a clear RPD layer is usually definable, and where little or no affect is encountered, the entire core is oxic and no RPD level is seen.

Total organic carbon (**TOC**) analysis measures the amount of carbon present in the sediment originating from organic rather than inorganic sources. Since cage culture operations add significant amounts of organic carbon in the form of fish feed, it was initially expected that the TOC values beneath and adjacent to the cages would be significantly higher than those found some distance from the cages, representing ambient conditions. However, as Figure 3.6 below shows, the combined results from three rounds of sampling show no clear trend towards elevated TOC content at near-cage stations.

Figure 3.6.
%Total organic carbon (TOC) in sediments at various distances from cage systems from 186 samples taken from 1992-94



As previously suggested, this is probably due to the varying carbon sources found at different distances from the cages. For example, directly beneath the cages waste feed, feces, and bacteria contribute to the total carbon. At several meters from the cage, polychaetes may account for the majority of the carbon, while at a considerable distance from the cage, epilithic (bottom-covering) diatom mats may account for most of the carbon. While the source of the carbon may change from one sampling location to another, the total amount of carbon found may vary only slightly, making interpretation of the results rather difficult. In addition, although measures are taken to eliminate them, carbonate-rich sediments can result in high TOC levels, thus confounding the interpretation of results.

Granulometric analyses are carried out for two reasons: 1) to determine changes which might occur in bottom sediments as a result of changes in deposition rates associated with the cages and 2) to correlate levels of impact with sediment types. Analyses have now been completed on samples taken in 1992 through 1994. Analysis of samples taken in 1995 are currently nearing completion.

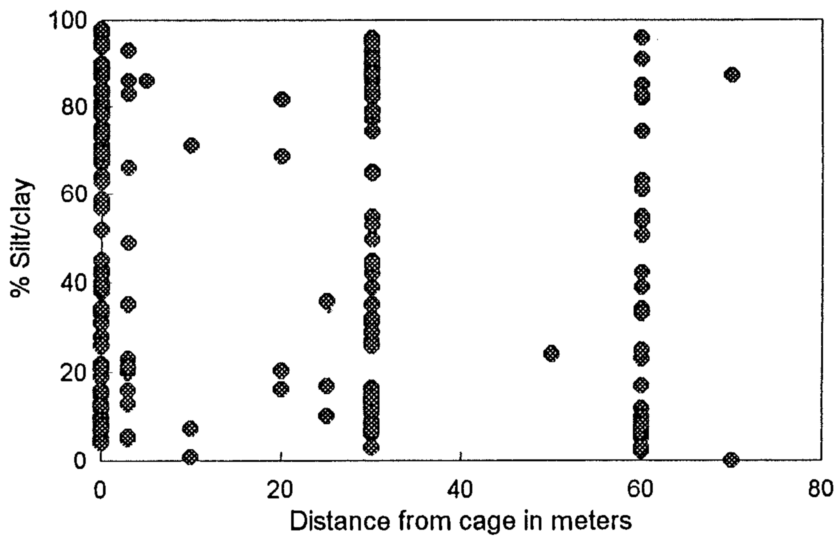
Few difficulties have been encountered with this method, but the treatment of "non-representative" materials in the sediment samples has raised questions on several occasions. Non-representative materials refers to materials which are oddities in sediment of otherwise similar composition. An example is where two or three moderate-sized rocks or shells are found in an otherwise silty sediment sample. Since the granulometry results are reported as dry weight fractions of the total sediment weight (percent), the rocks or shells can cause a bias towards coarseness despite their originating from a muddy, silty bottom.

To avoid these anomalies, non-representative material is removed from the sample and weighed separately. These weights are not reported as part of the sample, but are instead reported separately to allow their inclusion, if necessary.

The washed sieve method for granulometry yields results in up to 15 different size categories. To facilitate comparisons between sediment types and other parameters, the granulometry results have been reduced to percent composition as gravel, sand, fine sand, and silt/clay. These percentages are more readily compared to other sediment parameters and indicators of environmental quality to determine if any trends can be established. The relationship between sediment composition and environmental quality is discussed further in Section 3.3.2.2.

A major concern associated with cage culture operations is the eventual accumulation of organic material immediately beneath the cages. If this were to hold true for Maine cage culture operations, the percentage of fine sediments immediately beneath cages would be expected to be higher than the surrounding area, particularly in areas of predominantly coarse sediments such as those of Cobscook Bay. Figure 3.7. shows the percent of sediments falling into the silt/clay range from 186 samples taken at various distances from cages around the State. Although the frequency of silt/clay sediments is slightly higher in the immediate vicinity of cages, there is, again, no clear trend towards softer sediments beneath cages. It is important to note, however, that age of sites is not included in this comparison, therefore some sites now having higher silt/clay components may have initially had considerably coarser grained bottoms.

Figure 3.7.
%Silt/clay composition of sediments at various distances from cage systems from 186 samples taken from 1992-94



To determine if "softening" of the bottom is occurring beneath cages monitoring results need to be compared with pre-development conditions. Pre-development data exist for sites developed after 1992, however, most of the currently monitored sites were developed prior to 1992 and such information is consequently unavailable. As additional data are collected, these comparisons will become possible. It is important to note that changes in sediment composition can profoundly affect the composition of the benthic community by providing new habitat, i.e. increased opportunity for colonization by polychaetes.

Macrofauna

The benthic macrofaunal community analysis is the most time-consuming and expensive part of the monitoring program. In addition to being highly labor-intensive, the identification of the organisms requires specific expertise in taxonomy. Although costly, these analyses yield a great deal of information and provide a clearer understanding of the subtle, yet complex changes which take place beneath the cage systems once the systems are installed and operations begin.

As with the sediment granulometry analyses, the results of the biennial macrofaunal analyses are intended to be compared with pre-development conditions. However, as stated earlier, few opportunities currently exist where such comparisons can be made, since pre-development benthic macrofaunal analyses have only been required as part of the lease application process since 1992.

Several computer spreadsheets have been developed in Lotus 1-2-3 Release 4.01 for Windows® to tabulate all of the data and facilitate comparisons between individual samples as well as between sites. The spreadsheet lists all species found to date in the rows and provides column space for entering the number of individuals of each species found at each station.

The spreadsheets also carry out several calculations to assist in understanding and interpreting these data. The simplest is the summation of *total number of organisms*. This number is converted to *abundance* as number of organisms per $0.1m^2$ by

$$\textbf{\textit{Abundance}} = \textbf{total no. organisms} \bullet \textbf{12.345}$$

where 12.345 is used to convert the surface area of the 4-inch diameter corer to $0.1m^2$.

Species richness is simply the number of species represented in the sample. Species richness serves as an index of diversity indicating either a heterogeneous community where numerous species are represented, or a homogeneous community where only a few species are present.

Relative diversity, also referred to as *evenness*, is an index which relates the number of species represented to the number of individuals of each species. Thus, while a large number of species may be represented, most may be represented by a small number of individuals, while two or three may be represented by the bulk of the individuals found. Consequently, while the species richness may be high, the representation of the species, *relative to one another*, may be far from evenly split. The diversity index *H* used here (Shannon, 1948) is expressed as

$$H = \frac{n \log n - \sum_{i=1}^{k} f_i \log f_i}{n}$$

where n is the total number of organisms in the sample, k is the number of species in the sample, and f_i is the number of individuals in each species i. The theoretical

Lotus 1-2-3 Release 4.01 for Windows is a trademark of Lotus Development Corporation.

maximum diversity is given as

$$H_{max} = \log k$$

and the following proportion can be used to compare the actual and theoretical maximum diversity thus yielding a relative diversity *J*

$$J = H/H_{max}$$

Theoretically, under "normal", unaffected conditions the actual diversity should approach the theoretical maximum diversity and *J* should approach 1. In actuality "normal", unaffected conditions are now difficult, if not impossible, to find. Where environmental degradation favors certain tolerant species the actual diversity can be considerably less than the theoretical maximum and *J* may approach 0. Theoretically then, the smaller *J* becomes, the more affected the environment is assumed to be. As we shall see, however, this is not always necessarily the case.

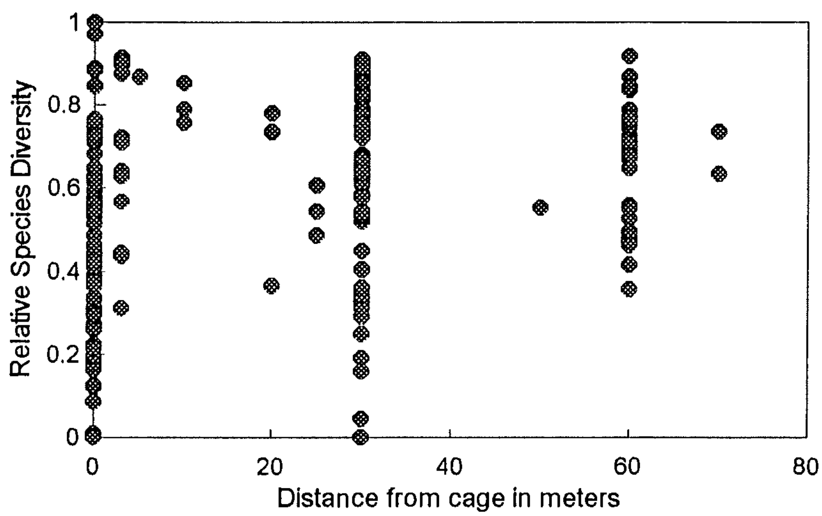
The capitellid polychaete *Capitella capitata* is considered to be highly tolerant of hypoxic, or oxygen depleted, conditions and is therefore considered a good indicator of environmental degradation. A determination of % *C. capitata* therefore allows a comparison of this species' relative abundance from one sample to another and provides some indication of the bottom conditions. Grassle and Grassle (1976) identified six separate "sibling" species of *Capitella* with very similar morphological characteristics. For the purposes of the monitoring program, all morphological forms are reported as *C. capitata*.

Each of these values or indices provides a means of interpreting the mass of numbers generated through the benthic analyses. However, no single value or index taken by itself can be relied upon to reflect the "complete story". For example, consider a case where two samples have similar *J* values of 0.335 and 0.314, and % *C. capitata* of 69% and 79%, respectively, but species richness values of 64 and 10, respectively. On the basis of *J* and % *C. capitata* the two samples may appear rather similar, but the fact that the first sample comes from an area supporting 64 species and the second from conditions supporting only 10 species suggests that the latter represents a more degraded environment that the former.

To avoid relying on either one of these values and better reflect the relationship between relative diversity and species richness we have simply multiplied the relative diversity value *J* by the species richness (**RD*SR**). Thus, the larger the product, the better the environmental condition.

Based on the assumption that benthic impacts should be greater in closer proximity to the cage systems, it would be expected that the macrobenthic indices would indicate increasing impact with decreasing distance from the cages. However, as Figure 3.8. shows, no clear trend can be demonstrated over the 186 samples analyzed, although lowered relative diversity values appear less frequently with increased distance from the cage system.

Figure 3.8.
Relative species diversity at various distances from cage systems from 186 samples taken from 1992-94



Similarly, no clear trend exists between species richness and distance from the cages, as shown in Figure 3.9. Abundance, Figure 3.10, however, does show some tendency to increase with increased proximity to the cage. Although the *mean* number of organisms in proximity to the cages may not be substantially higher than at some distance, the range of organisms supported adjacent to the cages is nearly three-fold the number supported 60+ meters beyond the cages. This is not surprising, since the carbon load to the bottom adjacent to the cages would be expected to be higher than at some distance. The fact that a greater abundance of organisms is or can be supported near the cages may explain the lower than expected TOC values in the immediate vicinity of the cages, since much of the carbon may be converted into biomass which is found below the 2 cm level at which TOC samples are taken.

Figure 3.9.
Species richness at various distances from cage systems from 186 samples taken from 1992-94

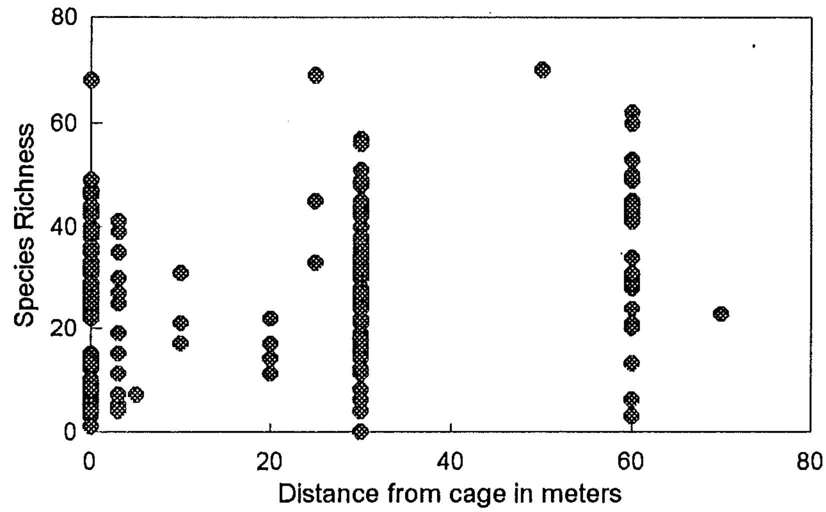
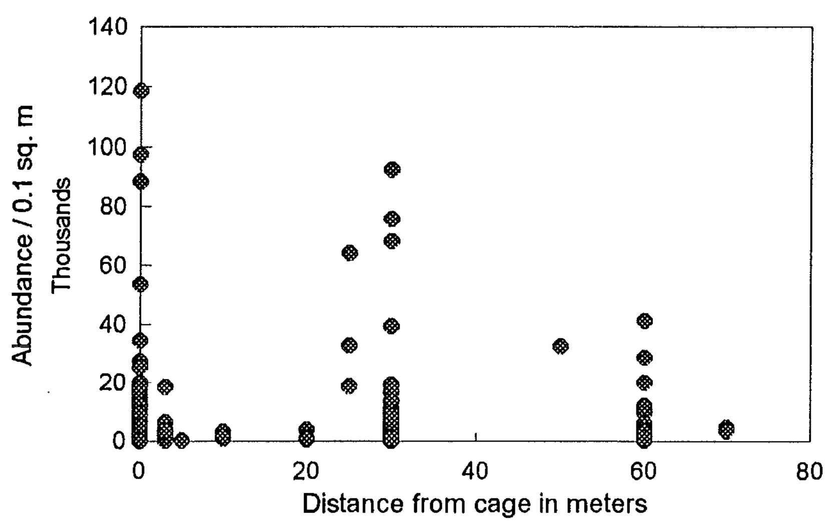


Figure 3.10.
Abundance at various distances from cage systems from 186 samples taken from 1992-94



3.3.2.2. Inter-parametric Approach

An analysis of the interrelationship between each of the key physical and biological parameters was presented in the *Preliminary Report* as a regression R^2 matrix. Based on the limited data available at that time, the relationship was weak between all parameters with the exception of percent *Capitella capitata* and relative diversity. A similar analysis has been performed on data compiled from three years of data collection representing 186 samples. As Table 3.5. below shows, the analysis results of this expanded data set corroborates the earlier findings of weak relationships.

Table 3.5.
Comparative analysis of parameters: Regression R^2 Matrix based on results from 186 samples taken from 1992-94

	RD	% Silt	SR	% Cap.	TOC	RPD
RD		0.02650	0.07780	**0.60988**	0.31170	0.08709
% Silt	0.02650		0.36746	0.01705	0.03678	0.06348
SR	0.07780	0.36746		0.11996	0.05057	0.10646
% Cap.	**0.60988**	0.01705	0.11996		0.26724	0.09534
TOC	0.31170	0.03678	0.05057	0.26724		0.07297
RPD	0.08709	0.06348	0.10646	0.09534	0.07297	

It is interesting to note that the strongest relationship (R2 = 0.60988) continues to be between *Capitella capitata* and relative diversity, although at a weaker level than previously noted. As indicated in the previous report, it is not surprising to see a strong relationship between these two parameters, for relative diversity is sensitive to the predominance of a particular species and *C. capitata* is well known for its opportunism and tolerance of hypoxic conditions. Its predominance in organically enriched environments has led some to use it as the "indicator of choice". However, reliance on the relative abundance of *C. capitata* as a <u>sole</u> indicator may be an oversimplification. The fact that the strength of the relationship appears to have weakened over the expanded data set may be a direct response to the decrease in the abundance and frequency of *C. capitata* in recent samples. This decrease in *C. capitata* may, in turn, be the result of decreased organic loading to the bottom as a result of changes in husbandry.

An attempt has also been made to determine whether a relationship exists between the environmental affect at a site as a whole and level of production and length of time of operation. Environmental affect at each site was estimated by averaging the relative diversity values of all samples collected at the site since monitoring began in 1992. Production was based on the average production on the site for the 92-93 and 94-95 calendar years. Length of time of operation was determined as the period from initiation of operations to the last year in which sampling took place. Data used in these analyses are not presented here due to the confidential nature of the information.

Once again, as with the physical and biological parameters, no clear relationship appears to exist between environmental affect, at least as measured by relative diversity, and level of production (R^2= 0.279) or length of operation (R^2= 0.019). The lack of a clear relationship may be attributable in part to the high level of variability of both benthic monitoring results from site to site as well as the constantly changing operations on each site.

The results of these individual parameter and inter-parameter analyses, based on all monitoring data available to-date, continue to support the observation made in the *Preliminary Report* that no single parameter by itself can adequately represent conditions beneath or adjacent to cage culture operations. Further, the variability of results over both space and time make it impossible to define an "average" condition and it may be more appropriate to evaluate environmental affect on a site-by-site basis.

