SALMON AQUACULTURE MONITORING AND RESEARCH FUND

Report to the
Joint Standing Committee on Marine Resources
as required by
12 MRSA §6078, Sub§ 5.B.

Submitted by:

The Maine Department of Marine Resources

Salmon Aquaculture Monitoring and Research Fund
Report to the
Joint Standing Committee on Marine Resources

Table of Contents

Maine Department of Marine Resources

Aquaculture Program Summary Report

February 9, 1994

by: Laurice U. Churchill

Summary

- A unified monitoring program had been implemented.
- Benthic impacts are minimal at 2/3rds of the leases.
- We believe our assessment methods are reasonable and fair.
- Modifications to the program are recommended.
- Program approval would not require increased fees.

Outline

Industry Status

The Maine finfish aquaculture leaseholders began reporting monthly harvest data officially to the Department of Marine Resources (DMR) July 1991 (fig. 1).

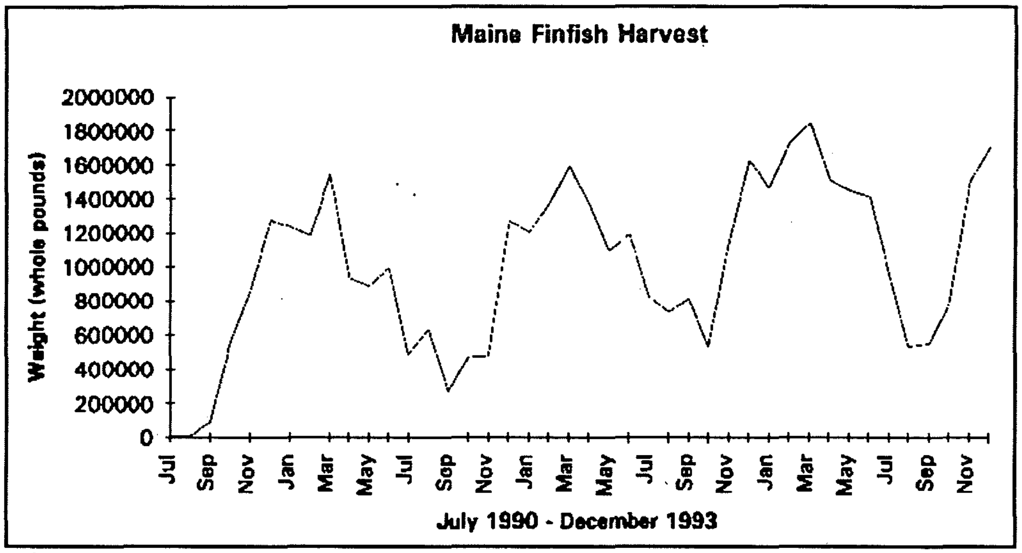


figure 1.

The 1993 annual finfish harvest increased by 2 million pounds to approximately 15.6 million pounds (fig 2).

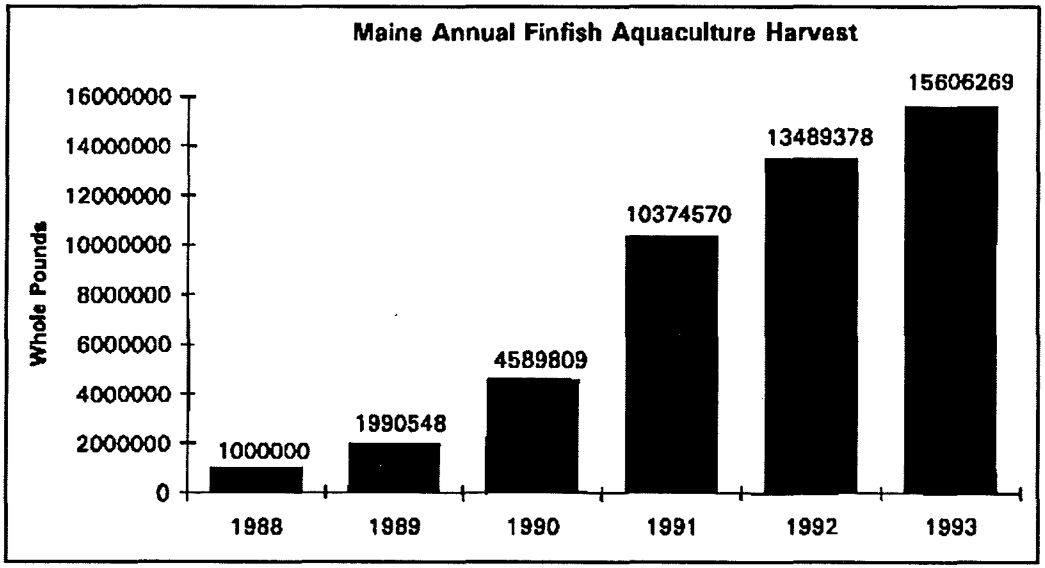


figure 2.

The largest number of salmon and trout smolts stocked annually occurred in 1993 (fig. 3).

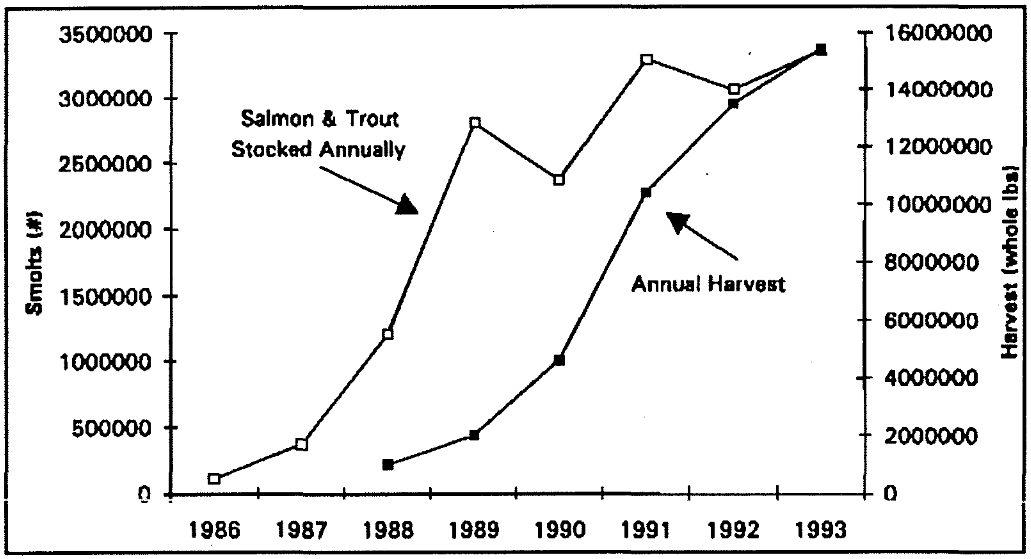


figure 3.

There is an approximate lag of 18 months from stocking of smolts to harvest. Stocking during the five year period 1987-1991 increased from less than 1 million to over 3 million smolts. During the corresponding harvest period of 1989-1993 the harvest increased from under 2 million to over 15 million pounds (fig. 4).

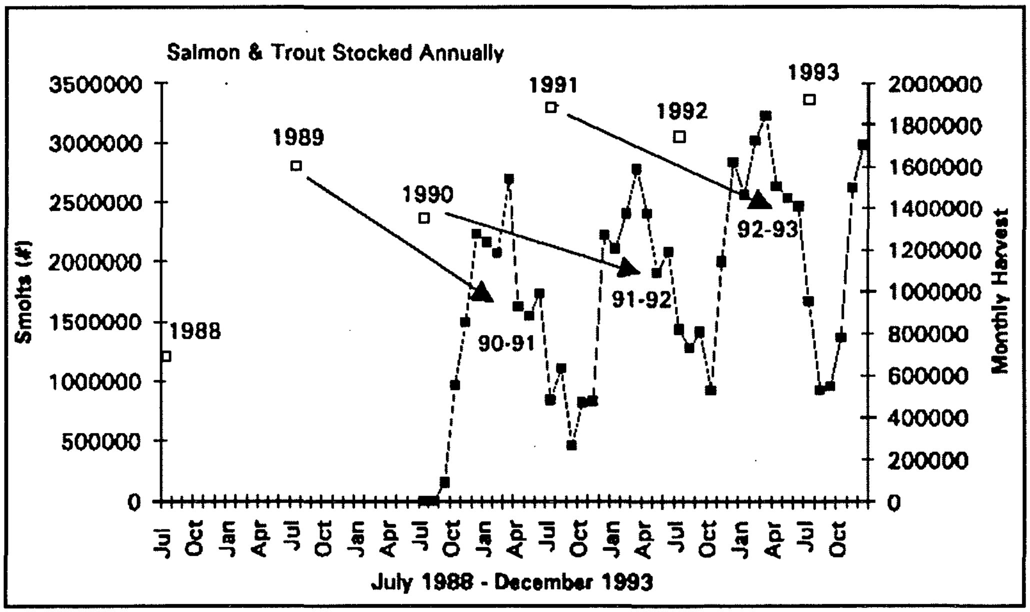


figure 4.

Chronology of Accomplishments to date:

1991

July 20	Public Law 381 signed by Governor McKernan.
July	Finfish fee began.
November	Publication: Experiments with a terrain-following hydrodynamic model... (Brooks and Churchill, 1991).
December	Fee reporting combined with the Finfish Aquaculture Monthly Report (FAMR) based on a former volunteer reporting program.