3.3.2.3. Site-by-site Approach

Data is now available for two complete rounds of sampling for half of the actively operated cage sites in Maine and covers the years 1992 and 1994. Data also exist for the remaining sites sampled in 1993 and 1995, although the latter samples are still being processed.

For those sites where two sampling periods have been completed, comparisons can be made between the two periods. Appendix II contains detailed station-by-station, site-by-site summaries along with graphic representations of key information developed from sampling during these periods.

Table 3.6., following, shows a comparison of key information for these sites for the two sampling periods and the net changes that have occurred.

Table 3.6.
Comparison of benthic analysis results for selected site for the 1992 and 1994 sampling periods

Site	Mean Abundance			Mean Richness			Mean Relative Diversity			Mean % C. capitella		
	'92	'94	Δ	'92	'94	Δ	'92	'94	Δ	'92	'94	Δ
ASMI CI	3533	5481	1948	13	11	-2	0.044	0.321	0.277	69	62	-7
CONA BC 5300	12577	4601	-7976	22	36	14	0.479	0.713	0.234	48	6	-42
CONA BC 6000	74200	21102	-53098	47	33	-14	0.377	0.429	0.052	62	48	-14
CONA CP	20902	9841	-11061	34	34	0	0.374	0.712	0.338	74	29	-45
CONA DC	40181	18456	-21725	49	45	-4	0.59	0.631	0.041	18	37	19
HARS JK	2649	2889	240	39	31	-8	0.793	0.765	-0.03	13	9	-4
IACO (MPLT) TC	1952	496	-1456	15	9	-6	0.642	0.729	0.087	6	3	-3
NBFI JC	3620	3510	-110	28	34	6	0.787	0.772	-0.01	2	18	16
NESC GN	6804	15263	8459	22	38	16	0.513	0.551	0.038	39	44	5
SFML JB	3174	639	-2535	13	16	3	0.342	0.718	0.376	63	28	-35
Mean Change			**-8731**			**0.5**			**0.14**			**-11**

The rather dramatic decrease in abundance, particularly at the CONA sites, is the most obvious change that has occurred. Such a decrease, if associated with declining relative diversity and richness values, would indicate deteriorating conditions unfavorable even to opportunistic species. The fact that these latter two values remain relatively unchanged, and even increase slightly, suggests that the organic load has decreased and the substrate can no longer support the elevated populations that previously existed. Most of this decrease is due to the precipitous decline in the number of *Capitella capitata*, the magnitude of which is not fully reflected in the percentage numbers alone. This decrease, in turn, may be attributable to intensified dragging activity in the general vicinity of cages associated with the scallop and urchin fisheries, as well as changes in feeds and improved husbandry practices.

The changes in species richness and relative diversity may appear rather small and insignificant, but they indicate that, at least for the time period covered, the environmental affects have remained relatively stable, and in some cases even improved. Indeed, the shaded rows indicate sites where cage systems were removed shortly after the 1992 sampling, thus representing areas of "recovery". The CONA BC 5300 site will be discussed further in the following section.

4. Related Work

In addition to the routine monitoring, several additional efforts have been undertaken to improve our understanding of the environmental affects of cage culture operations and the ways in which these affects might be mitigated. Efforts have also been directed towards improving the efficiency and effectiveness of monitoring while reducing the cost.

4.1. Benthic Recovery

As has been previously mentioned, it was initially believed that, based on the experiences in Norway and Washington State, the net-pen culture of salmon in Maine would result in serious and extensive degradation of the bottom, including heavy accumulation of organic material from waste feed and feces. The monitoring results of the past three years have now shown that, although environmental affects do occur at cage culture sites, these affects are not nearly as severe as initially expected and, in most cases, the area of affect is limited to the immediate vicinity of the cages.

A second concern expressed early in the cage culture environmental debate, and again based on experiences elsewhere, was the potential for long-term degradation of the bottom beneath and adjacent to culture operations. In 1993 a study was initiated on a limited budget with the cooperation of Connors Aquaculture at its Broad Cove, Eastport, Unit 5300 cage site to determine how long it would take a significantly affected bottom to "recover" once finfish culture operations ceased. A proposal was submitted to the Northeast Regional Aquaculture Center (NRAC) but failed to be selected for funding. Despite the lack of funding, sampling continued on a 10-week interval over an 18-month period from May 1993 through November 1994.

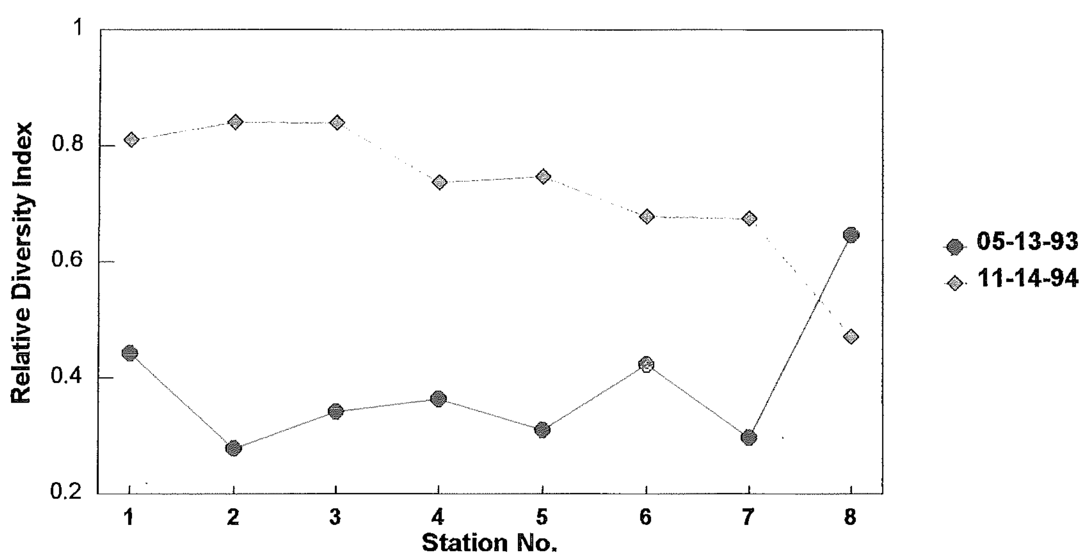
All of the nearly 168 samples taken for the study have now been processed and the results compiled and analyzed. A detailed review of all of the results is beyond the scope of this report, but the results of the first sampling in May 1993 and the final sampling of November 1994 are summarized in Table 4.1. Figure 4.1. shows the results of the relative diversity analysis for the first and last sampling dates, where the red line (●) represents the May 1993 relative diversity values and the green line (◆) the November 1994 values.

The substantial decrease in total abundance between the two dates, driven principally by a precipitous decline in the *Capitella capitata* population, combined with an increase in species richness and a significant increase in the relative diversity values all indicate that recovery of the bottom can occur relatively quickly.

Table 4.1.
Comparison of benthic analysis results for the first and last sampling periods at CONA BC Unit 5300 "Recovery" study site

	May 13, 1993				November 14, 1994			
Station	Abundance	SR	RD	% Cap.	Abundance	SR	RD	% Cap.
1	1634	22	0.443	68	886	26	0.811	1
2	6148	16	0.279	77	612	24	0.841	11
3	2336	9	0.342	71	261	13	0.840	27
4	3785	9	0.364	77	565	19	0.737	4
5	2528	8	0.310	84	453	16	0.740	9
6	2756	11	0.423	52	693	18	0.678	10
7	4673	21	0.297	79	1193	22	0.675	1
8	1321	19	0.647	1	2321	20	0.471	1
Means	**3148**	**14**	**0.388**	**64**	**873**	**20**	**0.724**	**8**

Figure 4.1.
Comparison of the relative diversity analysis results for the first and last sampling periods at CONA BC Unit 5300 "Recovery" study site



The purpose of this study was to investigate the rate at which recovery occurs but not the process by which it occurs. Nevertheless, there is little doubt that dragging activity within the previously affected area was a contributing factor to recovery. To evaluate recovery under non-dragging conditions, a second recovery study was initiated in cooperation with Atlantic Salmon of Maine at its Cross Island, Cutler "C"-farm site in May, 1995. This project is now into its fourth sampling round, but insufficient data have been developed to-date to allow any conclusions to be drawn. This study should be completed by the Spring of 1997.

4.2. Family level analysis

The benthic macro-infauna analyses are the most time-consuming components of the monitoring program, but yield the most useful information. In an effort to reduce the cost associated with these analyses a study was undertaken to determine if a simplification of the organism identification process would significantly affect the results of analyses. Data collected as part of the "recovery" project was analyzed at two different taxonomic levels: 1) the Species, or finest level, and 2) the Family level, or two steps higher (i.e. Family-Genus-Species). Table 4.2. summarizes the relative diversity analysis results at the two taxonomic levels.

Table 4.2.
Comparison of relative diversity analysis results carried out at two taxonomic levels on selected "Recovery" study samples

	May 13, 1993				November 14, 1994			
	Species		Family		Species		Family	
Station	**RD**	**Variance**	**RD**	**Variance**	**RD**	**Variance**	**RD**	**Variance**
1	0.443	0.005	0.439	0.005	0.811	0.005	0.747	0.006
2	0.279	0.001	0.285	0.002	0.841	0.003	0.800	0.003
3	0.342	0.002	0.342	0.002	0.840	0.000	0.834	0.000
4	0.364	0.001	0.367	0.001	0.737	0.002	0.738	0.001
5	0.310	0.001	0.310	0.001	0.740	0.003	0.749	0.003
6	0.423	0.002	0.426	0.001	0.678	0.030	0.684	0.028
7	0.297	0.003	0.300	0.003	0.675	0.000	0.695	0.000
8	0.647	0.007	0.641	0.007	0.471	0.004	0.473	0.004
Means	**0.388**	**0.003**	**0.389**	**0.003**	**0.724**	**0.006**	**0.715**	**0.006**

These results demonstrate that the difference between analyzing macro-infauna samples at the Species and Family level is minimal, particularly for the purpose of monitoring. These results were therefore used to support a change in the monitoring program which allows identification of organism to the Family level rather than the Species level as an acceptable "lowest practical level" of identification . This, combined with a screen mesh-size change from 0.5 mm to 1.0 mm, has allowed the cost of analyzing macro-infauna samples to be cut in half, resulting in a substantial savings for the Program.

4.3. Species index/site rating

Efforts towards developing a site rating system based on a species index related to the frequency and abundance at which various species occur under different environmental conditions are continuing. This effort, however, requires considerable manipulation of large amounts of data collected over several years, including years prior to the formal Finfish Aquaculture Monitoring Program. Given the effort and time required to develop the species index and the lack of current funding, this effort is being carried on outside of the FAMP. Once completed, however, the index may add to the analytical tools available for rating sites and, combined with other information, may be useful in forecasting future conditions at actively operated sites.

5.0 Conclusions

Since the Finfish Aquaculture Monitoring Program began in the Spring of 1992 environmental degradation resulting from finfish culture operations, as measured by water quality and benthic monitoring, has remained stable or improved at most sites. During this period at least three sites have been identified where degradation caused sufficient concern to require mitigation. In each of these cases mitigation measures were implemented voluntarily by the operators, avoiding severe degradation of the sites. It is important to note, however, that the level of production since 1992 has remained relatively stable, even declining slightly in 1994. Processing of the samples collected in 1995 has yet to be completed, but the results of the analyses should be interesting in view of the significant increase in production which occurred in 1995.

Based on all of the results to-date, it seems reasonable to conclude that the FAMP is effectively safe-guarding against excessive environmental degradation as a result of finfish aquaculture operations and that, in the vast majority of cases, the finfish aquaculture industry is acting responsibly in the management of their operations.

6.0 References

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Appendix I

Maine Department of Marine Resources
Finfish Aquaculture Monitoring Program

DMR Finfish Aquaculture Monitoring Program (FAMP)
(Pertaining to monitoring for the Fall 1994 through Spring 1996 survey work.)

Upon issuance of a MDMR lease the following monitoring program will be required. The objective of these monitoring requirements is to identify effects of farms on sediments and water quality. It also provides data with which to review the current environmental requirements for possible future modifications.

1. Diver Surveys, Semi-annual

Methods: A diver survey shall be conducted twice a year, once between April and May and once between the last two weeks of September and October. Accept as provided below the survey shall be documented with continuous video footage within the footprint of the net-pens and extend 60 meters (200 feet) beyond the ends of the system along the axis of the primary current. The diver shall document the sediment types and features noting erosional or depositional areas. Also document the flora/fauna observed as to their relative abundance. Relative abundance characterized approximately as follows: abundant, always present within the diver's view; common, seen occasionally throughout the dive, may be patchy; rare, only seen once or in a few places throughout the dive.

Note: Video format is preferred* but photographs taken at 10 meter (30 foot) intervals may be submitted if video is not available. A brief narrative with the tape or photos describing reference points must be provided. MDMR monitoring video or photos may be used for this requirement if available. All documentation must include the dates on which it was taken.

*For the purpose of this survey Hi8mm video format is required.

2. Water Quality

Methods: Three water samples must be analyzed for dissolved oxygen (DO), temperature and salinity every two weeks from July 1 through September 30.** The sampling locations should be placed such that the downcurrent samples represents water that has passed through the greatest number of pens. The samples shall be taken at mid-pen depth, ie. if the holding net is 6 meters deep, take the sample at 3 meters from the surface. The three stations to be sampled shall be located: 100 meters (300 feet) upcurrent of the operation, 100 meters (300 feet) downcurrent of the operation and within 5 meters (15 feet) downcurrent from the pens. Also, during the month of August a one-time detailed analysis of dissolved oxygen, temperature and salinity shall be prepared for each station consisting of 10 equally-spaced samples over the entire vertical depth of the station.**

Water samples may be collected or an electronic membrane probe may be used to measure the concentrations. Temperature and salinity measurements shall be used to determine percent saturation of dissolved oxygen and stratification. Samples shall be taken one hour before slack low water (preferably early in the morning).

Water column dissolved oxygen acceptable methodology and quality assurance procedures to monitor compliance with water quality standards are discussed in the following paragraph.

Although the preferred method is the "Winkler Titration" (Azide modification), of Standard Methods (APHA, AWWA, WPCF, most current edition), the use of the membrane electrode method is acceptable, considering the multiple depths required for the profile. The zero and standard calibration methods described in the most current edition of Standard Methods and the instrument manufacturer's instructions must be followed. Air calibration readings must be recorded at the beginning and end of each interval during which the meter is **on**. One duplicate reading per profile shall be taken and reported to verify that the meter is reading consistantly. Furthermore, at the beginning and end of each sample season, calibration curves comparing probe to Winkler readings for at least four dissolved oxygen concentrations ranging from less than 20% to 100% saturation shall be constructed. If more than one meter is used, curves shall be developed for each meter. These curves shall be submitted with all data.

**For the purpose of this survey the sampling dates and times are modified.

3. <u>Benthic Analyses</u>

Methods: Benthic monitoring will be required during the first period of peak feed. This generally coincides with the first harvest at the end of the growing season when two age classes are in the water, (such as September to November). <u>After this, monitoring will occur every other year.</u> There are two components to these monitoring requirements; sediments and infauna.

a. <u>Sediments</u>

Methods: Sediment cores shall be analyzed for sediment grain size (% gravel, sand, silt, clay); the depth of the redox discontinuity layer, the depth of the unconsolidated organic layer and TOC.***

<u>Single</u> core samples collected according to the approved sampling plan must be inserted to resistance or 15 cm, whichever is less. Depth of the core shall be reported. The depth of the discontinuity layer shall be measured from the surface using a Plexiglas type corer. The depth of the unconsolidated organic layer can also be measured visually with a Plexiglas corer.

Grain size analyses should be performed using the Wet Sieving methods described by Buchanan in Holme and McIntyre, 1984 (pp. 47-48) or a similar procedure (see appendix 1). The standard sieve sizes for gravel, sand, silt and clay shall be used. Full analyses of the silt-clay fractions may be calculated as the difference in dry weight between the original sample and the sum of the sieve fractions down to the 0.062 mm sieve (very fine sand). The fraction in each sieve shall be reported in grams (dry weight) and percent of total (dry weight) including the total dry weight of the initial sample.

The unconsolidated material and the top 2 cm of inorganic sediments shall be collected for the analysis of Total Organic Carbon (TOC). The applicant must insure that a minimum of 30 grams are collected for analysis. Multiple cores (which include the top 2 cm of inorganic material) if warranted, will be required.

Total Organic Carbon shall be analyzed using the methods described in the Puget Sound Estuary Program (1986), Hedges and Stern (1984) or Verado et al. (1990) Methods for TOC and sediment analyses, see appendix 1.

b. Infauna

Methods: Infauna samples shall be sieved through a 0.5 mm sieve and organisms identified to the lowest practical taxonomic level.

Single cores shall be taken at the same sample location listed in the approved sampling plan during the season of maximum feeding within the proposed lease area along the axis of the current. Cores must be inserted to resistance or 15 cm, whichever is less. Depth of the core shall be reported.

Individual benthic infauna cores collected by a diver shall have an area of at least 81 cm^2 (a four inch diameter PVC pipe will suffice). Or cores may be collected from a grab or box type corer having an area of at least 0.1 m^2 (1000 cm^2). If subsamples are taken from a grab or box type corer for the sediment analysis and the remaining sample used for infauna analysis, no more than one-quarter of the surface of each sample can have been removed for the sediment analysis.****

***For the purpose of survey TOC:TN is required.
**** For the purpose of this survey a Smith-McIntyre grab is required.

Appendix 1.