1992

May	Finfish Aquaculture Monitoring Program (FAMP) implemented. Eliminated redundant requirements in Department of Environmental Protection (DEP) and Army Corp of Engineers (ACOE) permits.
Spring	Annual Spring Diver/Video Survey; 1992 Contract awarded, work and reports completed by Intertide Corp.
August	ACOE formerly approves unified application and monitoring programs.
Summer	Summer Water Quality (Oxygen, Temperature, Salinity) Sampling data collected by leaseholders.
Fall	Annual Fall Diver/Video Survey and Biennial Benthic Survey; work and reports completed by Intertide Corp.

1993

February	Aquaculture Environment Interaction Workshop and to the Maine Industry at Eastport presentations. (Sowles, Churchill and Heinig, 1993).
Spring	Annual Spring Diver/Video Survey; 1993 Contract awarded, work and reports completed by MER Assessment Corporation (MER).
May	Recovery project (FAMP) initiated.
Summer	Database design initiated with assistance from a former SERVE Maine Volunteer, A. Thron and 1993 contractor MER.
Summer	Summer Water Quality (Oxygen, Temperature, Salinity) Sampling data collected by leaseholders. Analysis in progress by John Sowles (DEP).
Fall	Annual Fall Diver/Video Survey and Biennial Benthic Survey; work completed, reports and analysis in progress by MER.
December	Publication: The Effect of Benthic Carbon Loading... (Sowles, Churchill, and Silvert, 1993).

1994

January	Document: Preliminary Report... (Heinig, 1994).
February	Legislative Program Review.

Finfish Aquaculture Monitoring Program (FAMP)
Summary of Recommendations

- Replace **Spring Diver/Video Survey** with agency discretionary inspection dives.

- Replace **Summer Water Quality Sampling** with a coordinated DMR survey (see Appendix 1, J. Sowles memo).

- Change **Annual Fall Dive/Video Survey** sampling period to September 1 or 15 through November 15 to match peak temperatures for **Water Quality Profile Sampling** which could then be coupled with other Fall survey work. Temperatures in late September correspond to August temperatures now used which often do not target maximum temperatures.

- Modify **Biennial Fall Benthic Survey**, examples include:
  Add **TN** to TOC analysis.
  Grain Size Analysis, consider other procedures.
  Infauna: Family/Process level correlation results established and compare 1.0mm versus 0.5mm sieve sizes.
  Percent moisture content of sediments.
  Image Analysis development between videos and benthic data.
  Recovery project to include industry wide representative areas.
  Develop **Sensitivity Classification System** proposed (Heinig, 1994).
  Data refinements of cuurents, etc. to improve benthic impact model.
  Hydrographic model refinements, cont. work with D. Brooks.

Finfish Aquaculture Monthly Report (FAMR)
Summary of Recommendations

- **Database** development including all aspects of the aquaculture leasing and monitoring programs. Design has been initiated with expertise from A. Thron, a former DMR SERVE Maine Volunteer and computer expert. Time constraints prohibit fast development of the design which is intended to be GIS based. A contractor may be necessary to develop the database <u>after</u> design work is complete.

- **Feedback** reports to individual growers utilizing monitoring data and monthly production reports.

- **Refinement of data reported** to develop feedback is necessary. Results could be improved feeding efficiency, improved growth rates therefore less loss to surrounding environment and potential degradation (British Columbia Salmon Farmers Association CASH program for example).

- **Inventory Technology.** This would be a new project to test existing technology with possible development work. The greatest benefit to the industry would be cost savings in feed with improved feed conversions and decreased stress through less handling. (Example: Hitra losses in 1992.)

- A mechanism for the manufacturers of **medicated feed** to be required to provide **documentation** directly to DMR.
- Aquaculture **Inventory Publication** requires extensive proofing of original documents, drafting and software expertise to upgrade the publication materials to a GIS type document. This should be tied to the database development.
- Ultimately a **GIS database** utilizing available baseline data, hydrographic model, benthic impact model, FAMP data, FAMR data and sensitivity classification system can provide feedback to regulators for site specific assessment to best manage the environment and maximize production strategy for each grower.

Also, see Heinig, 1994, and Sowles, Appendix 1, recommendations.

Technical Developments and Considerations

Initiated in December 1991 the confidential Finfish Aquaculture Monitoring Report (FAMR), a production data reporting system based upon a former industry volunteer data program, allowed analyses to begin to understand actual relationships between production activities of pen culture in Maine and associated benthic impacts.

In May 1993 the Gulf of Maine Council on the Marine Environment (GOMCME) and the New Brunswick Department of Fisheries and Aquaculture (DFA) hosted the Aquaculture Environment Interaction Workshop. It served as an opportunity to present the first year, 1992 FAMP, preliminary results and explore methods used for assessing acceptable vs. unacceptable benthic impact (Sowles, Churchill and Heinig, 1993).

A presentation at the workshop by Dr. William Silvert confirmed our discomfort with the use of formulas such as Z-min (Sowles, 1988), based on data from elsewhere for assessing benthic impacts, which we felt was not adequate (Silvert, 1992). Knowing the new FAMP and FAMR had the potential to test and develop formulas or models based on real data from the industry the process to analyze physical and production data available to date was begun. Figure 5 shows the relationship between the expert rated Benthic Scores and the Benthic Index scores predicted by the analysis developed. The dashed line represents equality between predicted and observed scores and in short demonstrates the Benthic Index is a reasonable predictor of Benthic Score as a measure of bottom conditions. The four points well above the dashed line represent systems that are considerably older or have different management histories than the others (Sowles, Churchill and Silvert, 1993).

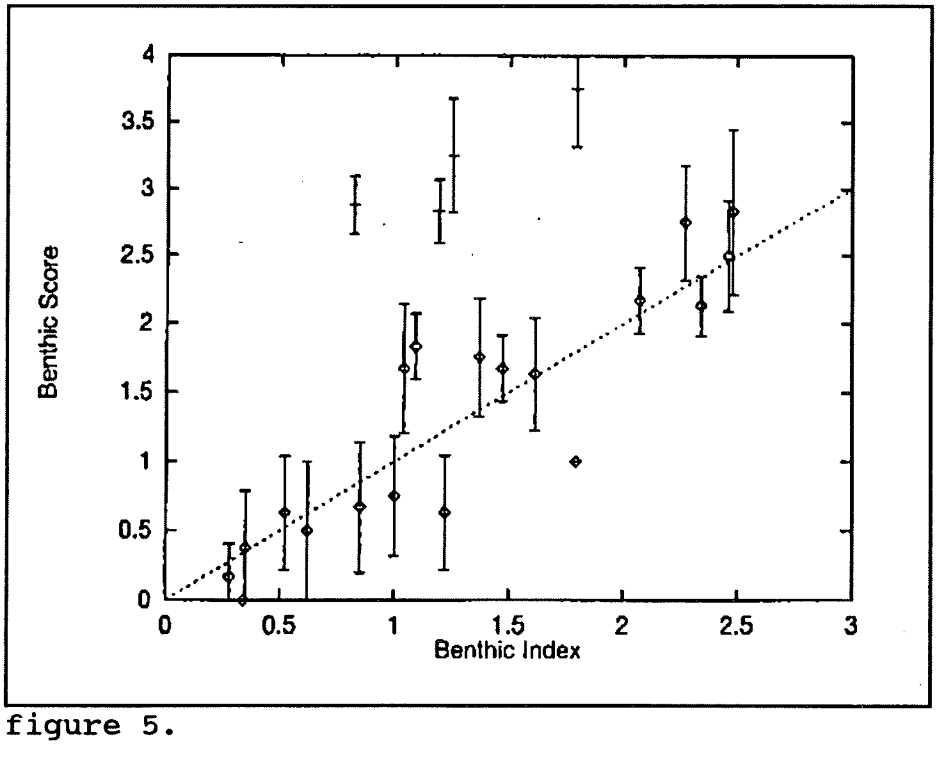


figure 5.

The model was recently run with corresponding sediment types for each system. The results indicate no pattern or relationship (figure 6). It has been generally assumed that softer sediments would develop higher degrees of impact than harder

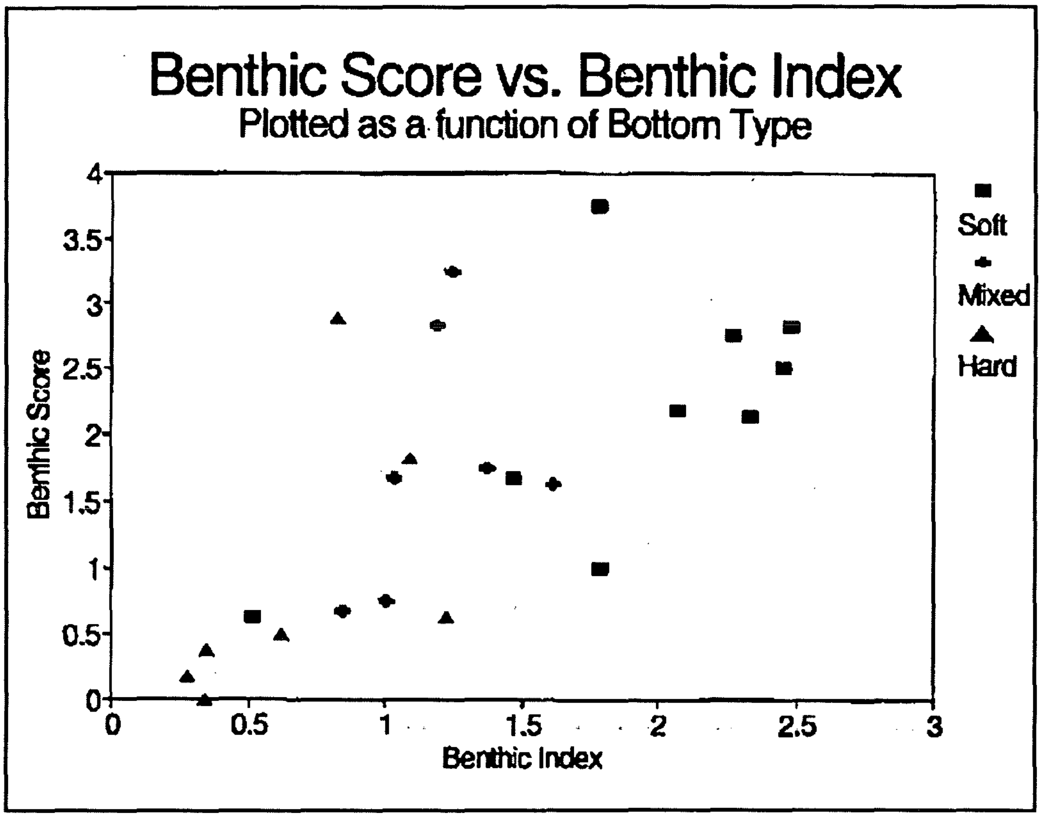


figure 6.

sediments. Independently, through analysis of specific monitoring program parameters of infauna and grain size a similar conclusion has been obtained (Heinig, 1994). The failure to obtain a clear relationship between increased sediment softness and increased benthic impact has been tentatively attributed to varying husbandry practices.

Considering the increasing number of pens per site (see fig. 2.1 in Heinig, 1994) and increasing harvest (fig. 2) the level of production, hence loading, and potential degradation increase. Husbandry includes the practice of periodically rotating pen(s) or system(s) within the lease area. How soon a previously used area has "recovered" and may be utilized again is uncertain and to an extent site specific. Therefore when the opportunity to investigate a rotated system during both pre and post-removal the Recovery project was initiated, (May 1993). Results from a recovery-type project could be used by growers to better plan system rotation as production on individual lease sites increase. This would avoid having regulators being forced to arbitrarily assign rotation schedules which may or may not be effective.

When the "unified" monitoring program was developed the intent was to keep the program as simple and direct as possible. Every effort has been made to maintain that intent.

References

Brooks, D.A., and L. Churchill, 1991. Experiments with a terrain-following hydrodynamic model for Passamaquoddy and Cobscook Bays in the Gulf of Maine. Proc. 2nd Int. Conf. on Estuarine and Coastal Modeling, Ed. Sparlding, Tampa. pp 215-225.

Heinig, C.S., 1994. Preliminary Report on the Maine Department of Marine Resources' Aquaculture Monitoring Program. MER Assessment Corporation, RFD 2 Box 109, S. Harpswell, ME 04079. 34 pp.

Sowles, J.W., 1988. Maine Dept. of Environmental Protection (DEP), Criteria for Issuance of Water Quality Certification for Net Pen Aquaculture Operations. Maine DEP, Station #17, Augusta, ME 04333.

Sowles, J.W., L. Churchill, and C.S. Heinig, 1993. The Status and Future of Pen Culture in Maine, An Environmental Management Perspective. Aquaculture-Environment Interaction Workshop, St. Andrews, N.B. February 1993, abstract.

Sowles, J.W., L. Churchill, and W. Silvert, 1993. The effect of benthic carbon loading on the degradation of bottom conditions under farm sites. In: *Modelling Benthic Impacts of Organic Enrichment from Marine Aquaculture*, Ed. B.T. Hargrave, Can. Tech. Rep. Fish. Aq. Sci. (in press). Chapter 4.

Silvert, W., 1992. Assessing environmental impacts of finfish aquaculture in marine waters. Aquaculture 107: 67-79.

Appendix 1

InterOffice Memo

To: Penn Estabrook, Department of Marine Resources
From: John W. Sowles, Department of Environmental Protection
Date: February 7, 1994
Subject: Comments on Aquaculture Monitoring Program

I have gone over the Aquaculture Monitoring Program with both Laurice Churchill of your Department and Chris Heinig, contractor to your Department. I have only a few comments that you may wish to consider as you make your report to the Legislature.

Most importantly, I congratulate you for a job well done. It is a rare experience in state government to see a program carried out as intended. Both in its quality and timeliness, this program demonstrates that we can be accountable. Too often programs go on and on without benefit of a review. As a consequence, such programs frequently end up with limited value for errors that could have been corrected early on had they only been uncovered. The aquaculture monitoring program is most definitely better off for this biennial review. My specific recommendations relate to those parts with which I have been involved, benthic impact and dissolve oxygen monitoring.

An immediate consequence of the standardized approach used in your Finfish Aquaculture Monitoring Program resulted in data of sufficient quality to assuage fears that pen culture will result in a catastrophic degradation of our coastal environment. Although benthic impacts from pen culture aquaculture in Maine are indeed experienced, those impacts are not nearly as severe as reported elsewhere. Second, the standardized approach enabled us in Maine to understand the dynamics of how impacts occur and develop a predictive index that can be used not only by regulators but the industry as well. The index relates loading (feed) and environmental variables to benthic impact. While at this point the index could be refined further, it and the raw monitoring data already have confirmed several positions that we, in the state, have long held. Benthic impacts are directly related to feed and inversely related to flushing and depth. Indeed, about 2/3rds of all Maine operations fall into the range where benthic impacts are minimal.

Video - As a monitoring tool, this is perhaps the most cost effective means of monitoring environmental impact. Video transect should continue as in the past with the possibility of eliminating the routine spring dive. Spring dives could be done on a case by case basis depending on the level of concern, for example, on sites having high benthic scores.

Infauna - Our work has demonstrated that operations having benthic scores below 2.5 (see Sowles, Churchill and Silvert, 1993 for full paper) have little likelihood of causing an adverse benthic impact. It is therefore feasible to reduce the frequency of benthic infauna sampling at operations having scores at or below 2.5. Whether this is on a once in four year frequency, at random, or on a case by case basis, is up to you. I would suggest, however, that a representative subset of low score sites be selected and followed in order to assess inter-annual variability. This would be important to differentiate community changes caused by weather, for example, from those cause by aquaculture activities.

Granulometry,TOC, and Redox Discontinuity Profile - The level of effort given to granulometry,TOC, and redox discontinuity profiles should equal that given to infauna analysis. In other words, if infauna sampling is scaled back, then these physical variables could also be scaled back and sampled at the same time as infauna samples are collected. Through analysis of the data collected thus far in the program, I would recommend that **% water** be added to the analysis list and reported with the granulometry data. Percent water correlates well with infauna community structure. Added cost to the analysis is minimal, requiring only one additional step, weighing the wet sample before drying. To complement the TOC values, you might also consider adding Total Nitrogen. I do not know about costs, but think that N is run on the same machine as TOC and can be easily reported at minimal additional expense. Combined with the reduced level of effort overall, I think that there will end up being a net savings.

Dissolved Oxygen - I have looked over the data collected by the industry. The results illustrate the value of having a standard protocol. Unlike the benthic analyses which were done by a single team, dissolved oxygen was measured by several individuals and techniques. Although the values reported appear consistent within an individual site, it is impossible to make comparisons industry-wide due to apparent accuracy problems. I therefore recommend that in lieu of industry collected dissolved oxygen profiles (at 1/10th depth intervals) the Department add profiles to the program but at a reduced frequency and only at peak stocking densities. Alternatively, the Department could work to improve the industry QA/QC so that the data they collect is more uniform. In any event, the data collected thus far confirms our prior held belief that oxygen is not a problem and that less sampling would adequately satisfy water quality standards.

Other Recommendations - I am aware that the Department is doing a benthic recovery study and recommend that this continue to be supported. The results of this study will be extremely useful to the State when looking at environmental risk and setting management priorities.

I also encourage that the video transects be refined to a quantitative level by relating measured benthic impacts to observable impacts. This will eventually further strengthen the value of video surveys while enabling a relaxation of the need to collect hard and expensive quantitative data. I think an investment early on will save everyone money in the long run.

My final comment is that I would like very much to appear before the Marine Resources Committee to express my congratulations on a job well done. I you would like me to do so, please let me know.

MER Assessment
CORPORATION

RFD 2 BOX 109
SOUTH HARPSWELL, MAINE 04079
TEL/FAX 207 729-4245

PRELIMINARY REPORT ON THE MAINE DEPARTMENT OF MARINE RESOURCES' AQUACULTURE MONITORING PROGRAM

Prepared by

Christopher S. Heinig

January 24, 1994

Table of Contents

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 consists 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 profilings 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 examples of the currently available video and benthic monitoring results developed since the program was initiated in the Spring of 1992. To date, two Spring video surveys and two Fall video and benthic monitoring surveys have been completed. Data have been compiled for each of the Spring surveys and for the Fall 1992 surveys. Samples collected during the Fall of 1993 are presently being processed. Consequently, benthic macrofauna and sediment monitoring data are available for only half of the sites currently operated, the balance to be added once the remaining analyses are completed in April/May 1994.