Methods References

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Appendix II

Site-by-site comparative summary of 1992 and 1994 benthic monitoring analyses results

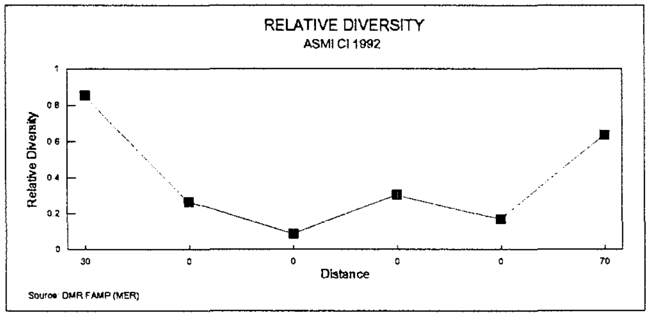
ALL SITES
BENTHIC ANALYSIS 1992 vs 1994 DATA

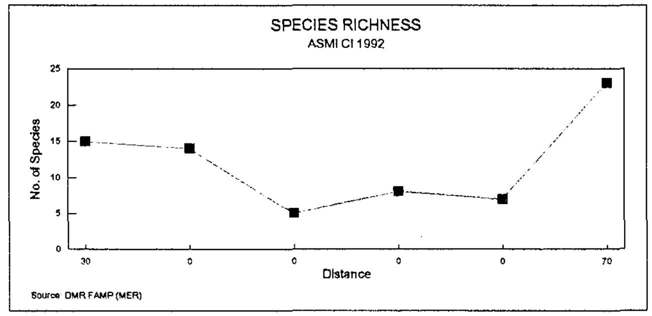
										DEPTHS IN CENTIMETERS					> #4	< #4—>#40	#40—>#200	<#200
SITE ID	DATE	STATION	TOTAL	ABUNDANCE	RICHNESS	DISTANCE	DIVERSITY	% C. cap	SR*RD	CORE	UMOL	RPDL	TOC	DISTANCE	GRAVEL	SAND	SAND(FINE)	SILT/CLAY
ASMI CI	10/12/92	1	43	531	12	30	0.9	18.6	10.8	10.5	0.5	0.5	1.59	30	0	11	5.5	83.5
ASMI CI	10/12/92	2	49	605	11	20	0.733	46.9	8.1	11	0.5	1.5	1.6	20	0	1.5	16.8	81.7
ASMI CI	10/12/92	3	730	9008	7	0	0.123	95.5	0.9	11	1.5	3	3.98	0	5.7	7.7	47.1	39.5
ASMI CI	10/12/92	4	310	3825	14	20	0.366	75.2	5.1	10.5	1	3.5	2.91	20	0	13.6	17.8	68.6
ASMI CI	10/12/92	5	292	3603	24	30	0.406	0.7	8.7	7	0	2	2.21	30	0	2.4	10.5	87.1
ASMI CI	10/12/92	6	70	864	15	30	0.852	28.6	12.8	8	1	1.5	1.32	30	0	3.4	9	87.6
ASMI CI	10/12/92	7	256	3159	14	0	0.265	65.9	3.7	9.5	0.8	2	2.02	0	0	12.5	12.1	75.4
ASMI CI	10/12/92	8	267	3295	5	0	0.085	97.8	0.4	8	0.5	4	3.91	0	0	10.1	15.3	74.6
ASMI CI	10/12/92	9	145	1789	8	0	0.304	86.2	2.4	9	0.5	3	3.61	0	0	4.6	21.4	74
ASMI CI	10/12/92	10	611	7540	7	0	0.169	93.3	1.2	10	1	3.5	3.54	0	0	6.9	14.9	78.2
ASMI CI	10/12/92	11	376	4640	23	70	0.635	2.1	14.6	6.5	N-T	N-T	1.84	70	N-T	N-T	N-T	N-T
ASMI CI "B" FARM	10/14/94	1	51	630	17	30	0.742	43	13	8	0.75	2.125	1.432	30	0.000	2	5	93
ASMI CI "B" FARM	10/14/94	2	419	5173	9	0	0.175	92	2	9	2.5	4	2.71	0	0.000	1	11	88
ASMI CI "B" FARM	10/14/94	3	4	49	4	0	0.010	25	0	12	2.75	0	4.276	0	0.000	2	18	80
ASMI CI "B" FARM	10/14/94	4	847	10456	13	0	0.164	91	2	5.5	2.5	0	4.442	0	0.000	0	3	97
ASMI CI "B" FARM	10/14/94	5	562	6938	16	30	0.331	12	5	NT	1.75	3	0.829	30	0.000	1	3	96
ASMI CI "C" FARM	10/13/94	1	367	4531	12	30	0.191	90	2	8.5	0.75	0.75	2.213	30	0.000	1	9	90
ASMI CI "C" FARM	10/13/94	2	986	12172	10	0	0.268	85	3	4	1.25	0	3.717	0	0.000	14	19	67
ASMI CI "C" FARM	10/13/94	3	481	5938	6	0	0.119	96	1	10	1.5	0	6.152	0	0.000	5	26	69
ASMI CI "C" FARM	10/13/94	4	737	9098	12	0	0.260	84	3	4	1	0	2.861	0	0.000	4	9	87
ASMI CI "C" FARM	10/13/94	5	769	9493	24	30	0.314	11	0	7	1	2.75	1.473	30	0.000	1	3	96
ASMI CI "D" FARM	10/14/94	1	43	531	11	30	0.788	19	9	9.0	2.5	4.0	1.75	30	0.0	1.0	4.0	95.0
ASMI CI "D" FARM	10/14/94	2	123	1518	9	0	0.439	65	4	8.5	6.0	0.0	3.36	0	0.0	2.0	3.0	95.0
ASMI CI "D" FARM	10/14/94	3	425	5247	8	0	0.187	92	1	8.0	3.0	0.0	12.31	0	0.0	2.0	8.0	90.0
ASMI CI "D" FARM	10/14/94	4	557	6876	10	0	0.424	70	4	6.5	3.0	0.0	2.96	0	0.0	3.0	24.0	73.0
ASMI CI "D" FARM	10/14/94	5	290	3580	11	30	0.404	60	4	4.5	2.0	1.5	2.61	30	0.0	3.0	6.0	91.0
ASMI II	10/12/94	1	242	2987	16	30	0.680	14	11	6	0	1.25	0.651	30	0.000	0	23	77
ASMI II	10/12/94	2	14	173	1	0	0.000	100	0	4.5	0.5	0	0.834	0	0.000	0	17	83
ASMI II	10/12/94	3	19	235	8	0	0.883	37	7	6.5	0.875	0	0.546	0	0.000	0	29	71
ASMI II	10/12/94	4	25	309	9	0	0.747	52	7	4	0.5	0.5	0.875	0	0.000	1	20	79
ASMI II	10/12/94	5	104	1284	21	30	0.793	0	17	7	0.75	0.75	0.605	30	0	1	13	86
CONA BC (5300)	10/06/92	1	283	3492	23	70	0.736	7.1	16.9	14	0.3	3	3.3	70	0	1.1	11.6	87.3
CONA BC (5300)	10/06/92	2	1119	13808	33	30	0.609	32	20.1	6	2.7	0	8.06	30	0	1.2	34.2	64.6
CONA BC (5300)	10/06/92	3	1167	14401	9	0	0.216	89	1.9	8	3	0	4.59	0	0	24.4	30.4	45.2
CONA BC (5300)	10/06/92	4	1629	20102	10	0	0.314	79	3.1	9	2.5	0	5.19	0	0	10	33.1	56.9
CONA BC (5300)	10/06/92	5	898	11081	37	30	0.519	30.6	19.2	9.5	1.5	N/A	3.13	30	0	6.1	14.6	79.3
CONA BC (5300)	09/27/94	1	198	2444	29	60	0.725	8	21	6.5	0.5	3.8	1.98	60	2.0	7.0	37.0	54.0
CONA BC (5300)	09/27/94	2	205	2531	31	30	0.777	13	24	8.5	0.8	1.0	1.54	30	18.0	21.0	30.0	31.0
CONA BC (5300)	09/27/94	3	497	6135	36	0	0.682	5	25	10.5	1.0	1.5	2.39	0	27.0	15.0	27.0	31.0
CONA BC (5300)	09/27/94	4	287	3543	24	0	0.629	10	15	7.0	0.0	1.3	0.86	0	0.0	24.0	18.0	58.0
CONA BC (5300)	09/27/94	5	304	3753	43	30	0.792	1	34	8.5	0.0	8.5	0.98	30	25.0	26.0	17.0	32.0
CONA BC (5300)	09/27/94	6	745	9197	50	60	0.670	0	34	9.5	0.3	3.0	NT	60	12.0	17.0	32.0	39.0
CONA BC (6000)	10/06/92	1	1619	19978	43	60	0.527	51.3	22.7	8.5	0.5	2.7	3.46	60	0	14.8	34.4	50.8
CONA BC (6000)	10/06/92	2	6126	75595	57	30	0.344	66	19.6	7.5	2	0	4.2	30	0	4.3	51.3	44.4
CONA BC (6000)	10/06/92	3	7885	97301	26	0	0.125	93	3.3	10	2.5	0	8.08	0	0	20.6	45.2	34.2
CONA BC (6000)	10/06/92	4	9595	118402	68	0	0.333	68.5	22.6	7	1.3	3	3.87	0	49	20.1	21.7	9.2
CONA BC (6000)	10/06/92	5	7498	92525	40	30	0.449	60.4	17.9	7	1.3	3	2.28	30	47.2	22.6	22	8.2
CONA BC (6000)	10/06/92	6	3355	41401	45	60	0.481	31.4	21.7	10	0.5	3	2.22	60	63.8	15.4	14.2	6.6
CONA BC (6000)	09/27/94	1	317	3913	24	60	0.462	66	11	10.5	0.5	2.5	2.46	60	0.0	6.0	31.0	63.0
CONA BC (6000)	09/27/94	2	3052	37677	22	30	0.249	80	5	4.0	1.8	0.0	4.17	30	0.0	9.0	36.0	55.0
CONA BC (6000)	09/27/94	3	3038	37504	15	0	0.161	91	2	10.0	1.3	0.0	3.50	0	0.0	16.0	44.0	40.0
CONA BC (6000)	09/27/94	4	2251	27789	43	0	0.391	31	17	5.0	0.7	1.5	1.65	0	5.0	36.0	40.0	19.0
CONA BC (6000)	09/27/94	5	921	11370	51	30	0.625	15	32	4.0	0.5	1.5	2.22	30	26.0	32.0	28.0	14.0
CONA BC (6000)	09/27/94	6	677	8358	44	60	0.687	3	30	3.0	0.0	3.0	0.83	60	17.0	45.0	28.0	10.0
CONA CP	10/05/92	1	2324	28678	53	50	0.472	56.2	25	11.5	1.5	5.3	1.44	50	40.8	29.2	21.9	8.1
CONA CP	10/05/92	2	3196	39439	30	25	0.158	91.1	4.7	12	2.3	0	8.15	25	31.8	37.5	16.1	14.6
CONA CP	10/05/92	3	2213	27308	33	0	0.176	89.5	5.8	3.5	3.5	N-T	5.32	0	51.4	25.1	15.4	8.1
CONA CP	10/05/92	4	923	11390	31	0	0.485	46.7	15	8.5	1.5	3	0.9	0	12.7	45.3	34.1	7.9
CONA CP	10/05/92	5	732	9033	28	30	0.535	54.5	15	5.8	3.5	6	2.48	30	18.6	47.3	27.3	6.8
CONA CP	10/05/92	6	775	9564	29	60	0.417	63.1	12.1	N-T	N-T	N-T	1.83	60	22	42.3	28	7.7
CONA CP	09/25/94	1	2043	25221	49	60	0.714	23	35	3.5	0.0	3.5	0.86	60	20.0	33.0	38.0	9.0
CONA CP	09/25/94	2	1355	16727	42	30	0.636	20	27	8.0	1.3	4.5	1.83	30	1.0	23.0	23.0	53.0
CONA CP	09/25/94	3	640	7901	22	0	0.534	55	12	11.0	1.0	1.5	2.93	0	3.0	16.0	38.0	43.0
CONA CP	09/25/94	4	562	6938	38	0	0.613	48	23	4.0	0.3	1.8	0.91	0	38.0	25.0	21.0	16.0
CONA CP	09/25/94	5	46	568	21	30	0.909	7	19	4.5	0.3	1.5	1.52	30	27.0	25.0	21.0	27.0
CONA CP	09/25/94	6	137	1691	34	60	0.868	7	30	5.0	0.0	5.0	0.75	60	44.0	24.0	15.0	17.0
CONA DC	10/07/92	1	998	12315	62	60	0.749	1.3	46.5	10.5	0.5	4	2.11	60	0	14.5	43.2	42.3
CONA DC	10/07/92	2	1564	19300	48	30	0.675	9.1	32.4	9	1	2	1.73	30	0	19.4	38.4	42.2
CONA DC	10/07/92	3	4336	53506	27	0	0.595	25.7	16.1	7	1	7	4.53	0	0	21.9	39.3	38.8
CONA DC	10/07/92	4	1521	18769	33	25	0.606	33.9	20	10	1.3	3.5	3.2	25	0	16.1	48.1	35.8
CONA DC	10/07/92	5	2643	32615	69	25	0.544	8.3	37.6	8	2	8	1.4	25	33.6	34.9	21.3	10.2
CONA DC	10/07/92	6	7168	88453	38	0	0.512	21.7	19.5	7.5	1.5	NA	4.7	0	0	15.7	53.5	30.8
CONA DC	10/07/92	7	5186	63995	45	25	0.485	19	21.8	7.5	2.5	5	3.95	25	8	12.5	62.5	17
CONA DC	10/07/92	8	2633	32491	70	50	0.552	4.9	38.7	11.5	0.5	4.5	2.62	50	0	38.1	37.8	24.1
CONA DC	09/28/94	1	360	4444	41	60	0.788	21	32	8.0	1.8	5.0	1.64	60	0.0	10.0	35.0	55.0
CONA DC	09/28/94	2	1203	14851	49	30	0.657	19	32	10.0	1.5	3.8	2.94	30	0.0	8.0	53.0	39.0
CONA DC	09/28/94	3	4574	56466	31	0	0.384	49	12	8.0	1.8	1.0	4.08	0	0.0	6.0	60.0	34.0
CONA DC	09/28/94	4	1028	12691	36	30	0.544	46	20	10.0	0.8	3.0	3.46	30	0.0	10.0	40.0	50.0
CONA DC	09/28/94	5	245	3025	45	30	0.768	22	35	3.0	0.3	0.0	1.29	30	0.0	51.0	35.0	14.0
CONA DC	09/28/94	6	1418	17505	40	0	0.623	19	25	5.0	0.0	4.5	0.77	0	0.0	4.0	32.0	64.0
CONA DC	09/28/94	7	2480	30616	56	30	0.543	39	30	2.5	0.0	0.0	1.21	30	0.0	34.0	54.0	12.0
CONA DC	09/28/94	8	652	8049	60	60	0.744	25	45	7.0	0.3	3.0	1.18	60	0.0	33.0	55.0	12.0
HARS JK	10/04/92	1	111	1370	35	3	0.897	22.5	31.4	10.5	0	>5.0	0.64	3	53.7	22	19.4	4.9
HARS JK	10/04/92	2	248	3060	44	0	0.761	22.6	33.5	11	0.3	1	0.51	0	50.4	22.9	22.7	4
HARS JK	10/04/92	3	285	3517	39	3	0.721	0	28.1	11	0	>5.0	0.74	3	48.2	24.8	21.3	5.6
HARS JK	09/25/94	1	427	5271	45	30	0.722	0	32	8.0	0.0	8.0	0.67	30	17.0	35.0	42.0	6.0
HARS JK	09/25/94	2	106	1309	26	0	0.846	0	22	6.5	0.3	3.3	0.78	0	27.0	43.0	20.0	10.0
HARS JK	09/25/94	3	212	2617	29	0	0.716	32	21	8.5	0.5	1.0	0.98	0	21.0	56.0	18.0	5.0
HARS JK	09/25/94	4	191	2358	25	30	0.775	10	19	9.0	0.0	2.0	0.86	30	33.0	47.0	13.0	7.0
IACO TC	10/27/94	1	106	1309	20	30	0.687	0	14	7.0	0.0	2.0	1.24	30	0.0	0.0	4.0	96.0
IACO TC	10/27/94	2	29	358	8	10	0.777	14	6	5.5	2.0	0.0	1.34	10	0.0	1.0	10.0	89.0
IACO TC	10/27/94	3	50	617	6	0	0.379	6	2	5.5	3.8	0.0	6.89	0	0.0	1.0	18.0	81.0
IACO TC	10/27/94	4	9	111	7	10	0.971	0	7	6.5	0.5	1.5	1.39	10	0.0	1.0	10.0	89.0
IACO TC	10/27/94	5	7	86	4	30	0.832	0	3	6.0	0.5	1.5	1.92	30	0.0	3.0	10.0	87.0
MPLT TC	10/20/92	1	11	136	6	60	0.916	9.1	5.5	7	0.3	1.5	1.42	60	0	3.3	22.4	74.3
MPLT TC	10/20/92	2	165	2036	24	30	0.781	12.1	18.7	9	0.3	1	1.02	30	0	2.6	23.1	74.3
MPLT TC	10/20/92	3	3	37	3	0	1	0	3	5.5	2	0	0.94	0	0	0.6	12.4	87
MPLT TC	10/20/92	4	124	1530	14	30	0.747	5.6	10.5	10.5	0.8	0	0.75	30	0	0.9	15	84.1
MPLT TC	10/20/92	5	488	6022	30	60	0.677	3.5	20.3	11	11	2.5	1.12	60	0	0.8	16.7	82.5
NBFI CC	10/09/92	1	66	814	22	20	0.735	0	16.2	3.5	>3.5	>3.5	0.93	20	28	39.3	12.2	20.5
NBFI CC	10/09/92	2	136	1678	26	0	0.54	7.4	14.1	8	0.8	0	1.62	0	67.9	14.8	10.4	6.9
NBFI CC	10/09/92	3	78	963	17	20	0.781	30.8	13.3	4	>4.0	>4.0	1.53	20	40.9	21.4	21.4	16.3
NBFI JC	10/04/92	1	255	3147	31	10	0.789	3.1	24.5	4	0.3	>4.0	2.22	10	16.5	9.8	66.4	7.3
NBFI JC	10/04/92	2	546	6738	36	0	0.721	0.2	26	8	0.5	>8.0	2.28	0	24.6	14.2	53.8	7.4
NBFI JC	10/04/92	3	79	975	17	10	0.852	5.1	14.5	9	0	>9.0	3.87	10	88.2	3.2	7.7	0.9
NBFI JC	09/25/94	1	276	3407	42	30	0.760	1	32	1.5	0.0	1.5	1.77	30	0.0	13.0	84.8	2.2
NBFI JC	09/25/94	2	505	6259	38	0	0.669	29	25	7.0	0.0	2.5	1.20	0	0.0	29.0	56.0	15.0
NBFI JC	09/25/94	3	70	864	23	30	0.888	6	20	5.0	0.0	5.0	0.39	30	0.0	10.0	81.0	9.0
NESC GN	10/09/92	1	387	4776	35	30	0.814	8.8	28.5	7	0.3	7	1.91	30	0	11.1	72.3	16.6
NESC GN	10/09/92	2	1505	18572	30	3	0.567	28.6		11.5	2.5	4	4.82	3	0	6.4	44.5	49.1
NESC GN	10/09/92	3	527	6503	13	0	0.264	87.9	3.4	10	1.5	5	0.97	0	45.3	23.5	18.6	12.6
NESC GN	10/09/92	4	123	1518	7	3	0.312	85.4	2.2	8.5	2	0	0.73	3	31.2	14.2	33.3	21.3
NESC GN	10/09/92	5	215	2653	24	30	0.608	22.8	14.6	10.5	0.5	5.5	1.77	30	0	47.4	23.6	29
NESC GN	09/27/94	1	333	4111	49	30	0.755	2	37	10.0	0.3	5.0	1.24	30	14.0	29.0	22.0	35.0
NESC GN	09/27/94	2	1212	14962	26	0	0.339	73	9	7.5	0.3	3.0	0.52	0	21.0	17.0	40.0	22.0
NESC GN	09/27/94	3	3363	41516	42	0	0.412	44	17	6.0	0.3	0.0	1.28	0	33.0	26.0	26.0	15.0
NESC GN	09/27/94	4	509	6284	24	0	0.513	57	12	7.5	0.5	1.0	2.83	0	0.0	2.0	60.0	38.0
NESC GN	09/27/94	5	765	9444	49	30	0.736	8	36	10.0	0.0	10.0	0.86	30	2.0	2.0	70.0	26.0
SFML JB	10/08/92	1	234	2888	26	30	0.819	0.4	21.3	10.5	10.5	7	1.56	30	0	4.7	11.2	84.1
SFML JB	10/08/92	2	745	9193	7	0	0.224	90.7	1.6	10	0.5	1.3	3.27	0	0	4.7	32.6	62.7
SFML JB	10/08/92	3	163	2011	4	0	0.215	93.3	0.9	9.5	1.3	0	4.75	0	0	3	29.5	67.5
SFML JB	10/08/92	4	216	2665	13	0	0.576	29.2	7.5	11	0.8	1.5	1.91	0	0	1	14.8	84.2
SFML JB	10/08/92	5	57	703	22	30	0.877	1.8	19.3	13.5	0.5	4.5	1.92	30	0	6.5	11.3	82.2
SFML JB	10/08/92	6	614	7577	6	30	0.044	98.9	0.3	10.5	1.5	5.8	3.36	30	0	4.4	30.5	65.1
SFML JB	10/08/92	7	144	1777	1	0	0	100	0	7	2	4	3.69	0	0	6	24.7	69.3
SFML JB	10/08/92	8	58	716	5	0	0.462	79.3	2.3	9.5	1.3	4.3	2.64	0	0	6.7	6.4	86.9
SFML JB	10/08/92	9	279	3443	25	0	0.564	0.4	14.1	15	0.5	4	1.53	0	0	26.8	14.3	58.9
SFML JB	10/08/92	10	191	2357	27	30	0.638	0	17.2	9	9	6	1.61	30	0	5.3	3.4	91.3
SFML JB3	09/29/94	1	47	580	20	30	0.844	2	17	9.5	0.5	2.5	1.59	60	0.0	4.0	5.0	91.0
SFML JB3	09/29/94	2	71	876	28	0	0.658	23	24	8.5	1.0	4.0	1.73	30	0.0	1.0	4.0	95.0
SFML JB3	09/29/94	3	35	432	10	0	0.765	23	8	9.0	1.3	0.0	2.51	0	0.0	1.0	1.0	98.0
SFML JB3	09/29/94	4	53	654	6	0	0.296	89	2	12.0	0.3	0.5	1.76	0	1.0	3.0	2.0	94.0
SFML JB3	09/29/94	5	53	654	18	30	0.828	2	15	9.0	0.3	5.5	1.53	30	1.0	1.0	5.0	93.0
TISF HI	10/21/94	1	79	975	4	0	0.544	14	2	10.0	0.0	0.0	1.68	0	0.0	1.0	10.0	89.0
TISF HI	10/21/94	2	173	2136	12	30	0.291	6	3	12.0	0.0	1.8	2.12	30	0.0	3.0	18.0	79.0
TISF HI	10/21/94	3	117	1444	13	60	0.496	4	6	9.5	0.0	9.5	1.72	60	0.0	4.0	14.0	82.0
TISF HI	10/21/94	4	104	1284	8	0	0.421	6	3	9.5	0.0	4.0	1.17	0	4.0	5.0	39.0	52.0
TISF HI	10/21/94	5	187	2309	31	60	0.766	6	24	8.5	0.0	3.5	0.61	60	33.0	20.0	24.0	23.0