A semi-quantitative benthic condition index has been developed to assist in categorizing levels of impact which numerically identifies four environmental conditions:

0-1	"Natural", unaffected condition
1-2	Slightly or mildly affected
2-3	Moderately affected, and
3-4	Heavily affected.

Based on these categories and the site ratings of an "expert" panel consisting of individuals familiar with aquaculture impacts, the distribution of aquaculture-related benthic affects in Maine at twenty-three actively operated cage systems is:

0-1	9 of 23 or ~39%
1-2	5 of 23 or ~22%
2-3	7 of 23 or ~30%, and
3-4	2 of 23 or ~ 9%.

Thus, approximately 60% of the affects are considered to be imperceptible to slight, 30% moderate, and just under 10% heavy. It should be noted, however, that the two "heavily affected" ratings are for separate cage systems on the same lease site, so that in actuality only one lease site would be considered heavily affected. Once all of the results for the remaining sites have been completed, the actual monitoring results will be used to quantitatively validate the semi-quantitative index.

The relationships between observed environmental impacts and the parameters used in the monitoring program are also discussed. Although strong correlations can be found between certain parameters and the level of environmental impact, others are poorly correlated. For example, the abundance of *Capitella capitata*, a commonly used indicator species, is strongly correlated with relative diversity, an environmental quality index. In contrast, sediment type appears to have little influence on degree of impact. This is particularly surprising since it is generally believed that softer sediment bottoms are more prone to pen-related impacts than coarser sediment bottoms.

Based on the results of these relationship analyses, specific recommendations are provided for modifying the program to enhance the reliability of the information collected and improve the efficiency and efficacy of the program.

Finally, the work reported here is related to other current, as well as future, aquaculture environmental impact assessment and management efforts.

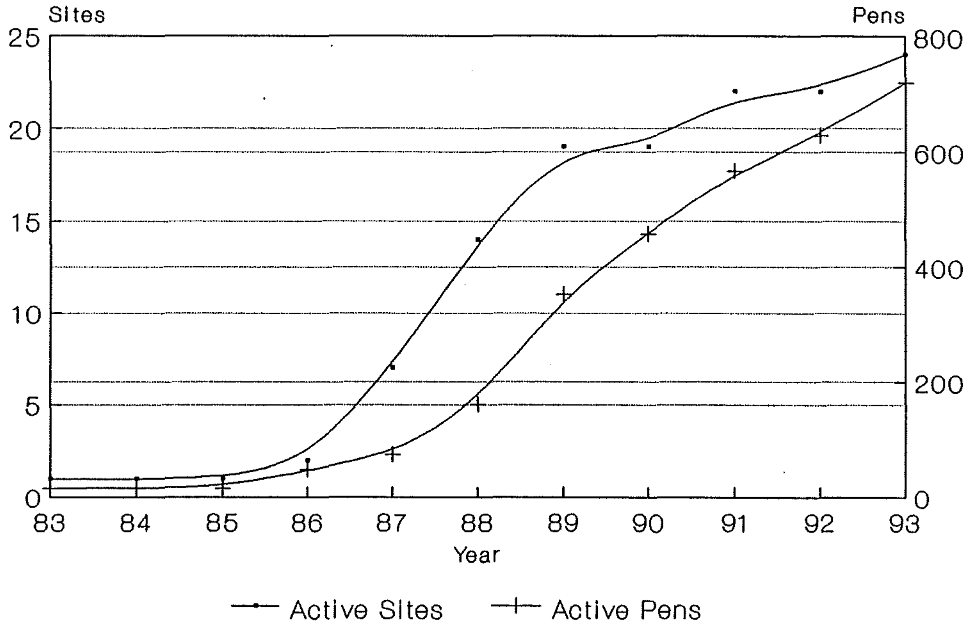
1. Introduction

This report briefly summarizes the results of the first two years of the Semiannual Aquaculture Underwater Video Monitoring and the first year of Benthic Sediment and Macrofauna Analyses. This report also includes some preliminary conclusions developed from these results, as well as early recommendations for modifications to the program.

2. Background

Finfish culture, specifically salmonid culture, began in Maine in the early to mid 70's at a single site in Blue Hill. After several years, the site was abandoned. By 1983 another finfish culture site had been established, but the number of active culture sites remained at one and the total number of cages operated was only 16. Development of the finfish culture industry remained static at this level through 1985. In 1986 a second site was added and the total number of cages operated increased threefold to 48. Over the course of the next four years, 1987 through 1990, the industry increased tenfold to 19 active sites holding 458 cages. From 1990 to the present only 5 new sites have been added, however, the number of cages has continued to increase to its current level of just over 700 (Figure 2.1.).

FIGURE 2.1.
NUMBER OF FINFISH SITES AND PENS
1983-1993



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 Aquaculture Monitoring Program 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. The program also includes summer dissolved oxygen monitoring and monthly confidential production reporting by lease holders. These data are treated separately and are consequently not discussed here.

3. Program Review

The contract between MER Assessment Corporation and the Maine Department of Marine Resources includes a review and critique of the current monitoring program and recommendations for modifications. Following is a detailed description of each of the monitoring program components with a summary of the results obtained to date. Where available data permits, an analysis and interpretation of those data is presented, followed by conclusions pertaining to the relevance of the components to the program and recommendations on how the components might be modified to improve the overall program.

3.1. 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. One objective of the program is to eventually correlate these images will actual benthic impacts, thus enhancing the utility of the video monitoring.

3.1.1. 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.

3.1.2. Procedure Review

Video recording is a relatively inexpensive, rapid, and highly effective means of documenting and visually representing conditions around and beneath the cages. It is, however, subject to individual interpretation based on individual reactions to specific visual cues.

To quantify the variability in subjective interpretation of under-cage video recordings, selected, unidentified segments were presented to various audiences which were asked to rate the environmental conditions shown on a scale of 0 to 4 where 0 represents a "normal", unaffected, natural condition and 4 an "unacceptable" condition. The results of rating exercise are presented in tabular form in Table 3.1.

TABLE 3.1.

AUDIENCE RESPONSES TO VIDEO MONITORING SEGMENTS

SEGMENT No.	1	2	3	4	5	6	7	8	9	10	11	12	13	TYPE
Industry														
	4	3	2	1	1	1	3	4	4	2	1	3	3	I
	1	2	2	3	1	0	2	4	4	3	3	1	2	P
	4	1	3	0	0	1	1	3	3	2	3	1	1	I
	0	0	0	0	0	0	1	0	0	1	1	1	1	I
	2	2	2	1	0	3	3	3	1	2	3	3	1	I
	2	3	3	1	0	1	3	1	1	1	2	2	1	
	2	3	2	1	1	1	2	2	1	1	2	1	2	
	2	0	4	0	0	0	4	4	1	0	4	2	2	
	4	2	3	1	1	1	3	4	4	2	3	2	1	
	3	2	4	0	0	0	4	3	4	2	3	2	2	I
	3	3	4	1	0	1	3	3	2	1	4	3	1	I
	4	3	4	1	2	3	4	4	3	2	3	4	3	
	3	0	3	1	0	0	2	2	2	1	1	1	0	A
	2	2	3	1	0	0	2	2	2	1	3	1	1	I
Workshop														
	3	2	4	1	0	0	2	4	1	2	4	0	1	R
	3	3	3	3	0	4	1		2	0	2	4	2	S
	4	3	4	0	1	3	4	4	4	2	4	3	2	I
	3	3	3	4	3	3	4	3	3	3	4	4	3	S
	3	4	4	0	1	2	4	4	3	2	3	4	3	S
	2	3	3	1	0	2	3	3	2	0	4	2	2	E
	3	4	4	0	0	0	3	2	2	1	4	1	1	T
	2	3	3	0	0	2	2	1	3	1	4	3	3	
	2	3	1	0	0	0	2	0	1	0	3	3	1	M
	2	4	3	1	0	2	4	3	3	1	4	2	1	S
	2	3	3	0	1	2	3	3	4	2	3	4	3	S
	2	3	3	1	1	2	3	3	4	3	4	4	3	S
	1	2	1	2	2	1	3	3	2	0	2	2	1	S
	1	1	0	0	0	0	3		1	2	2	3	2	R
	3	2	1	1	0	1	3	4	3	1	2	3	2	R
	2	3	2	4	0	0	1	1	2	0	0	0	0	R
	3	2	2	1	0	4	3	3	4	1	2	3	2	A
	2	2	3	1	0	0	2	4	3	0	3	4	2	R
	3	2	3	0	0	1	2	1	4	1	4	2	1	R
	3	2	1	0	1	0	2	3	3	0	2	3	1	C
	2	3	1	1	0	2	3	1	2	0	2	4	3	A
	2	3	4	1	0	2	3	2	2	0	4	3	2	
	2	3	3	2	3	0	2	0	2	0	3	4	2	
	2	3	3	1	0	1	2	3	2	1	3	1	1	A
	3	1	4	0	0	0	2	2	3	0	4	2	1	R
	3	0	2	1	0	0	1	2	0	0	2	0	0	R
	3	2	1	0	0	0	2	4	3	1	3	3	2	R
	0	1	4	0	0	3	0	0	1	0	2	0	0	
	2	3	3	0	0	1	1	3	3	1	3	3	2	
	2	3	2	0	0	2	3	4	3	3	2	1	2	R
	4	4	4	2	0	3	3	3	3	1	4	4	3	S
	1	3	4	0	0	1	3	1	2	0	4	2	1	A
	2	1	3	1	0	1	2	4	3	0	4	2	2	T
	3	1	2	0	0	1	2	3	3	1	3	2	1	A
	1	2	2	0	1	1	2	1	1	0	2	1	0	I
	4	3	3	1	1	0	3	2	3	1	3	1	2	I
	2	3	3	2	1	3	3	1	3	1		2	1	R
	3	2	1	1	0	1	3	2	2	0	0	0	1	R
	3	3	3	1	1	2	3	3	3	1	2	3	3	R
	2	3	2	1	1	0	2	2	3	3	2	3	1	
	1	3	1	1	0	1	1	3	2	1	3	3	2	
	1	4	3	2	1	1	3	0	3	2	3	3	2	
	1	3	3	3	1	3	3	4	1	0	3	3	1	
	2	0	3	0	0	1	3	1	2	0	3	2	0	
	4	3	3	2	1	2	3	4	3	0	3	3	2	
	1	2	2	0	2	0	1	2	1	1	2	1	0	R
	2	3	4	3	1	2	2	2	0	2	3	1	2	A
	2	1	3	1	0	1	3	4	1	0	2	3	1	A
	1	2	3	1	0	2	4	2	3	1	4	3	2	R
	1	3	2	1	0	3	2	4	3	0	4	2	1	A
	2	1	3	0	0	3	2	3	4	2	3	2	1	A

"Unacceptable" is, by necessity, an arbitrary term, for "unacceptable" conditions have yet to be specifically defined. In the absence of such a definition, visual cues associated with environmental degradation, e.g. presence of white bacterial-mold, feed pellets, dark sediments, etc., were presented as examples of factors to be considered. Consequently, the rating of degree of affect and the attainment of an "unacceptable" condition were allowed to be individually assessed.

The "Industry" category refers to the responses from 14 industry representatives from the Maine aquaculture industry. The "Workshop" category refers to the responses from a mixed audience (Type) including industry representatives (I), academics (A), students(S), teachers (T), researchers (R), environmentalists (E), and the public (P).

Table 3.2. presents an analysis of the responses where **n** is the number of respondents, **Mean** is the mean rating, and **S.D.** is the standard deviation of the responses. The "experts" responses refers to ratings given to each segment by four individuals with extensive experience with the environmental affects of salmon culture in Maine, namely, Laurice Churchill, aquaculture coordinator for MDMR, Todd LaJeunesse, biologist with Intertide Corporation, Christopher Heinig, President of Intertide Corporation and MER Assessment Corporation, and Brian Tarbox, diver and underwater video cameraman for Intertide Corporation and a fisheries biologist.

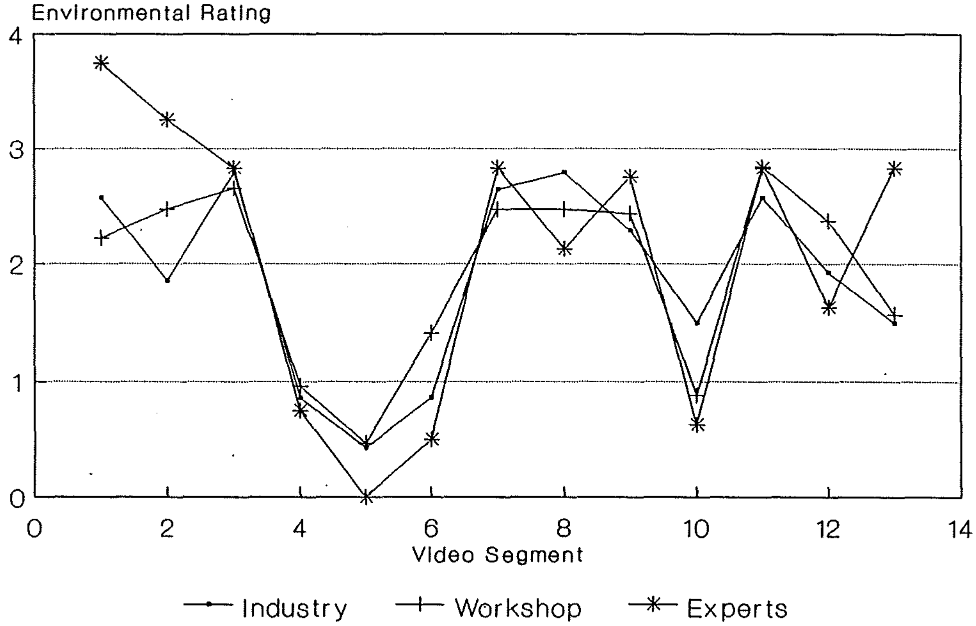
TABLE 3.2.

ANALYSIS OF RESPONSES TO VIDEO MONITORING SEGMENTS

SEGMENT No.	1	2	3	4	5	6	7	8	9	10	11	12	13
COMBINED													
n	65	65	65	65	65	65	65	63	65	65	65	65	65
Mean	**2.29**	**2.34**	**2.68**	**0.94**	**0.46**	**1.29**	**2.51**	**2.54**	**2.4**	**1.02**	**2.78**	**2.28**	**1.55**
S.D.	1.00	1.05	1.05	1.00	0.73	1.16	0.92	1.25	1.1	0.94	1.05	1.18	0.88
INDUSTRY													
n	14	14	14	14	14	14	14	14	14	14	14	14	14
Mean	**2.57**	**1.86**	**2.79**	**0.86**	**0.43**	**0.86**	**2.64**	**2.79**	**2.29**	**1.5**	**2.57**	**1.93**	**1.5**
S.D.	1.22	1.17	1.12	0.77	0.65	1.03	1.01	1.25	1.38	0.76	1.02	1.00	0.85
WORKSHOP													
n	51	51	51	51	51	51	51	49	51	51	51	51	51
Mean	**2.22**	**2.47**	**2.65**	**0.96**	**0.47**	**1.41**	**2.47**	**2.47**	**2.43**	**0.88**	**2.84**	**2.37**	**1.57**
S.D.	0.92	0.99	1.04	1.06	0.76	1.17	0.9	1.26	1.02	0.95	1.07	1.22	0.9
"EXPERTS"	**3.75**	**3.25**	**2.83**	**0.75**	**0**	**0.5**	**2.83**	**2.13**	**2.75**	**0.63**	**2.83**	**1.63**	**2.83**
EX-WRK	1.53	0.78	0.18	-0.2	-0.5	-0.9	0.36	-0.3	0.32	-0.3	-0.0	-0.7	1.26
EX-IND	1.18	1.39	0.04	-0.1	-0.4	-0.4	0.19	-0.7	0.46	-0.9	0.26	-0.3	1.33

The **EX-WRK** and **EX-IND** rows show the difference between the mean "expert" ratings and those of the mean workshop and industry audience ratings, respectively. A positive difference indicates that the "experts" rated the segment more harshly than the audience while a negative difference indicates a more lenient rating by the "experts". It is interesting to note that positive differences tend to be larger than negative differences, indicating less agreement between the experts and the audiences on more heavily affected areas, the experts being more critical than the less informed observer. This has been interpreted to reflect the "experts' " higher level of confidence in rendering a decision, presumably the result of greater knowledge, or conversely, the audiences' reluctance to "take a stand" due to lack of confidence and/or insufficient knowledge. The relationship between the responses of the various audiences and the experts is shown graphically in Figure 3.1. below.

FIGURE 3.1
ANALYSIS OF RESPONSES TO VIDEO SEGMENTS
EXPERTS/INDUSTRY/N.B. WORKSHOP



Based on these results it is clear that, given similar visual cues, audiences with varying levels of knowledge on the environmental affects of salmon culture can arrive at similar conclusions. It is important to bear in mind, however, that these conclusions are strictly qualitative based on relative differences between sites and little, if any, understanding of the actual implications of the conditions represented by the visual cues. Consequently, although the "visceral" reaction to a particular image may be strong, the actual affect to the bottom may not be understood, and in some case, incorrectly assumed to be severe, when in fact, more in-depth study may prove otherwise. An example of this situation will be presented later.

3.2. Benthic Monitoring

Benthic monitoring is carried out adjacent, beneath, and on occasion, in the vicinity of, 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.

3.2.1. Procedure

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.

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. The contents of the cores is washed through a U.S. Standard No. 35 sieve (500µ 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.

3.2.2. Procedure Review

Sediments

All of the parameters reviewed as part of the benthic sediment monitoring are reported quantitatively, however two require interpretation.

The **unconsolidated layer** usually appears as a loosely compacted to flocculent layer on the surface of an otherwise relatively compacted sediment core. Unfortunately, the depth of the unconsolidated organic material layer is usually difficult to establish since there is rarely a discrete line of demarkation 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. Generally speaking, however, 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.

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 or representative of ambient conditions. The results obtained thus far are highly variable with no clear trend for near-cage stations. 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.