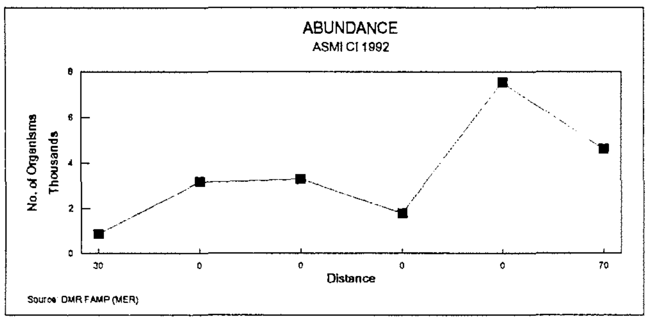
ASMI CI

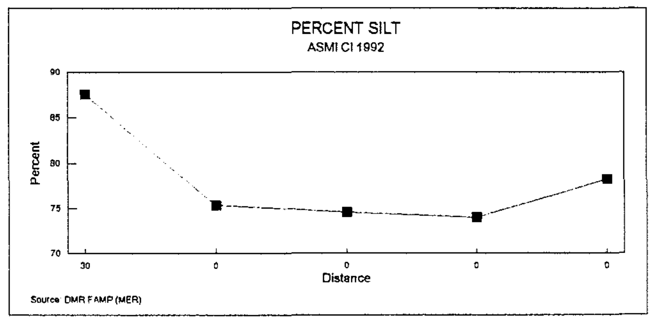
BENTHIC ANALYSIS 1992 DATA

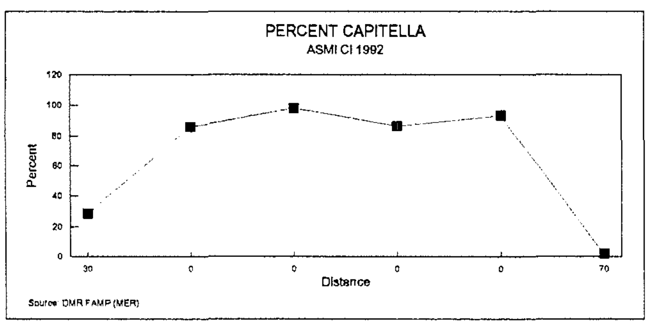
										DEPTHS IN CENTIMETERS					> #4	< #4-->#40	#40-->#200	<#200
SITE ID	DATE	STATION	TOTAL	ABUNDANCE	RICHNESS	DISTANCE	DIVERSITY	% C. cap	SR*RD	CORE	UMOL	RPDL	TOC	DISTANCE	GRAVEL	SAND	SAND(FINE)	SILT/CLAY
ASMI CI	10/12/92	6	70	864	15	30	0.852	28.6	12.8	8	1	1.5	1.32	30	0	3.4	9	87.6
ASMI CI	10/12/92	7	256	3159	14	0	0.265	85.9	3.7	9.5	0.8	2	2.02	0	0	12.5	12.1	75.4
ASMI CI	10/12/92	8	267	3295	5	0	0.085	97.8	0.4	8	0.5	4	3.91	0	0	10.1	15.3	74.6
ASMI CI	10/12/92	9	145	1789	8	0	0.304	86.2	2.4	9	0.5	3	3.61	0	0	4.6	21.4	74
ASMI CI	10/12/92	10	611	7540	7	0	0.169	93.3	1.2	10	1	3.5	3.54	0	0	6.9	14.9	78.2
ASMI CI	10/12/92	11	376	4640	23	70	0.635	2.1	14.6	6.5	N-T	N-T	1.84	70	N-T	N-T	N-T	N-T







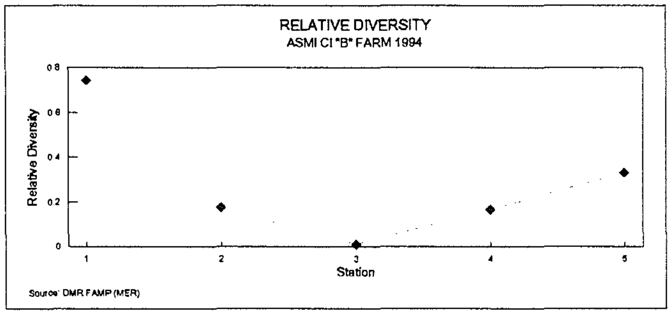


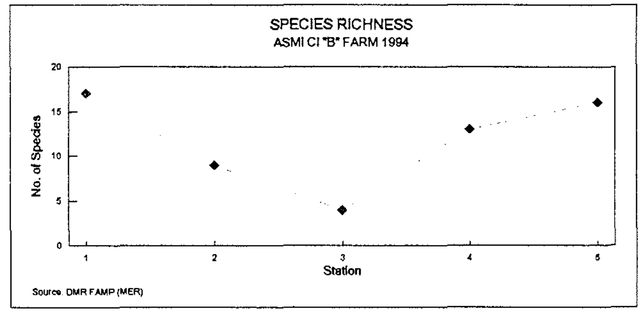


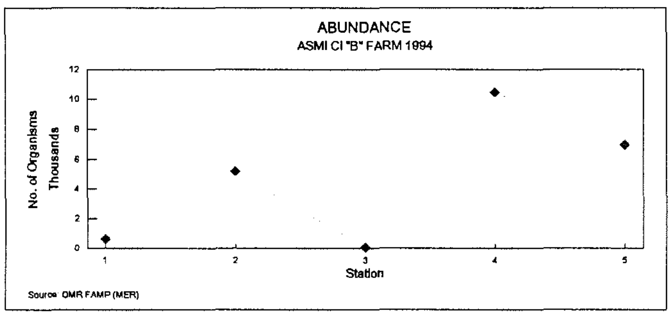
ASMI CI "B" FARM

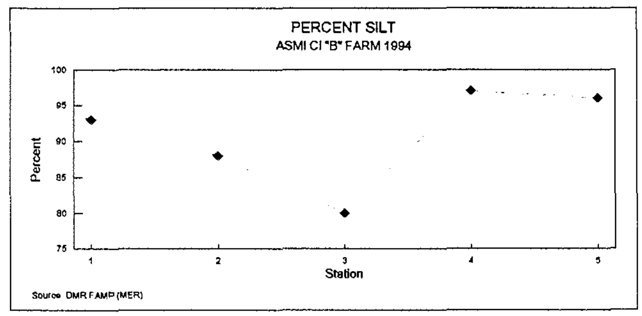
BENTHIC ANALYSIS 1994 DATA

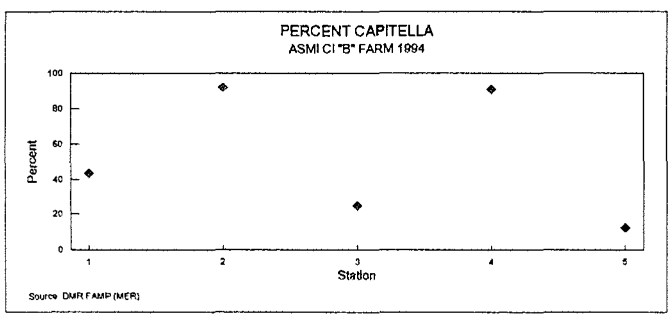
SITE ID	DATE	STATION	TOTAL	ABUNDANCE	RICHNESS	DISTANCE	DIVERSITY	% C. cap	SR*RD	DEPTHS IN CENTIMETERS CORE	UMOL	RPDL	TOC	DISTANCE	> #4 GRAVEL	< #4-->#40 SAND	#40-->#200 SAND(FINE)	<#200 SILT/CLAY
ASMI CI "B" FARM	10/14/94	1	51	630	17	30	0.742	43	13	8	0.75	2.125	1.432	30	0	2	5	93
ASMI CI "B" FARM	10/14/94	2	419	5173	9	0	0.175	92	2	9	2.5	4	2.71	0	0	1	11	88
ASMI CI "B" FARM	10/14/94	3	4	49	4	0	0.01	25	0	12	2.75	0	4.276	0	0	2	18	80
ASMI CI "B" FARM	10/14/94	4	847	10456	13	0	0.164	91	2	5.5	2.5	0	4.442	0	0	0	3	97
ASMI CI "B" FARM	10/14/94	5	562	6938	16	30	0.331	12	5	NT	1.75	3	0.829	30	0	1	3	96







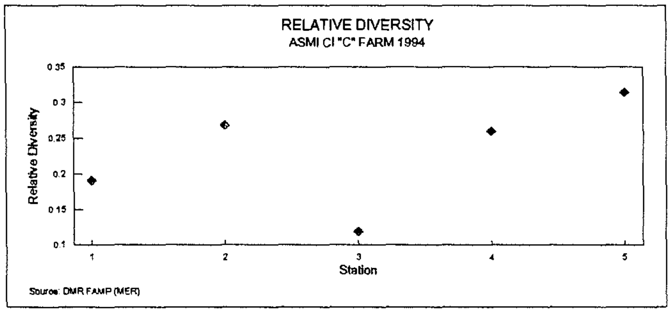


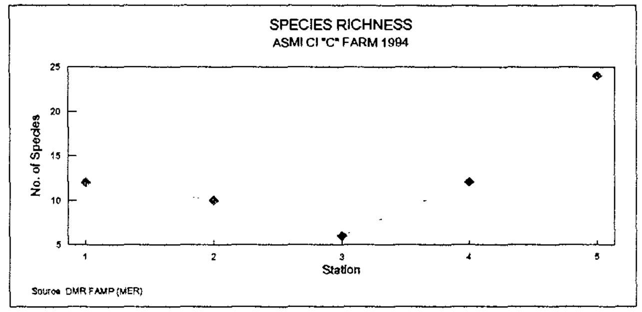


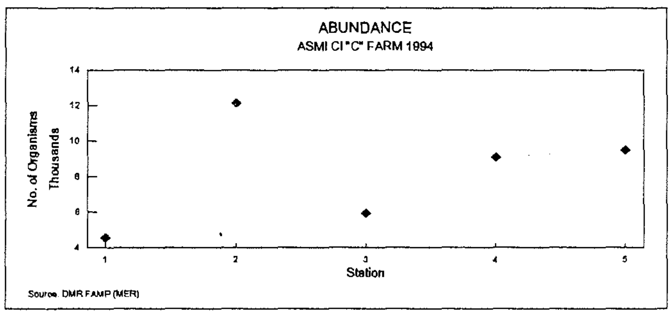
ASMI CI "C" FARM

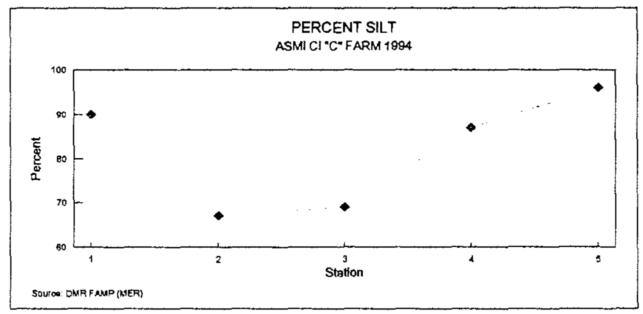
BENTHIC ANALYSIS 1994 DATA

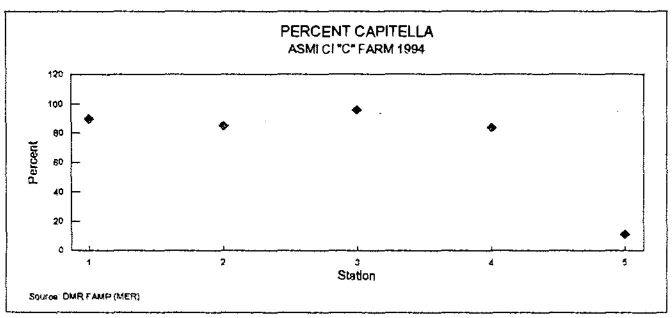
										DEPTHS IN CENTIMETERS					> #4	< #4-->#40	#40-->#200	<#200
SITE ID	DATE	STATION	TOTAL	ABUNDANCE	RICHNESS	DISTANCE	DIVERSITY	% C. cap	SR*RD	CORE	UMOL	RPDL	TOC	DISTANCE	GRAVEL	SAND	SAND(FINE)	SILT/CLAY
ASMI CI "C" FARM	10/13/94	1	367	4531	12	30	0.191	90	2	8.5	0.75	0.75	2.213	30	0	1	9	90
ASMI CI "C" FARM	10/13/94	2	986	12172	10	0	0.268	85	3	4	1.25	0	3.717	0	0	14	19	67
ASMI CI "C" FARM	10/13/94	3	481	5938	6	0	0.119	96	1	10	1.5	0	6.152	0	0	5	26	69
ASMI CI "C" FARM	10/13/94	4	737	9098	12	0	0.26	84	3	4	1	0	2.861	0	0	4	9	87
ASMI CI "C" FARM	10/13/94	5	769	9493	24	30	0.314	11	8	7	1	2.75	1.473	30	0	1	3	96