Grain size - Granulometry

There are two purposes for conducting the granulometry analyses: 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 been completed on samples taken in Fall 1992 and the samples taken in 1993 are currently being processed.

The first purpose assumes the existence of pre-development sediment composition information, but for most of the currently monitored sites, such information is unavailable since the sites were developed prior to implementation of the new application process which now requires information on granulometry. Consequently there is no way to compare existing conditions to pre-development conditions. Comparisons will be possible over time as subsequent results become available.

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 are being reduced to percent composition as gravel, sand, fine sand, and silt/clay. These percentages are then 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 4.

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.

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

In a recent paper by Chang *et al.* (1992), species have been statistically assigned to each of four categories of environmental sensitivity according to the frequency of their occurrence in samples taken at a variety of locations representing different degrees of environmental degradation. The four categories are; I. Most contaminant sensitive, II. Contaminant sensitive, III. Contaminant insensitive, and IV. Most contaminant insensitive. A list of species has been developed for each category. By assigning each species the number of its respective category, the species can be used to rate the environmental conditions from which it was taken. Further, by multiplying the species rating by the occurrence of the species, summing these values, and dividing by the total number of rated organisms, we can develop a weighted mean environmental rating for the sample which rates the conditions from which the sample was taken on the basis of the sensitivity of the species represented in the sample.

Calculations carried out to date on specific sites have tended towards greater environmental degradation than the relative diversity or other indices might suggest. This may be due to the preponderance of insensitively rated species as opposed to sensitively rated species. This latter situation results from the fact that the species comprising the insensitive category seem likely to be found here in Maine as well as in the New York Bight where the samples Chang *et al.* based their work on were obtained. By contrast, few of the sensitive species listed by Chang *et al.* are normally found in Maine, and species normally found here associated with unaffected conditions do not appear on their list. Consequently, the rating is biased toward the higher, insensitive values.

This classification scheme could prove useful and merits additional investigation. However, to be effective, all of the species currently found on sites must be assigned to one of the four "tolerance" or "environmental sensitivity" categories.

4. Data and Analysis

Video surveys and sampling under the Aquaculture Monitoring Program began in the Spring of 1992. To date, two Spring video monitoring and two Fall video and benthic monitoring surveys have been completed. Data have been compiled for each of the Spring surveys and for the Fall 1992 surveys. Samples collected during the Fall of 1993 are presently being processed. Consequently, benthic macrofauna and sediment monitoring data is available for only half of the sites currently operated, the balance to be added once analyses are completed in April/May 1994.

Despite incomplete data, the results to date support the "expert" environmental index discussed in Section 2. The benthic condition index can be viewed as representing four environmental conditions:

0-1	"Natural", unaffected condition
1-2	Slightly or mildly affected
2-3	Moderately affected, and
3-4	Heavily affected.

Based on these categories and the site ratings of the "expert" panel, the distribution of aquaculture-related benthic affects in Maine is:

0-1	9 of 23 or ~39%
1-2	5 of 23 or ~22%
2-3	7 of 23 or ~30%, and
3-4	2 of 23 or ~ 9%.

Thus, approximately 60% of the affects are considered to be imperceptible to slight, 30% moderate, and just under 10% heavy. It should be noted that the two 'heavily affected" ratings are for separate cage systems on the same site, so that in actuality only one <u>lease</u> site would be considered as heavily affected. Once the analyses for the remaining sites have been completed, the actual monitoring results will be used to quantitatively validate the semi-quantitative index. In the interim, data from three sites representing different situations have been selected for discussion here.

4.1. Case Studies

The first site, designated HARS JK, is located in an area subjected to strong tidal currents for at least three hours of each ebb and flood tide. The bottom is coarse, consisting principally of gravel and coarse sand. The site has been occupied by one ten cage system, which has recently been expanded to sixteen, and a smaller four cage system. Sampling was carried out only beneath and adjacent to the larger cage system.

A layout of the site is shown in Figure 4.1. where sampling locations are indicated by station number. Results of the 1992 benthic macrofauna and sediment analyses are shown below in Tables 4.1. and 4.2., respectively.

Figure 4.1. Site Layout for HARS JK

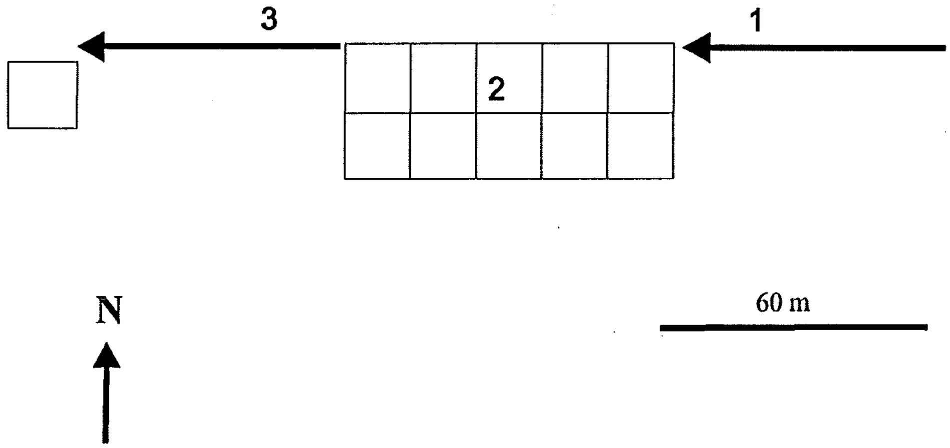


TABLE 4.1 BENTHIC INFAUNA ANALYSES RESULTS SUMMARY

MER ASSESSMENT CORPORATION
BENTHIC ANALYSIS REPORT
PAGE 7 OF 7

DATE	10-04-92
LOCATION	HARS JK
NO. SAMPLES	3

	1	2	3									Total	Mean
Total organisms	285	248	111	0	0	0	0	0	0	0	0	644	215
Abundance as No. organisms/0.1 m²	1563	1360	609	0	0	0	0	0	0	0	0	3531	1177
Species richness (No. species)	39	44	35	0	0	0	0	0	0	0	0		39.3
Distance in meters	0	0	0	0	0	0	0	0	0	0	0		
Rel. Diversity	0.721	0.761	0.897	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.793
% Capitella capitata	8.8	22.6	0.0	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR		12.6
RD*SR	28.1	33.5	31.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		31.0

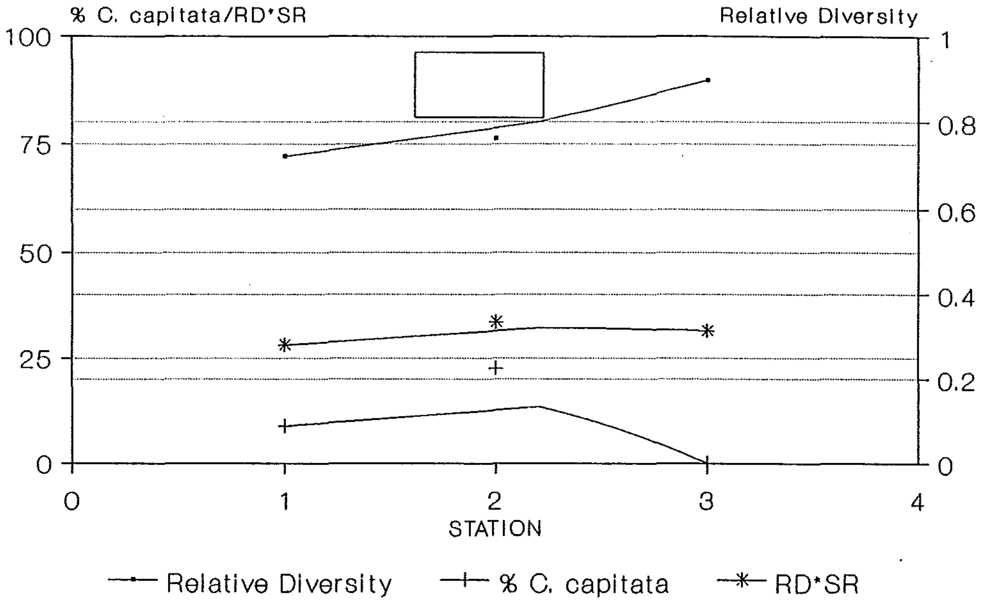
	Site
Impact Index	2.39
Expert Rating	0.17
Abundance/0.1 m²	1177
Species richness	39.3
Mean Rel. Div.	0.793
% C. capitata	12.6
Mean RD*SR	31.0