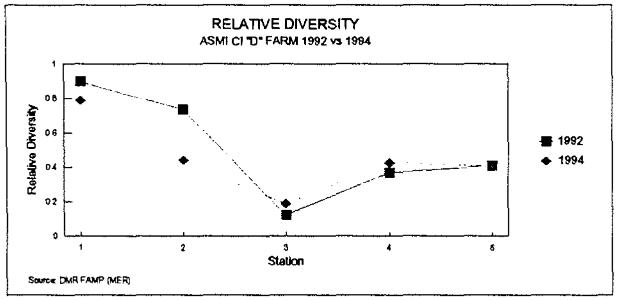


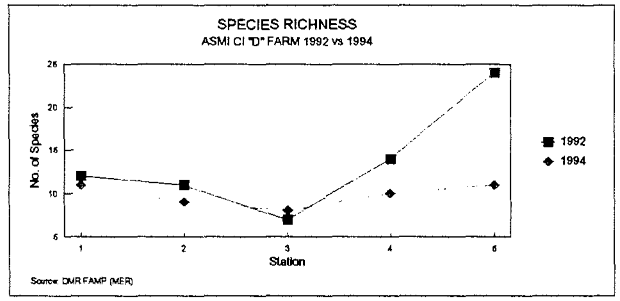


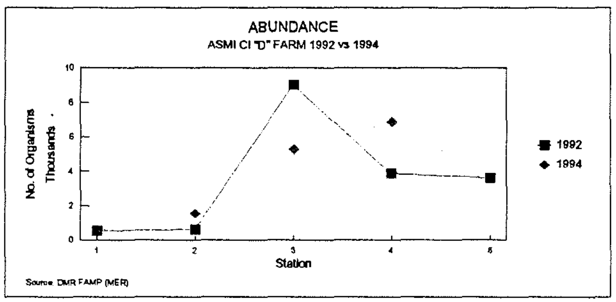
ASMI CI "D" FARM

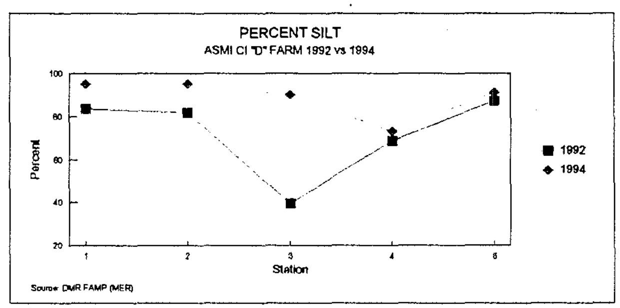
BENTHIC ANALYSIS 1992 vs 1994 DATA

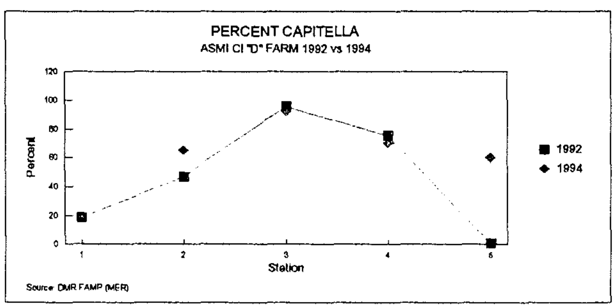
										DEPTHS IN CENTIMETERS					> #4	< #4–>#40	#40–>#200	<#200
SITE ID	DATE	STATION	TOTAL	ABUNDANCE	RICHNESS	DISTANCE	DIVERSITY	% C. cap	SR*RD	CORE	UMOL	RPDL	TOC	DISTANCE	GRAVEL	SAND	SAND(FINE)	SILT/CLAY
ASMI CI	10/12/92	1	43	531	12	30	0.9	18.6	10.8	10.5	0.5	0.5	1.59	30	0	11	5.5	83.5
ASMI CI	10/12/92	2	49	605	11	20	0.733	46.9	8.1	11	0.5	1.5	1.6	20	0	1.5	16.8	81.7
ASMI CI	10/12/92	3	730	9008	7	0	0.123	95.5	0.9	11	1.5	3	3.98	0	5.7	7.7	47.1	39.5
ASMI CI	10/12/92	4	310	3825	14	20	0.366	75.2	5.1	10.5	1	3.5	2.91	20	0	13.6	17.8	68.6
ASMI CI	10/12/92	5	292	3603	24	30	0.406	0.7	9.7	7	0	2	2.21	30	0	2.4	10.5	87.1
ASMI CI "D" F	10/14/94	1	43	531	11	30	0.788	19	9	9.0	2.5	4.0	1.75	30	0.0	1.0	4.0	95.0
ASMI CI "D" F	10/14/94	2	123	1518	9	0	0.439	65	4	8.5	6.0	0.0	3.36	0	0.0	2.0	3.0	95.0
ASMI CI "D" F	10/14/94	3	425	5247	8	0	0.187	92	1	8.0	3.0	0.0	12.31	0	0.0	2.0	8.0	90.0
ASMI CI "D" F	10/14/94	4	557	6876	10	0	0.424	70	4	6.5	3.0	0.0	2.96	0	0.0	3.0	24.0	73.0
ASMI CI "D" F	10/14/94	5	290	3580	11	30	0.404	60	4	4.5	2.0	1.5	2.61	30	0.0	3.0	6.0	91.0







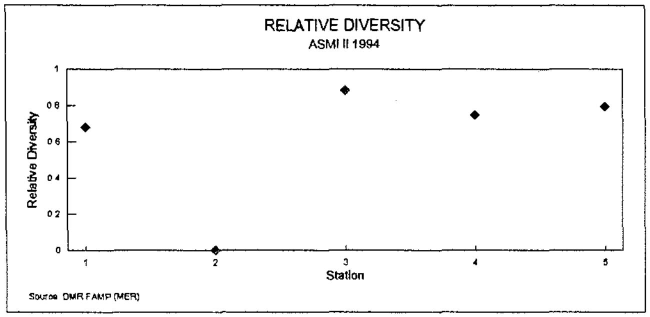


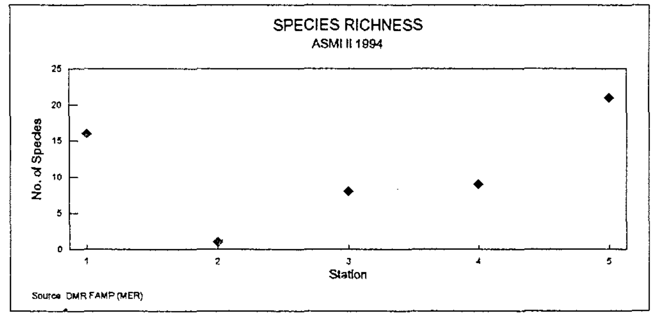


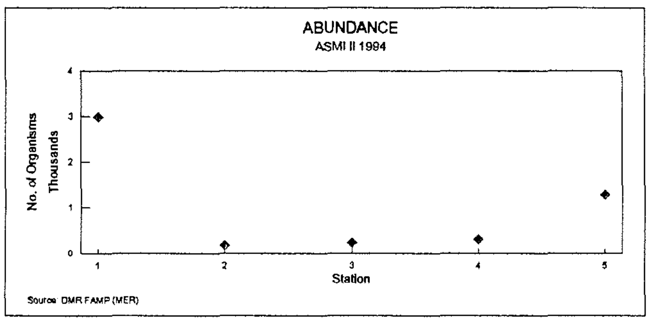
ASMI II

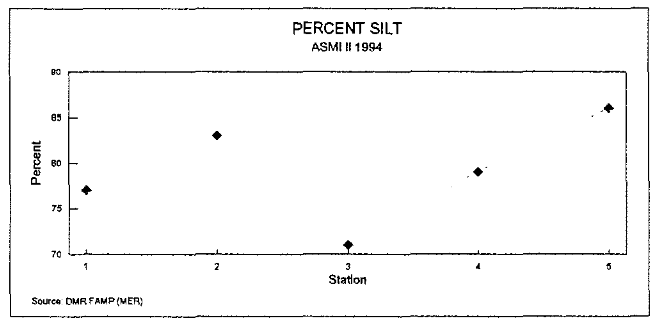
BENTHIC ANALYSIS 1994 DATA

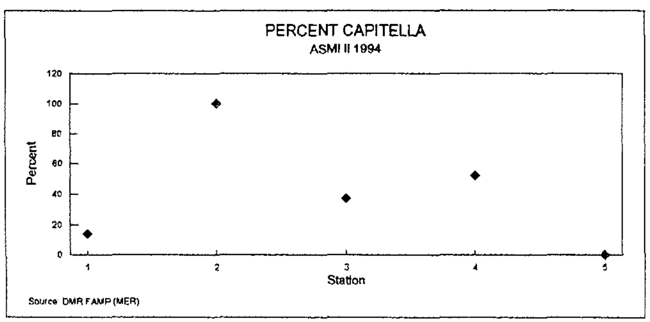
										DEPTHS IN CENTIMETERS					> #4	< #4-->#40	#40-->#200	<#200
SITE ID	DATE	STATION	TOTAL	ABUNDANCE	RICHNESS	DISTANCE	DIVERSITY	% C. cap	SR*RD	CORE	UMOL	RPDL	TOC	DISTANCE	GRAVEL	SAND	SAND(FINE)	SILT/CLAY
ASMI II	10/12/94	1	242	2987	16	30	0.680	14	11	6	0	1.25	0.651	30	0.000	0	23	77
ASMI II	10/12/94	2	14	173	1	0	0.000	100	0	4.5	0.5	0	0.834	0	0.000	0	17	83
ASMI II	10/12/94	3	19	235	8	0	0.883	37	7	6.5	0.875	0	0.546	0	0.000	0	29	71
ASMI II	10/12/94	4	25	309	9	0	0.747	52	7	4	0.5	0.5	0.875	0	0.000	1	20	79
ASMI II	10/12/94	5	104	1284	21	30	0.793	0	17	7	0.75	0.75	0.605	30	0	1	13	86







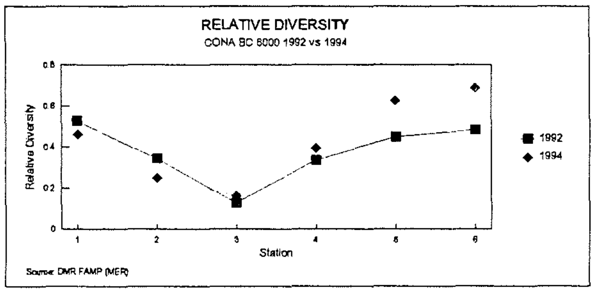


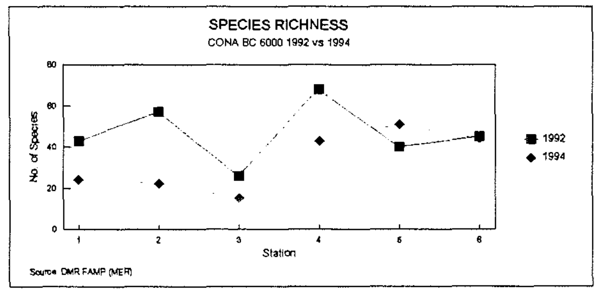


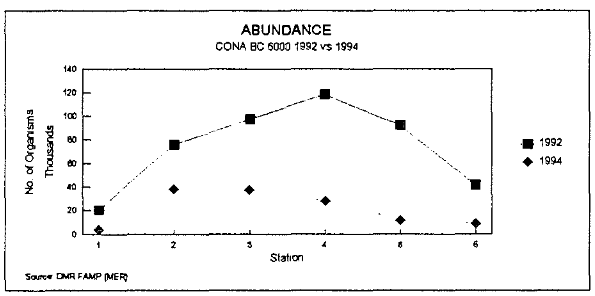
CONA BC 6000

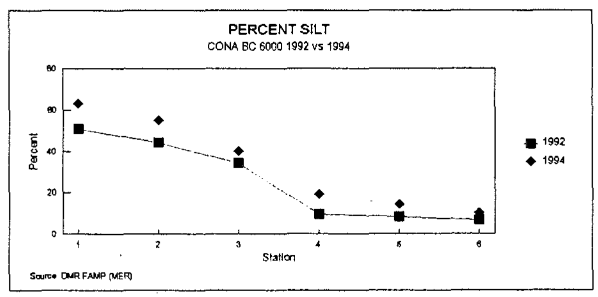
BENTHIC ANALYSIS 1992 vs 1994 DATA

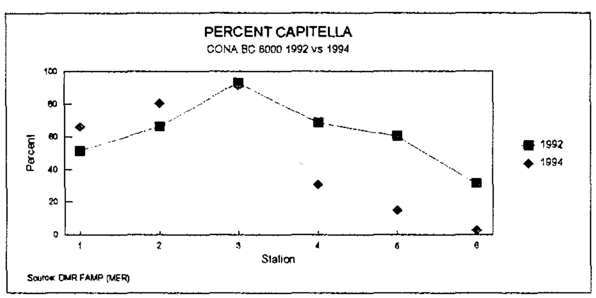
										DEPTHS IN CENTIMETERS					> #4	< #4-->#40	#40-->#200	<#200
SITE ID	DATE	STATION	TOTAL	BUNDANCE	RICHNESS	DISTANCE	DIVERSITY	% C. cap	SR*RD	CORE	UMOL	RPDL	TOC	DISTANCE	GRAVEL	SAND	SAND(FINE)	SILT/CLAY
CONA BC (60	10/06/92	1	1619	19978	43	60	0.527	51.3	22.7	8.5	0.5	2.7	3.46	60	0	14.8	34.4	50.8
CONA BC (60	10/06/92	2	6126	75595	57	30	0.344	66	19.6	7.5	2	0	4.2	30	0	4.3	51.3	44.4
CONA BC (60	10/06/92	3	7885	97301	26	0	0.125	93	3.3	10	2.5	0	8.08	0	0	20.6	45.2	34.2
CONA BC (60	10/06/92	4	9595	118402	68	0	0.333	68.5	22.6	7	1.3	3	3.87	0	49	20.1	21.7	9.2
CONA BC (60	10/06/92	5	7498	92525	40	30	0.449	60.4	17.9	7	1.3	3	2.28	30	47.2	22.6	22	8.2
CONA BC (60	10/06/92	6	3355	41401	45	60	0.481	31.4	21.7	10	0.5	3	2.22	60	63.8	15.4	14.2	6.6
CONA BC (60	09/27/94	1	317	3913	24	60	0.462	66	11	10.5	0.5	2.5	2.46	60	0.0	6.0	31.0	63.0
CONA BC (60	09/27/94	2	3052	37677	22	30	0.249	80	5	4.0	1.8	0.0	4.17	30	0.0	9.0	36.0	55.0
CONA BC (60	09/27/94	3	3038	37504	15	0	0.161	91	2	10.0	1.3	0.0	3.50	0	0.0	16.0	44.0	40.0
CONA BC (60	09/27/94	4	2251	27789	43	0	0.391	31	17	5.0	0.7	1.5	1.65	0	5.0	36.0	40.0	19.0
CONA BC (60	09/27/94	5	921	11370	51	30	0.625	15	32	4.0	0.5	1.5	2.22	30	26.0	32.0	28.0	14.0
CONA BC (60	09/27/94	6	677	8358	44	60	0.687	3	30	3.0	0.0	3.0	0.83	60	17.0	45.0	28.0	10.0







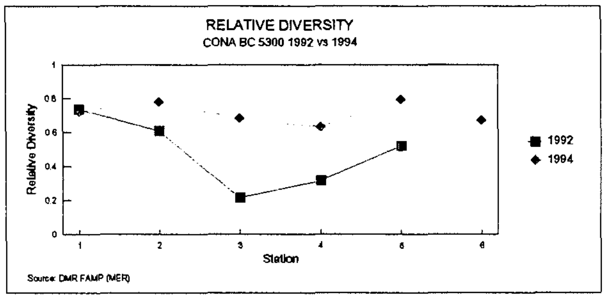




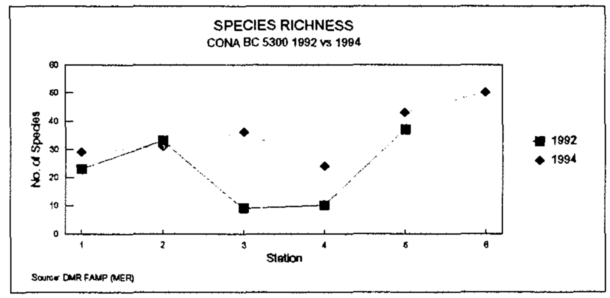
CONA BC 5300

BENTHIC ANALYSIS 1992 vs 1994 DATA

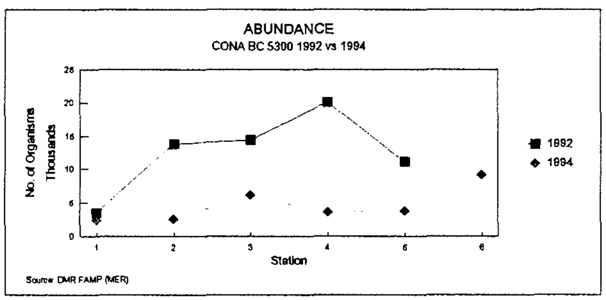
SITE ID	DATE	STATION	TOTAL	ABUNDANCE	RICHNESS	DISTANCE	DIVERSITY	% C. cap	SR*RD	DEPTHS IN CENTIMETERS CORE	UMOL	RPDL	TOC	DISTANCE	> #4 GRAVEL	< #4-->#40 SAND	#40-->#200 SAND(FINE)	<#200 SILT/CLAY
CONA BC (53	10/06/92	1	283	3492	23	70	0.736	7.1	16.9	14	0.3	3	3.3	70	0	1.1	11.6	87.3
CONA BC (53	10/06/92	2	1119	13808	33	30	0.609	32	20.1	6	2.7	0	8.06	30	0	1.2	34.2	64.6
CONA BC (53	10/06/92	3	1167	14401	9	0	0.216	89	1.9	8	3	0	4.59	0	0	24.4	30.4	45.2
CONA BC (53	10/06/92	4	1629	20102	10	0	0.314	79	3.1	9	2.5	0	5.19	0	0	10	33.1	56.9
CONA BC (53	10/06/92	5	898	11081	37	30	0.519	30.6	19.2	9.5	1.5	N/A	3.13	30	0	6.1	14.6	79.3
CONA BC (53	09/27/94	1	198	2444	29	60	0.725	8	21	6.5	0.5	3.8	1.98	60	2.0	7.0	37.0	54.0
CONA BC (53	09/27/94	2	205	2531	31	30	0.777	13	24	8.5	0.8	1.0	1.54	30	18.0	21.0	30.0	31.0
CONA BC (53	09/27/94	3	497	6135	36	0	0.682	5	25	10.5	1.0	1.5	2.39	0	27.0	15.0	27.0	31.0
CONA BC (53	09/27/94	4	287	3543	24	0	0.629	10	15	7.0	0.0	1.3	0.86	0	0.0	24.0	18.0	58.0
CONA BC (53	09/27/94	5	304	3753	43	30	0.792	1	34	8.5	0.0	8.5	0.98	30	25.0	26.0	17.0	32.0
CONA BC (53	09/27/94	6	745	9197	50	60	0.670	0	34	9.5	0.3	3.0	NT	60	12.0	17.0	32.0	39.0



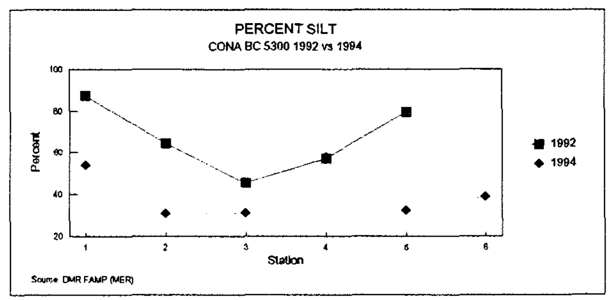
RELATIVE DIVERSITY
CONA BC 5300 1992 vs 1994



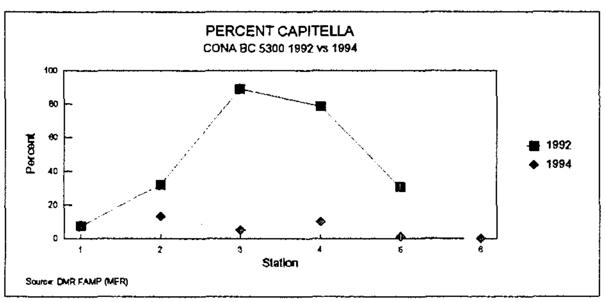
SPECIES RICHNESS
CONA BC 5300 1992 vs 1994



ABUNDANCE
CONA BC 5300 1992 vs 1994



PERCENT SILT
CONA BC 5300 1992 vs 1994

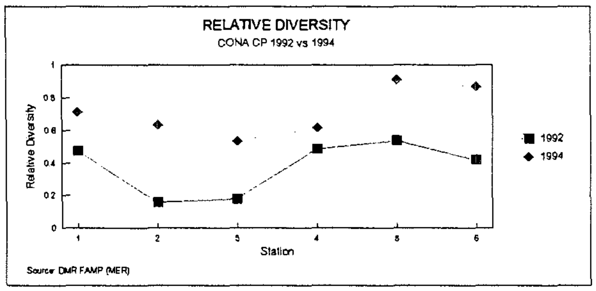


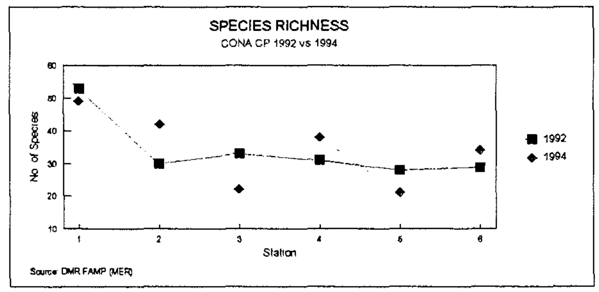
PERCENT CAPITELLA
CONA BC 5300 1992 vs 1994

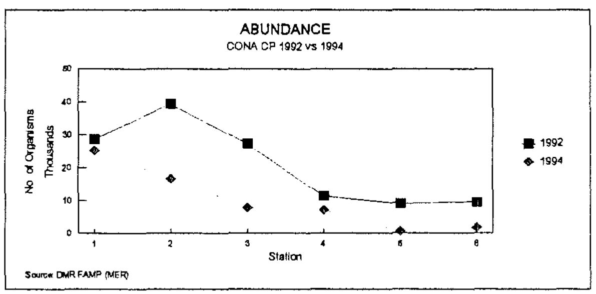
CONA CP

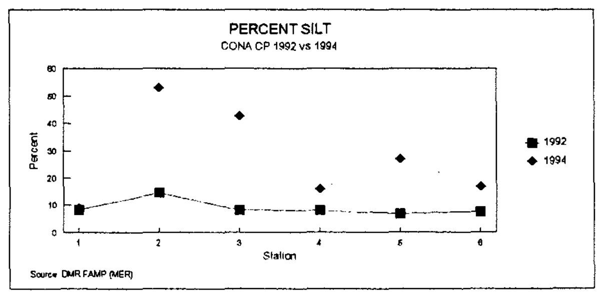
BENTHIC ANALYSIS 1992 vs 1994 DATA

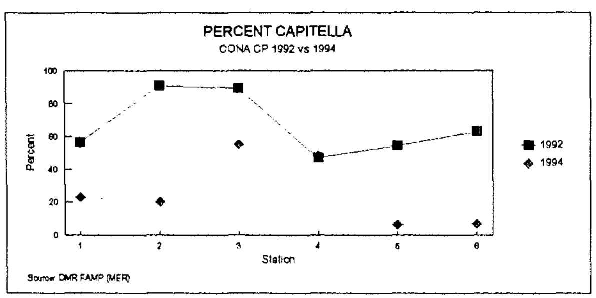
										DEPTHS IN CENTIMETERS					> #4	< #4-->#40	#40-->#200	<#200
SITE ID	DATE	STATION	TOTAL	BUNDANCE	RICHNESS	DISTANCE	DIVERSITY	% C. cap	SR*RD	CORE	UMOL	RPDL	TOC	DISTANCE	GRAVEL	SAND	SAND(FINE)	SILT/CLAY
CONA CP	10/05/92	1	2324	28678	53	50	0.472	56.2	25	11.5	1.5	5.3	1.44	50	40.8	29.2	21.9	8.1
CONA CP	10/05/92	2	3196	39439	30	25	0.158	91.1	4.7	12	2.3	0	8.15	25	31.8	37.5	16.1	14.6
CONA CP	10/05/92	3	2213	27308	33	0	0.176	89.5	5.8	3.5	3.5	N-T	5.32	0	51.4	25.1	15.4	8.1
CONA CP	10/05/92	4	923	11390	31	0	0.485	46.7	15	8.5	1.5	3	0.9	0	12.7	45.3	34.1	7.9
CONA CP	10/05/92	5	732	9033	28	30	0.535	54.5	15	5.8	3.5	6	2.48	30	18.6	47.3	27.3	6.8
CONA CP	10/05/92	6	775	9564	29	60	0.417	63.1	12.1	N-T	N-T	N-T	1.83	60	22	42.3	28	7.7
CONA CP	09/25/94	1	2043	25221	49	60	0.714	23	35	3.5	0.0	3.5	0.86	60	20.0	33.0	38.0	9.0
CONA CP	09/25/94	2	1355	16727	42	30	0.636	20	27	8.0	1.3	4.5	1.83	30	1.0	23.0	23.0	53.0
CONA CP	09/25/94	3	640	7901	22	0	0.534	55	12	11.0	1.0	1.5	2.93	0	3.0	16.0	38.0	43.0
CONA CP	09/25/94	4	562	6938	38	0	0.613	48	23	4.0	0.3	1.8	0.91	0	38.0	25.0	21.0	16.0
CONA CP	09/25/94	5	46	568	21	30	0.909	7	19	4.5	0.3	1.5	1.52	30	27.0	25.0	21.0	27.0
CONA CP	09/25/94	6	137	1691	34	60	0.868	7	30	5.0	0.0	5.0	0.75	60	44.0	24.0	15.0	17.0







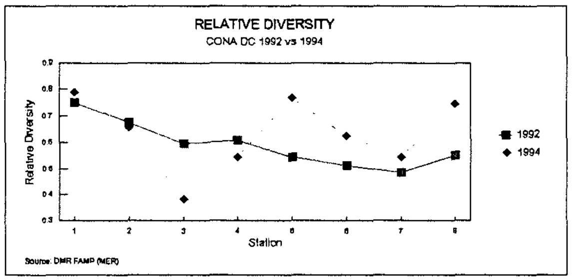


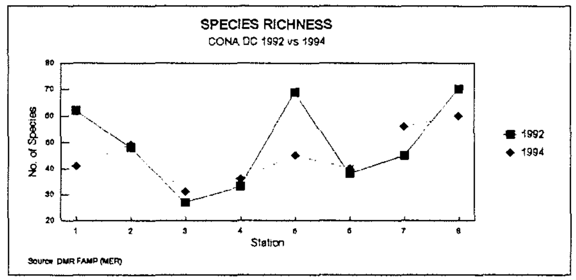


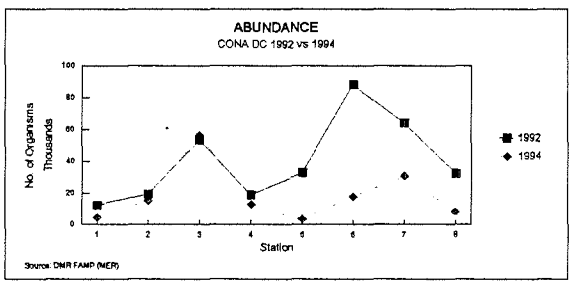
CONA DC

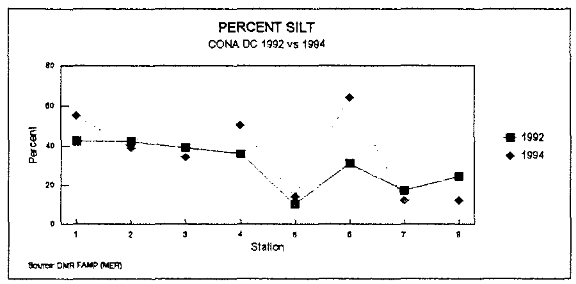
BENTHIC ANALYSIS 1992 vs 1994 DATA

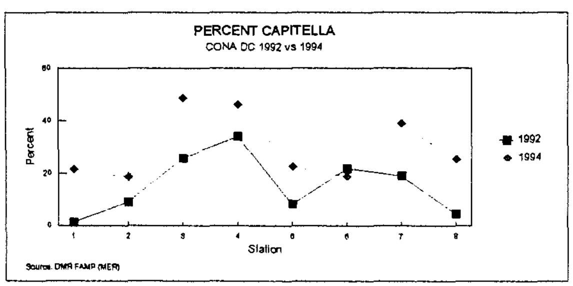
SITE ID	DATE	STATION	TOTAL	ABUNDANCE	RICHNESS	DISTANCE	DIVERSITY	% C. cap	SR*RD	DEPTHS IN CENTIMETERS CORE	UMOL	RPDL	TOC	DISTANCE	> #4 GRAVEL	< #4-->#40 SAND	#40-->#200 SAND(FINE)	<#200 SILT/CLAY
CONA DC	10/07/92	1	998	12315	62	60	0.749	1.3	46.5	10.5	0.5	4	2.11	60	0	14.5	43.2	42.3
CONA DC	10/07/92	2	1564	19300	48	30	0.675	9.1	32.4	9	1	2	1.73	30	0	19.4	38.4	42.2
CONA DC	10/07/92	3	4336	53506	27	0	0.595	25.7	16.1	7	1	7	4.53	0	0	21.9	39.3	38.8
CONA DC	10/07/92	4	1521	18769	33	25	0.606	33.9	20	10	1.3	3.5	3.2	25	0	16.1	48.1	35.8
CONA DC	10/07/92	5	2643	32615	69	25	0.544	8.3	37.6	8	2	8	1.4	25	33.6	34.9	21.3	10.2
CONA DC	10/07/92	6	7168	88453	38	0	0.512	21.7	19.5	7.5	1.5	NA	4.7	0	0	15.7	53.5	30.8
CONA DC	10/07/92	7	5186	63995	45	25	0.485	19	21.8	7.5	2.5	5	3.95	25	8	12.5	62.5	17
CONA DC	10/07/92	8	2633	32491	70	50	0.552	4.9	38.7	11.5	0.5	4.5	2.62	50	0	38.1	37.8	24.1
CONA DC	09/28/94	1	360	4444	41	60	0.788	21	32	8.0	1.8	5.0	1.64	60	0.0	10.0	35.0	55.0
CONA DC	09/28/94	2	1203	14851	49	30	0.657	19	32	10.0	1.5	3.8	2.94	30	0.0	8.0	53.0	39.0
CONA DC	09/28/94	3	4574	56466	31	0	0.384	49	12	8.0	1.8	1.0	4.08	0	0.0	6.0	60.0	34.0
CONA DC	09/28/94	4	1028	12691	36	30	0.544	46	20	10.0	0.8	3.0	3.46	30	0.0	10.0	40.0	50.0
CONA DC	09/28/94	5	245	3025	45	30	0.768	22	35	3.0	0.3	0.0	1.29	30	0.0	51.0	35.0	14.0
CONA DC	09/28/94	6	1418	17505	40	0	0.623	19	25	5.0	0.0	4.5	0.77	0	0.0	4.0	32.0	64.0
CONA DC	09/28/94	7	2480	30616	56	30	0.543	39	30	2.5	0.0	0.0	1.21	30	0.0	34.0	54.0	12.0
CONA DC	09/28/94	8	652	8049	60	60	0.744	25	45	7.0	0.3	3.0	1.18	60	0.0	33.0	55.0	12.0