TABLE 4.4 SEDIMENT ANALYSES RESULTS SUMMARY

		1	2	3	4	5	6	7	8	9	10	Mean
Core Depth (cm)		10.5	11.0	11.0	–	–	–	–	–	–	–	10.8
UOML Depth (cm)		0.0	0.3	0.0	–	–	–	–	–	–	–	0.1
RPDL Depth (cm)		>5.	1.0	>5.	–	–	–	–	–	–	–	0.3
TOC		0.64	0.51	0.74	–	–	–	–	–	–	–	0.6
Grain Size	Screen											
Coarse gravel 1	3.0 "	0.0	0.0	0.0	–	–	–	–	–	–	–	0.0
Coarse gravel 2	2.0 "	0.0	0.0	0.0	–	–	–	–	–	–	–	0.0
Coarse gravel3	1.50 "	4.9	5.1	9.3	–	–	–	–	–	–	–	6.4
Medium gravel	0.75 "	22.3	16.5	24.6	–	–	–	–	–	–	–	21.1
Fine gravel 1	0.50 "	19.4	21.7	9.2	–	–	–	–	–	–	–	16.8
Fine gravel 2	0.38 "	7.1	7.1	5.1	–	–	–	–	–	–	–	6.4
Coarse sand	# 4	10.0	9.1	7.7	–	–	–	–	–	–	–	8.9
Cr/med sand	# 10	5.7	7.0	8.1	–	–	–	–	–	–	–	6.9
Med. sand	# 20	6.3	6.8	9.1	–	–	–	–	–	–	–	7.4
Med/fine sand	# 40	8.7	8.9	9.7	–	–	–	–	–	–	–	9.1
Fine sand 1	# 60	7.9	9.9	8.0	–	–	–	–	–	–	–	8.6
Fine sand 2	# 100	2.8	3.9	3.6	–	–	–	–	–	–	–	3.4
Very fine sand	# 200	1.2	1.3	1.3	–	–	–	–	–	–	–	1.3
Silt	# 250	0.2	0.1	0.1	–	–	–	–	–	–	–	0.1
Clay	<# 250	3.5	2.6	4.2	–	–	–	–	–	–	–	3.4
Gravel	> # 4	53.7	50.4	48.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.8
Sand	<# 4 - ># 40	22.0	22.9	24.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.3
Fine sand	#40 - >#200	19.4	22.7	21.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.1
Silt/Clay	<# 200	4.9	4.0	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8
		100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

The trends of three of the indices described above are shown graphically in Figure 4.2. The rectangle at the top indicates the location of the cage relative to the sampling stations. Distances are only relative, indicating stations located away from the cages or adjacent to and beneath the cages.

FIGURE 4.2.
BENTHIC MACROFAUNA ANALYSIS RESULTS
INDICES COMPARISON



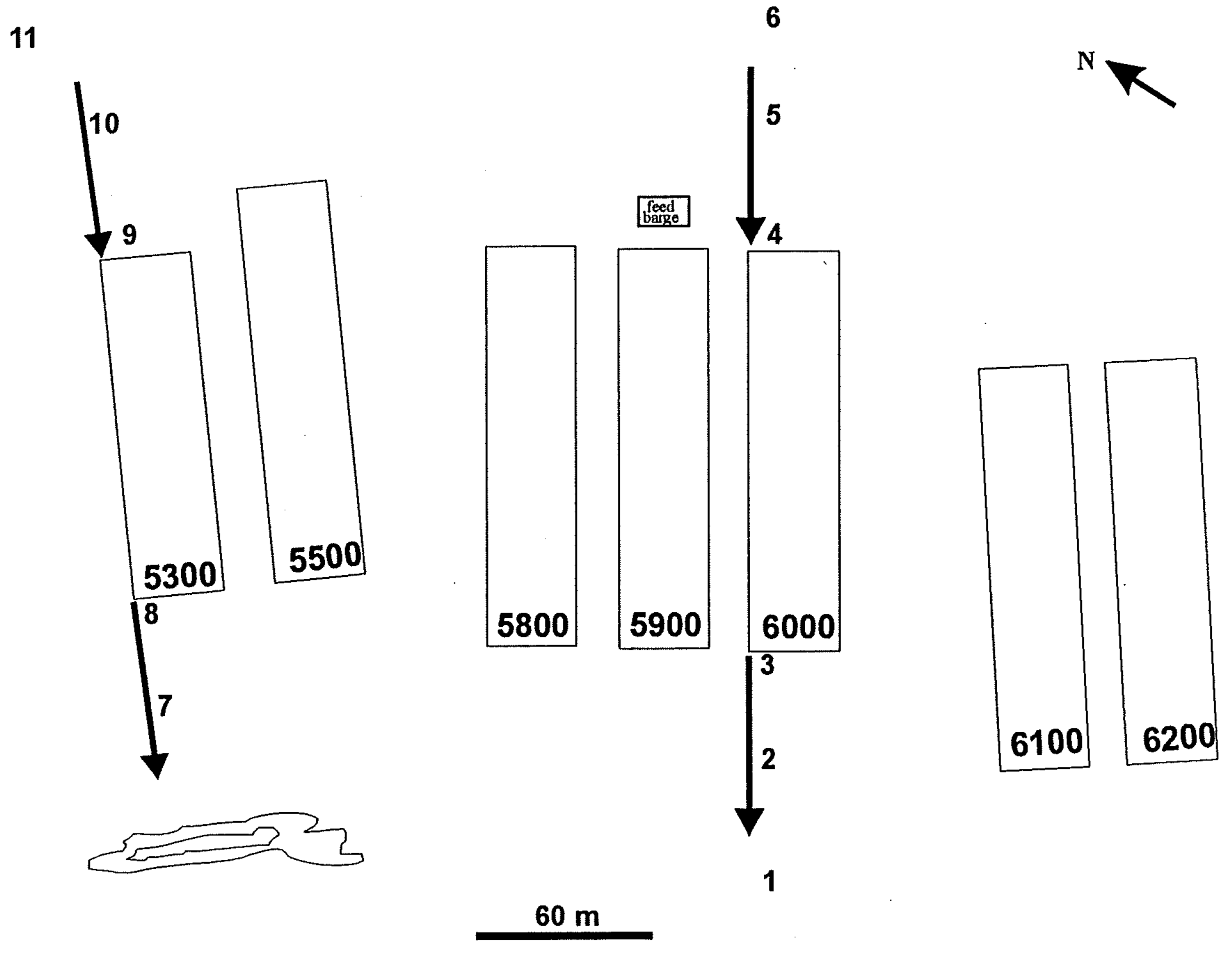
HARS JK 1992
Box indicates cage location

In this case the relative diversity (■) adjacent and beneath the cages differs little from stations located some distance from the cages. Similarly, the percentage of *C. capitata* (+) in the samples remains low across the stations, although there is a slight increase beneath the cage system. Between stations, species richness (not indicated) is also relatively constant at 39, 44, and 35. Thus the RD*SR (*) values are high at 28.1, 33.5, and 31.4.

All of these index values indicate that the site remains essentially unaffected by the operation. The increase in the number of species found immediately beneath the cages suggests a low level of biostimulation resulting from carbon deposition on the bottom, either as waste feed or feces.

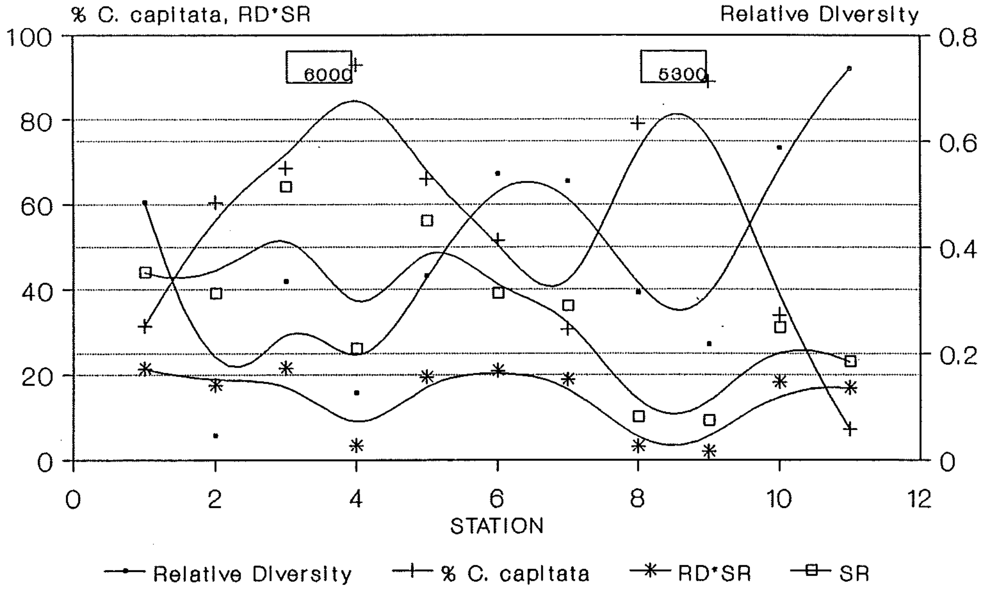
The second site, CONA BC, is a large site which has been operated intensively for several years. Cages located at the southern end of the site are subjected to rather strong currents compared to cages in the northern section. Depth at the south end of the site is ~65 feet at mean low water (MLW) as opposed to ~20-25 feet at the northern end. Two cage systems within the site were selected for comparative purposes, Unit 6000 towards the south and Unit 5300 to the north. Figure 4.3. below shows the arrangement of cage systems on the site and the location of sampling stations.

Figure 4.3. Site Layout for CONA BC



Results of the 1992 benthic macrofauna and sediment analyses at CONA BC are shown in Tables 4.3. and 4.4., respectively. Figure 4.4. below shows a graphic comparison of the same parameters as shown for site HARS JK.