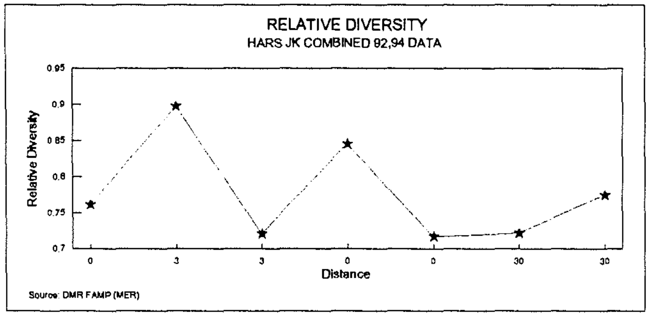


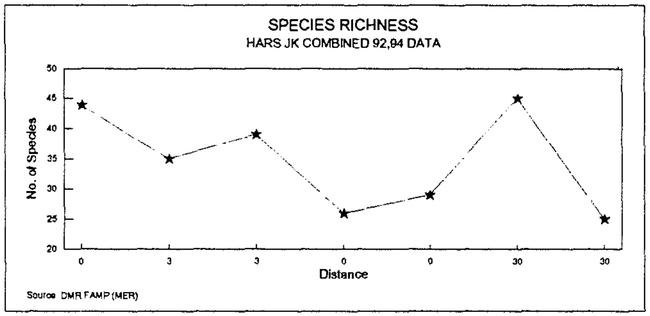


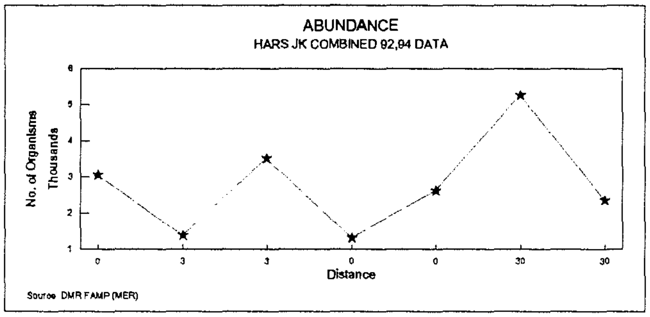
HARS JK

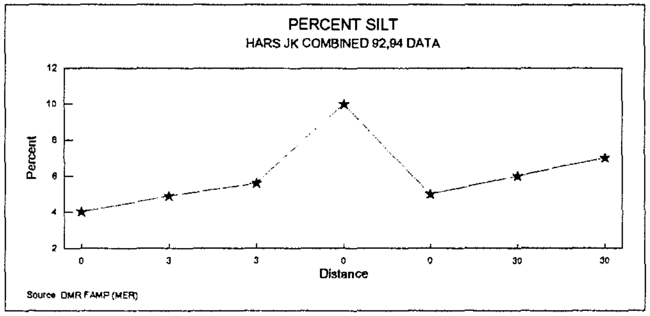
BENTHIC ANALYSIS 1992,1994 COMBINED DATA

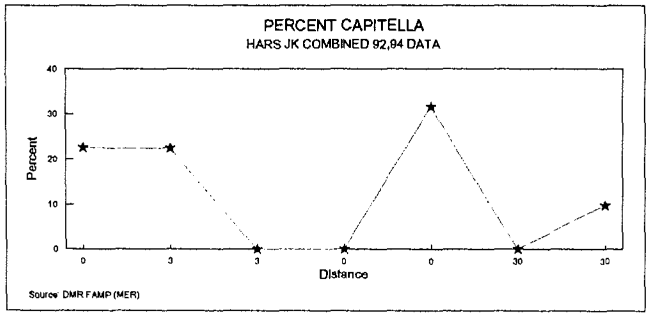
										DEPTHS IN CENTIMETERS					> #4	< #4-->#40	#40-->#200	<#200
SITE ID	DATE	STATION	TOTAL	ABUNDANCE	RICHNESS	DISTANCE	DIVERSITY	% C. cap	SR*RD	CORE	UMOL	RPDL	TOC	DISTANCE	GRAVEL	SAND	SAND(FINE)	SILT/CLAY
HARS JK	10/04/92	2	248	3060	44	0	0.761	22.6	33.5	11	0.3	1	0.51	0	50.4	22.9	22.7	4
HARS JK	10/04/92	1	111	1370	35	3	0.897	22.5	31.4	10.5	0	>5.0	0.64	3	53.7	22	19.4	4.9
HARS JK	10/04/92	3	285	3517	39	3	0.721	0	28.1	11	0	>5.0	0.74	3	48.2	24.9	21.3	5.6
HARS JK	09/25/94	2	106	1309	26	0	0.846	0	22	6.5	0.3	3.3	0.78	0	27.0	43.0	20.0	10.0
HARS JK	09/25/94	3	212	2617	29	0	0.716	32	21	8.5	0.5	1.0	0.98	0	21.0	56.0	18.0	5.0
HARS JK	09/25/94	1	427	5271	45	30	0.722	0	32	8.0	0.0	8.0	0.67	30	17.0	35.0	42.0	6.0
HARS JK	09/25/94	4	191	2358	25	30	0.775	10	19	9.0	0.0	2.0	0.86	30	33.0	47.0	13.0	7.0







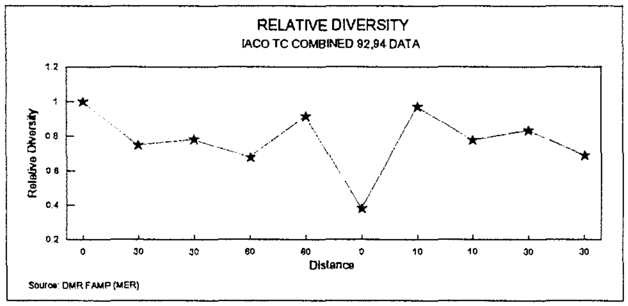


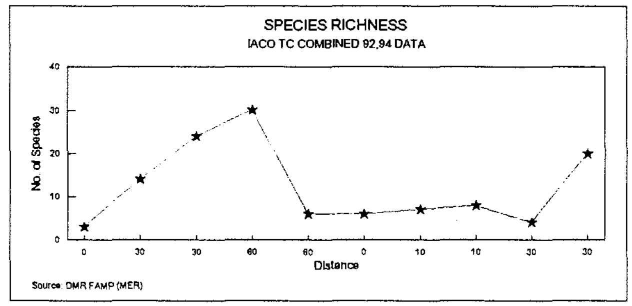


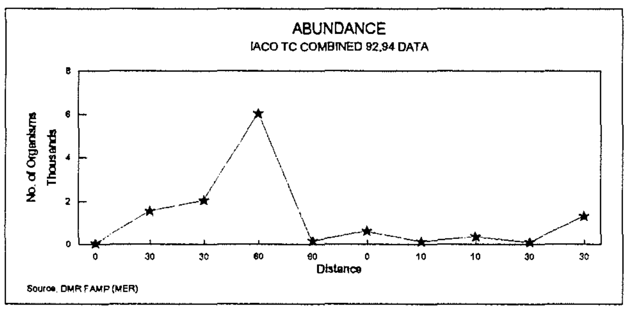
MPLT/IACO TC

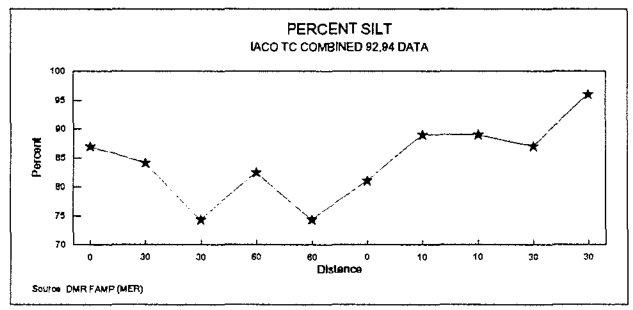
BENTHIC ANALYSIS 1992,1994 COMBINED DATA

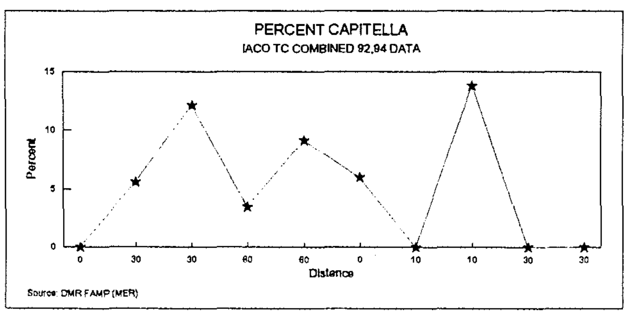
										DEPTHS IN CENTIMETERS					> #4	< #4-->#40	#40-->#200	<#200
SITE ID	DATE	STATION	TOTAL	BUNDANCE	RICHNESS	DISTANCE	DIVERSITY	% C. cap	SR*RD	CORE	UMOL	RPDL	TOC	DISTANCE	GRAVEL	SAND	SAND(FINE)	SILT/CLAY
MPLT TC	10/20/92	3	3	37	3	0	1	0	3	5.5	2	0	0.94	0	0	0.6	12.4	87
MPLT TC	10/20/92	4	124	1530	14	30	0.747	5.6	10.5	10.5	0.8	0	0.75	30	0	0.9	15	84.1
MPLT TC	10/20/92	2	165	2036	24	30	0.781	12.1	18.7	9	0.3	1	1.02	30	0	2.6	23.1	74.3
MPLT TC	10/20/92	5	488	6022	30	60	0.677	3.5	20.3	11	11	2.5	1.12	60	0	0.8	16.7	82.5
MPLT TC	10/20/92	1	11	136	6	60	0.916	9.1	5.5	7	0.3	1.5	1.42	60	0	3.3	22.4	74.3
IACO TC	10/27/94	3	50	617	6	0	0.379	6	2	5.5	3.8	0.0	6.89	0	0.0	1.0	18.0	81.0
IACO TC	10/27/94	4	9	111	7	10	0.971	0	7	6.5	0.5	1.5	1.39	10	0.0	1.0	10.0	89.0
IACO TC	10/27/94	2	29	358	8	10	0.777	14	6	5.5	2.0	0.0	1.34	10	0.0	1.0	10.0	89.0
IACO TC	10/27/94	5	7	86	4	30	0.832	0	3	6.0	0.5	1.5	1.92	30	0.0	3.0	10.0	87.0
IACO TC	10/27/94	1	106	1309	20	30	0.687	0	14	7.0	0.0	2.0	1.24	30	0.0	0.0	4.0	96.0







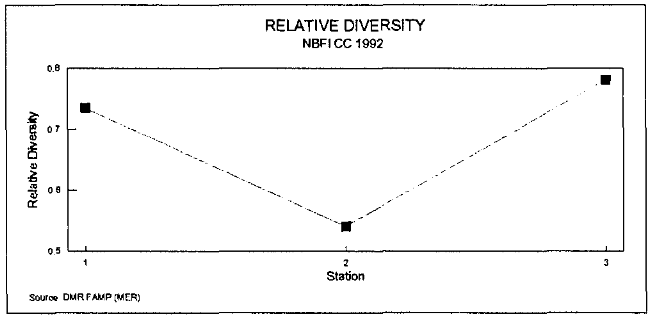


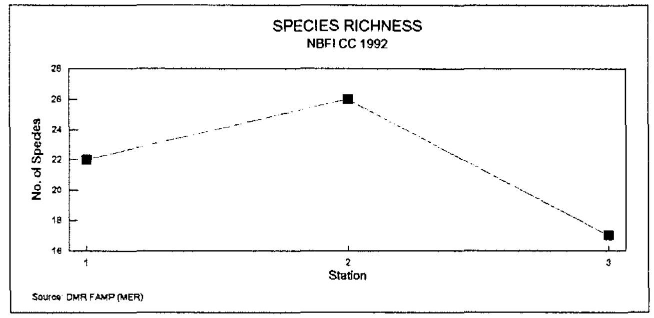


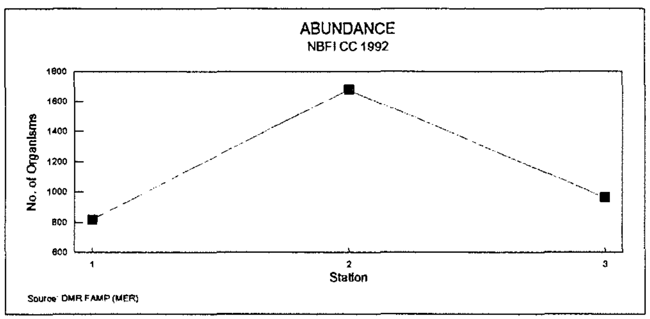
NBFI CC

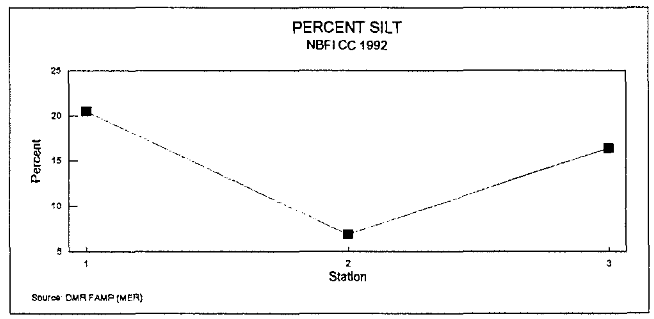
BENTHIC ANALYSIS 1992 DATA

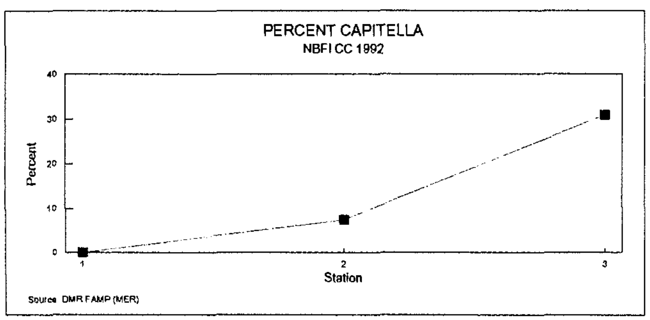
										DEPTHS IN CENTIMETERS					> #4	< #4-->#40	#40-->#200	<#200
SITE ID	DATE	STATION	TOTAL	ABUNDANCE	RICHNESS	DISTANCE	DIVERSITY	% C. cap	SR*RD	CORE	UMOL	RPDL	TOC	DISTANCE	GRAVEL	SAND	SAND(FINE)	SILT/CLAY
NBFI CC	10/09/92	1	66	814	22	20	0.735	0	16.2	3.5	>3.5	>3.5	0.93	20	28	39.3	12.2	20.5
NBFI CC	10/09/92	2	136	1678	26	0	0.54	7.4	14.1	8	0.8	0	1.62	0	67.9	14.8	10.4	6.9
NBFI CC	10/09/92	3	78	963	17	20	0.781	30.8	13.3	4	>4.0	>4.0	1.53	20	40.9	21.4	21.4	16.3







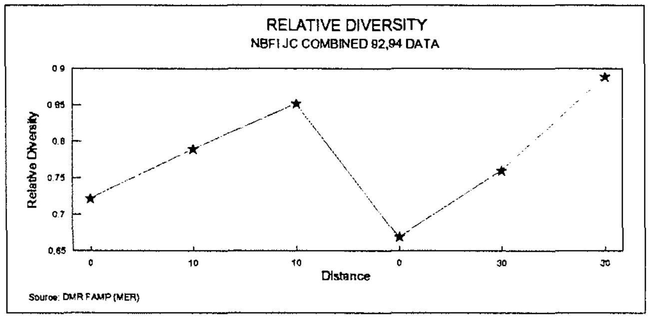


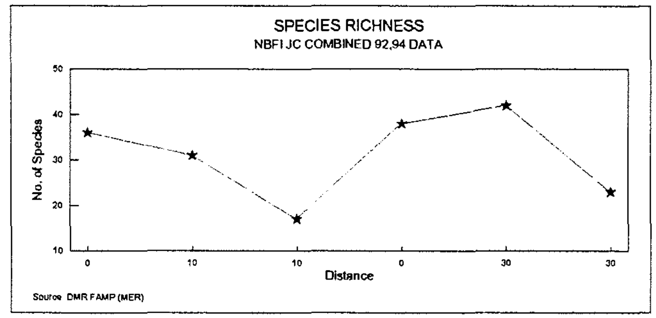


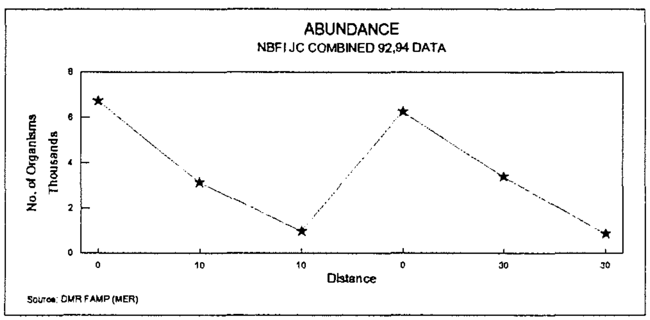
NBFI JC

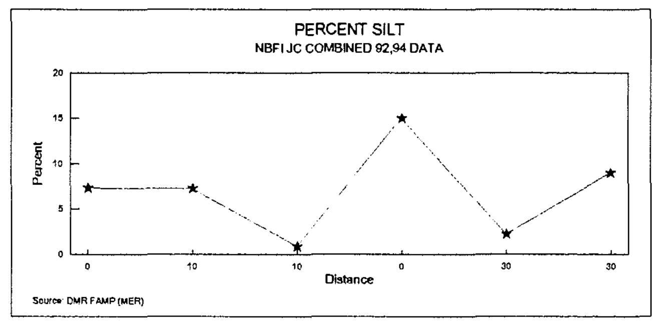
BENTHIC ANALYSIS 1992,1994 COMBINED DATA

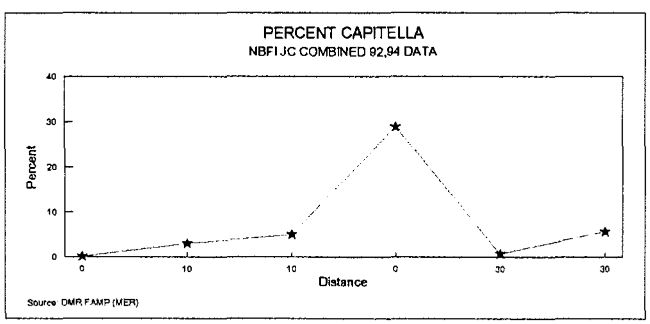
										DEPTHS IN CENTIMETERS					> #4	< #4->#40	#40->#200	<#200
SITE ID	DATE	STATION	TOTAL	ABUNDANCE	RICHNESS	DISTANCE	DIVERSITY	% C. cap	SR*RD	CORE	UMOL	RPDL	TOC	DISTANCE	GRAVEL	SAND	SAND(FINE)	SILT/CLAY
NBFI JC	10/04/92	2	546	6738	36	0	0.721	0.2	26	8	0.5	>8.0	2.28	0	24.6	14.2	53.8	7.4
NBFI JC	10/04/92	1	255	3147	31	10	0.789	3.1	24.5	4	0.3	>4.0	2.22	10	16.5	9.8	66.4	7.3
NBFI JC	10/04/92	3	79	975	17	10	0.852	5.1	14.5	9	0	>9.0	3.87	10	88.2	3.2	7.7	0.9
NBFI JC	09/25/94	2	505	6259	38	0	0.669	29	25	7.0	0.0	2.5	1.20	0	0.0	29.0	56.0	15.0
NBFI JC	09/25/94	1	276	3407	42	30	0.760	1	32	1.5	0.0	1.5	1.77	30	0.0	13.0	84.8	2.2
NBFI JC	09/25/94	3	70	864	23	30	0.888	6	20	5.0	0.0	5.0	0.39	30	0.0	10.0	81.0	9.0







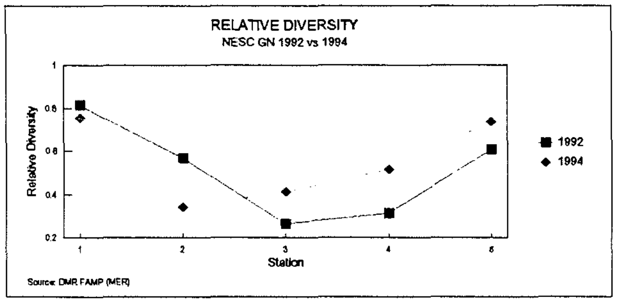


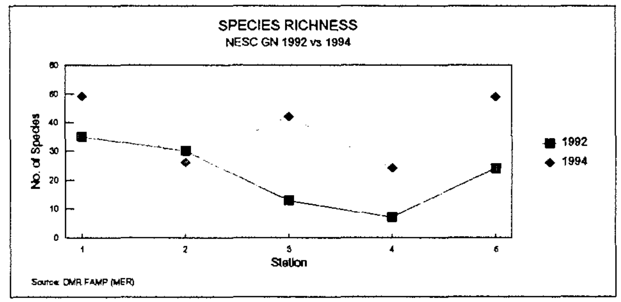


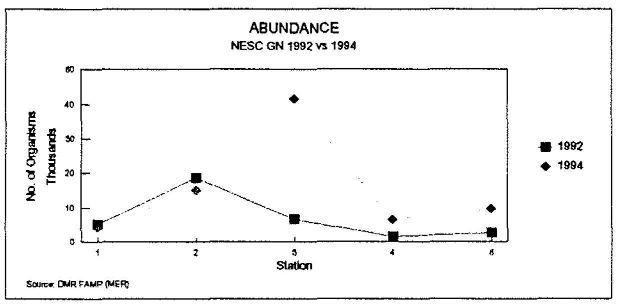
NESC GN

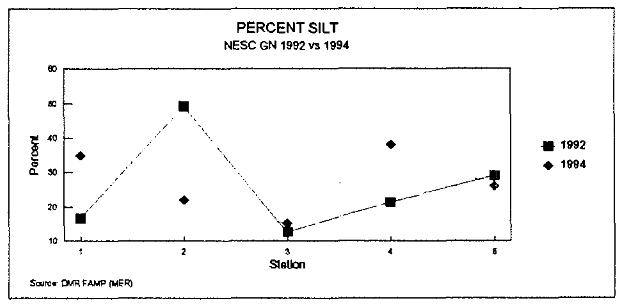
BENTHIC ANALYSIS 1992 vs 1994 DATA

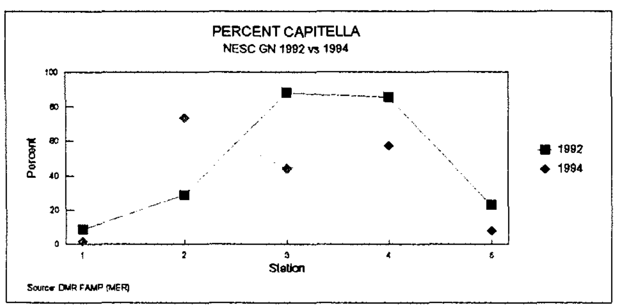
SITE ID	DATE	STATION	TOTAL	ABUNDANCE	RICHNESS	DISTANCE	DIVERSITY	% C. cap	SR*RD	DEPTHS IN CENTIMETERS CORE	UMOL	RPDL	TOC	DISTANCE	> #4 GRAVEL	< #4-->#40 SAND	#40-->#200 SAND(FINE)	<#200 SILT/CLAY
NESC GN	10/09/92	1	387	4776	35	30	0.814	8.8	28.5	7	0.3	7	1.91	30	0	11.1	72.3	16.6
NESC GN	10/09/92	2	1505	18572	30	3	0.567	28.6		11.5	2.5	4	4.82	3	0	6.4	44.5	49.1
NESC GN	10/09/92	3	527	6503	13	0	0.264	87.9	3.4	10	1.5	5	0.97	0	45.3	23.5	18.6	12.6
NESC GN	10/09/92	4	123	1518	7	3	0.312	85.4	2.2	8.5	2	0	0.73	3	31.2	14.2	33.3	21.3
NESC GN	10/09/92	5	215	2653	24	30	0.608	22.8	14.6	10.5	0.5	5.5	1.77	30	0	47.4	23.6	29
NESC GN	09/27/94	1	333	4111	49	30	0.755	2	37	10.0	0.3	5.0	1.24	30	14.0	29.0	22.0	35.0
NESC GN	09/27/94	2	1212	14962	26	0	0.339	73	9	7.5	0.3	3.0	0.52	0	21.0	17.0	40.0	22.0
NESC GN	09/27/94	3	3363	41516	42	0	0.412	44	17	6.0	0.3	0.0	1.28	0	33.0	26.0	26.0	15.0
NESC GN	09/27/94	4	509	6284	24	0	0.513	57	12	7.5	0.5	1.0	2.83	0	0.0	2.0	60.0	38.0
NESC GN	09/27/94	5	765	9444	49	30	0.736	8	36	10.0	0.0	10.0	0.86	30	2.0	2.0	70.0	26.0







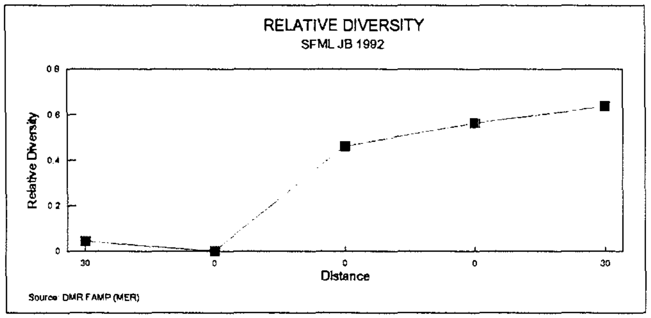


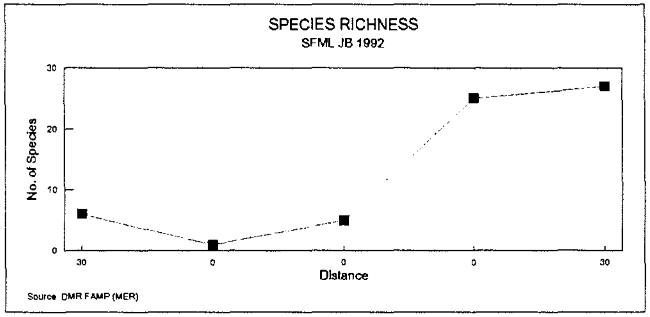


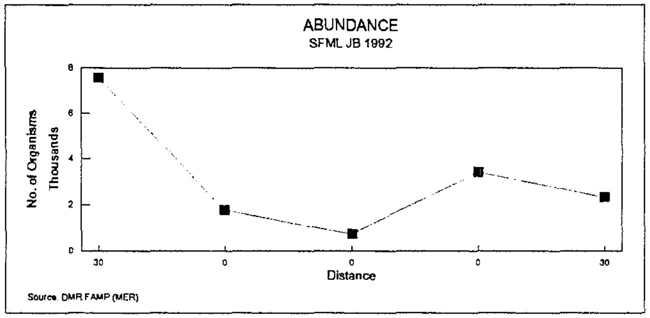
SFML JB

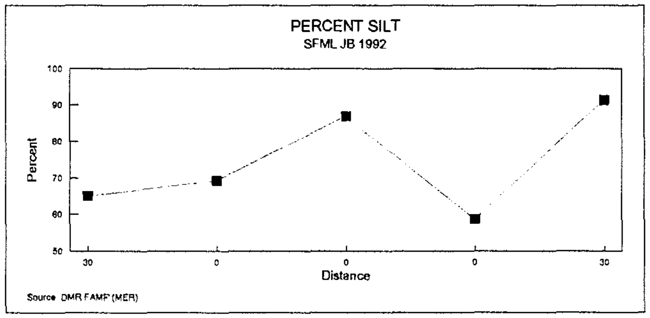
BENTHIC ANALYSIS 1992 DATA

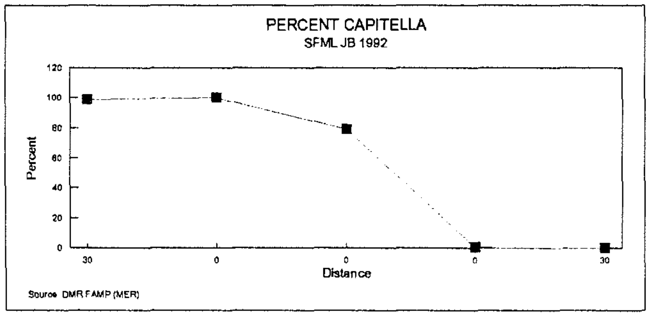
SITE ID	DATE	STATION	TOTAL	ABUNDANCE	RICHNESS	DISTANCE	DIVERSITY	% C. cap	SR*RD	DEPTHS IN CENTIMETERS CORE	UMOL	RPDL	TOC	DISTANCE	> #4 GRAVEL	< #4-->#40 SAND	#40-->#200 SAND(FINE)	<#200 SILT/CLAY
SFML JB	10/08/92	6	614	7577	6	30	0.044	98.9	0.3	10.5	1.5	5.8	3.36	30	0	4.4	30.5	65.1
SFML JB	10/08/92	7	144	1777	1	0	0	100	0	7	2	4	3.69	0	0	6	24.7	69.3
SFML JB	10/08/92	8	58	716	5	0	0.462	79.3	2.3	9.5	1.3	4.3	2.64	0	0	6.7	6.4	86.9
SFML JB	10/08/92	9	279	3443	25	0	0.564	0.4	14.1	15	0.5	4	1.53	0	0	26.8	14.3	58.9
SFML JB	10/08/92	10	191	2357	27	30	0.638	0	17.2	9	9	6	1.61	30	0	5.3	3.4	91.3







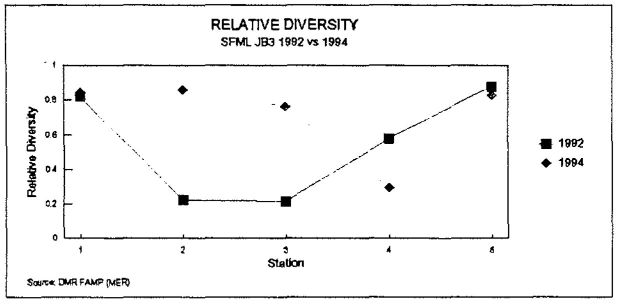


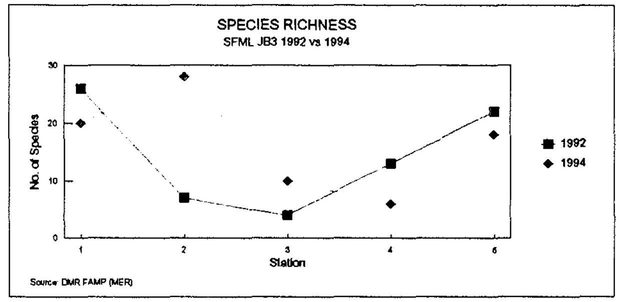


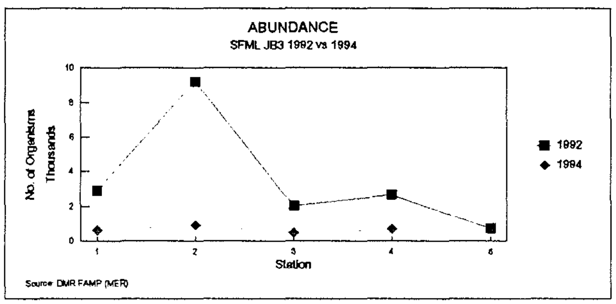
SFML JB3

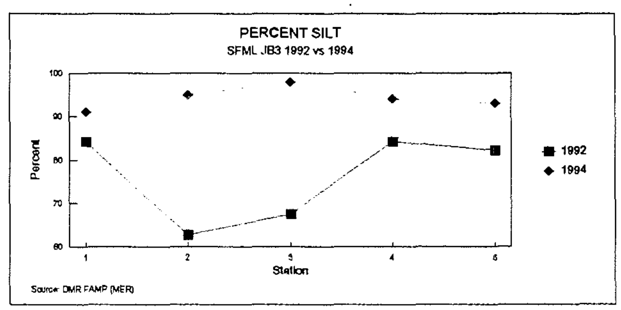
BENTHIC ANALYSIS 1992 vs 1994 DATA

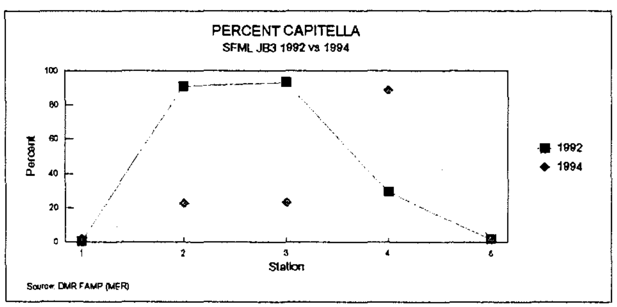
										DEPTHS IN CENTIMETERS					> #4	< #4-->#40	#40-->#200	<#200
SITE ID	DATE	STATION	TOTAL	ABUNDANCE	RICHNESS	DISTANCE	DIVERSITY	% C. cap	SR*RD	CORE	UMOL	RPDL	TOC	DISTANCE	GRAVEL	SAND	SAND(FINE)	SILT/CLAY
SFML JB	10/08/92	1	234	2888	26	30	0.819	0.4	21.3	10.5	10.5	7	1.56	30	0	4.7	11.2	84.1
SFML JB	10/08/92	2	745	9193	7	0	0.224	90.7	1.6	10	0.5	1.3	3.27	0	0	4.7	32.6	62.7
SFML JB	10/08/92	3	163	2011	4	0	0.215	93.3	0.9	9.5	1.3	0	4.75	0	0	3	29.5	67.5
SFML JB	10/08/92	4	216	2665	13	0	0.576	29.2	7.5	11	0.8	1.5	1.91	0	0	1	14.8	84.2
SFML JB	10/08/92	5	57	703	22	30	0.877	1.8	19.3	13.5	0.5	4.5	1.92	30	0	6.5	11.3	82.2
SFML JB3	09/29/94	1	47	580	20	30	0.844	2	17	9.5	0.5	2.5	1.59	60	0.0	4.0	5.0	91.0
SFML JB3	09/29/94	2	71	876	28	0	0.858	23	24	8.5	1.0	4.0	1.73	30	0.0	1.0	4.0	95.0
SFML JB3	09/29/94	3	35	432	10	0	0.765	23	8	9.0	1.3	0.0	2.51	0	0.0	1.0	1.0	98.0
SFML JB3	09/29/94	4	53	654	6	0	0.296	89	2	12.0	0.3	0.5	1.76	0	1.0	3.0	2.0	94.0
SFML JB3	09/29/94	5	53	654	18	30	0.828	2	15	9.0	0.3	5.5	1.53	30	1.0	1.0	5.0	93.0











TISF HI

BENTHIC ANALYSIS 1994 DATA

										DEPTHS IN CENTIMETERS					> #4	< #4-->#40	#40-->#200	<#200
SITE ID	DATE	STATION	TOTAL	ABUNDANCE	RICHNESS	DISTANCE	DIVERSITY	% C. cap	SR*RD	CORE	UMOL	RPDL	TOC	DISTANCE	GRAVEL	SAND	SAND(FINE)	SILT/CLAY
TISF HI	10/21/94	1	79	975	4	0	0.544	14	2	10.0	0.0	0.0	1.68	0	0.0	1.0	10.0	89.0
TISF HI	10/21/94	2	173	2136	12	30	0.291	6	3	12.0	0.0	1.8	2.12	30	0.0	3.0	18.0	79.0
TISF HI	10/21/94	3	117	1444	13	60	0.496	4	6	9.5	0.0	9.5	1.72	60	0.0	4.0	14.0	82.0
TISF HI	10/21/94	4	104	1284	8	0	0.421	6	3	9.5	0.0	4.0	1.17	0	4.0	5.0	39.0	52.0
TISF HI	10/21/94	5	187	2309	31	60	0.766	6	24	8.5	0.0	3.5	0.61	60	33.0	20.0	24.0	23.0