FIGURE 4.4
BENTHIC INFAUNA ANALYSIS RESULTS
INDICES COMPARISON



CONA BC 1992
Box indicates cage location

Again, the relative location of the cage systems to the stations is indicated by the rectangles at the top of the graph. In sharp contrast to the previous set of graphs, here the curves show great fluctuations. First, the relative diversity values (■) drop sharply beneath and adjacent to the cage, increasing as sharply away from the cages. The % *Capitella capitata* (+) shows a strong inverse relationship to relative diversity, that is, as relative diversity drops, the percentage of *C. capitata* in the population increases. This is not surprising, since relative diversity is sensitive to increased abundance of any given species, and *C. capitata* abundance increases with increased organic enrichment, as is the case beneath the cages.

TABLE 4.3. BENTHIC MACROFAUNA ANALYSES RESULTS SUMMARY

MER ASSESSMENT CORPORATION
BENTHIC ANALYSIS REPORT
PAGE 7 OF 7

DATE	10-06-92
LOCATION	CONA BC
NO. SAMPLES	11

	1	2	3	4	5	6	7	8	9	10	11	Total	Mean
Total organisms	3358	7488	9595	7885	6126	1616	898	1629	1167	1054	283	41099	3736
Abundance as No. organisms/0.1 m²	18412	41057	52609	43233	33589	8861	4924	8932	6399	5779	1552	225346	20486
Species richness (No. species)	44	39	64	26	56	39	36	10	9	31	23		34.3
Distance in meters	60	30	0	0	30	60	30	0	0	30	70		
Rel. Diversity	0.484	0.450	0.335	0.125	0.346	0.537	0.523	0.314	0.216	0.587	0.736		0.423
% C. capitata	31.4	60.5	68.5	93.0	66.0	51.4	30.6	79.0	89.0	34.0	7.1		66.5
RD*SR	21.3	17.5	21.5	3.3	19.4	20.9	18.8	3.1	1.9	18.2	16.9		14.5

	SITE	6000	5300
Impact Index	3.74		
Expert Rating	3.29	2.88	3.75
Mean Rel. Div.	0.423	0.230	0.265
% Capitella capitata	66.5	80.7	84.0
Mean RD*SR	14.5	12.4	2.5

TABLE 4.4. SEDIMENT ANALYSES RESULTS SUMMARY

		1	2	3	4	5	6	7	8	9	10	11	Mean
Core Depth (cm)		10.0	7.0	7.0	10.0	7.5	8.5	9.5	9.0	8.0	6.0	14.0	8.8
UOML Depth (cm)		0.5	1.3	1.3	2.5	2.0	0.5	1.5	2.5	3.0	2.7	0.3	1.6
RPDL Depth (cm)		3.0	3.0	3.0	0.0	0.0	2.7	N/A	0.0	0.0	0.0	3.0	1.3
TOC		2.22	2.28	3.87	8.08	4.20	3.46	3.13	5.19	4.59	8.06	3.30	4.398
Grain Size	Screen												
Coarse gravel 1	3.0 "	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coarse gravel 2	2.0 "	27.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5
Coarse gravel3	1.50 "	12.0	16.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6
Medium gravel	0.75 "	12.9	22.4	29.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8
Fine gravel 1	0.50 "	5.9	5.8	12.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2
Fine gravel 2	0.38 "	5.3	2.1	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4
Coarse sand	# 4	6.4	8.8	13.9	0.0	1.1	4.1	0.8	0.0	5.4	0.0	0.0	3.7
Cr/med sand	# 10	4.9	8.2	2.8	8.7	2.0	2.8	2.7	5.3	8.8	0.3	0.7	4.3
Med. sand	# 20	4.1	5.6	3.4	11.9	1.2	7.9	2.6	4.7	10.2	0.9	0.4	4.8
Med/fine sand	# 40	4.4	5.8	4.2	12.2	6.5	7.7	4.6	6.0	10.1	6.2	1.7	6.3
Fine sand 1	# 60	5.3	8.5	7.7	3.2	11.0	8.0	4.5	9.9	10.4	8.9	2.6	7.3
Fine sand 2	# 100	4.5	7.7	9.8	29.8	33.8	18.7	5.5	17.2	9.9	19.1	7.3	14.8
Very fine sand	# 200	1.7	2.7	3.3	12.0	24.4	20.5	5.6	12.6	12.8	41.1	36.0	15.7
Silt	# 250	0.2	0.3	0.3	0.7	1.2	1.4	0.7	1.1	1.4	3.5	3.5	1.3
Clay	<# 250	4.7	5.2	5.6	21.5	18.8	28.9	73.0	43.2	31.0	20.0	47.8	27.2
Gravel	> # 4	63.8	47.2	49.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.5
Sand	<# 4 - ># 40	15.4	22.6	20.1	20.6	4.3	14.8	6.1	10.0	24.4	1.2	1.1	12.8
Fine sand	#40 - >#200	14.2	22.0	21.7	45.2	51.3	34.4	14.6	33.1	30.4	34.2	11.6	28.4
Silt/Clay	<# 200	6.6	8.2	9.2	34.2	44.4	50.8	79.3	56.9	45.2	64.6	87.3	44.2
		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	

It is important to note the elevated species richness at stations 2, 3, 4, and 5, in the vicinity of Unit 6000, even though the percentage of *C. capitata* is high (refer to Table 4.3). Thus, despite the predominance of *C. capitata*, the environmental conditions can still support many other species, a situation shown particularly well by the results at station 3 located at the west end of Unit 6000. These results suggest that considerable carbon loading is occurring around Unit 6000, but at a rate which can support a substantial number of species and biomass while not exceeding the benthic macrofauna's assimilative capacity.

The relative diversity values in the immediate vicinity of Unit 5300 are higher than those of Unit 6000, but the species richness values are significantly lower. Thus, despite the higher relative diversity values, fewer species are supported in the vicinity of these cages, suggesting a higher loading rate, resulting from a higher feeding rate or reduced dispersal of the load. Regardless of the cause, the loading rate appears to exceed the benthos' assimilative capacity causing severe oxygen depletion in the sediments thus favoring a select group of organisms. The shallow redox discontinuity layer depths (RPD) for these stations, in most cases reaching the surface, support this conclusion (refer to Table 4.4.).

Although the relative diversity values around Unit 5300 are higher than those found around Unit 6000, by factoring in species richness, the RD*SR (*) values are lower for Unit 5300 than 6000, thus indicating a more degraded condition around 5300, as suggested above. The significance of these results and the relationship between these indices will be discussed further below.

The third example site, SFML JB, is shallow and subjected to very weak tidal currents by comparison to the previous sites. This site has been operated rather intensively for several years and shifting of cage locations within the site is a standard operating procedure.

Figure 4.5. shows the position of the cages on the site and the location of the sampling stations. The shaded area beneath the inner system indicates the system's location just prior to its being moved to is new location shortly before sampling was conducted. A graphic comparison of the same parameters used for the previous two sites is shown in Figure 4.6. below. The rectangles at the top of the graph indicate the relative position of the cages to the sampling stations with the shaded area indicating the relative position of the inner cage system just prior to sampling. Tables 4.5 and 4.6. summarize the 1992 benthic macrofauna and sediment analyses for SFML JB., respectively.

Figure 4.5. Site Layout for SFML JB

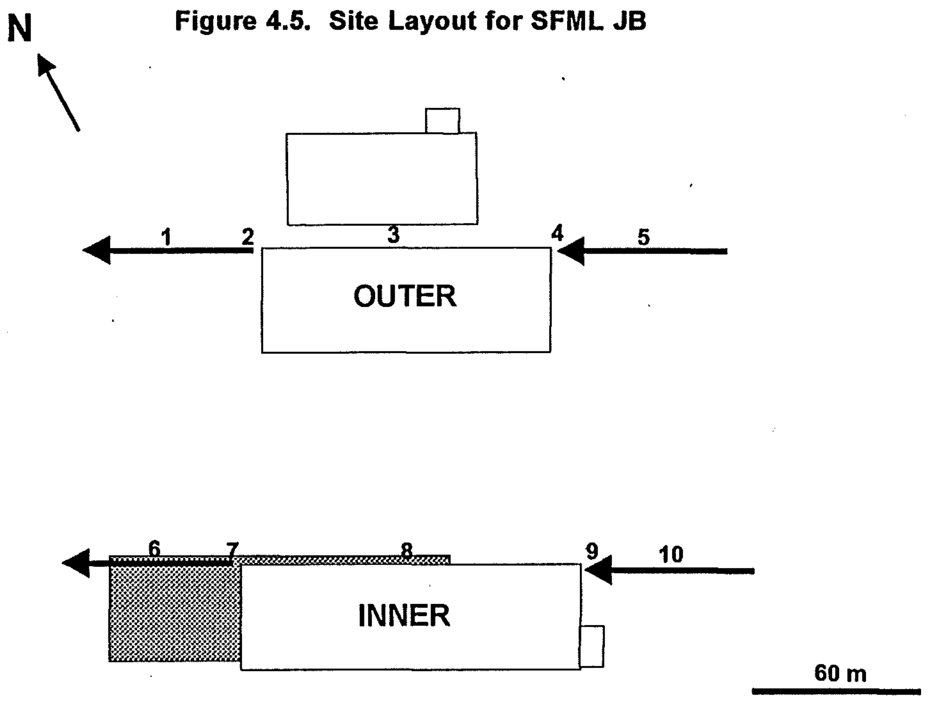
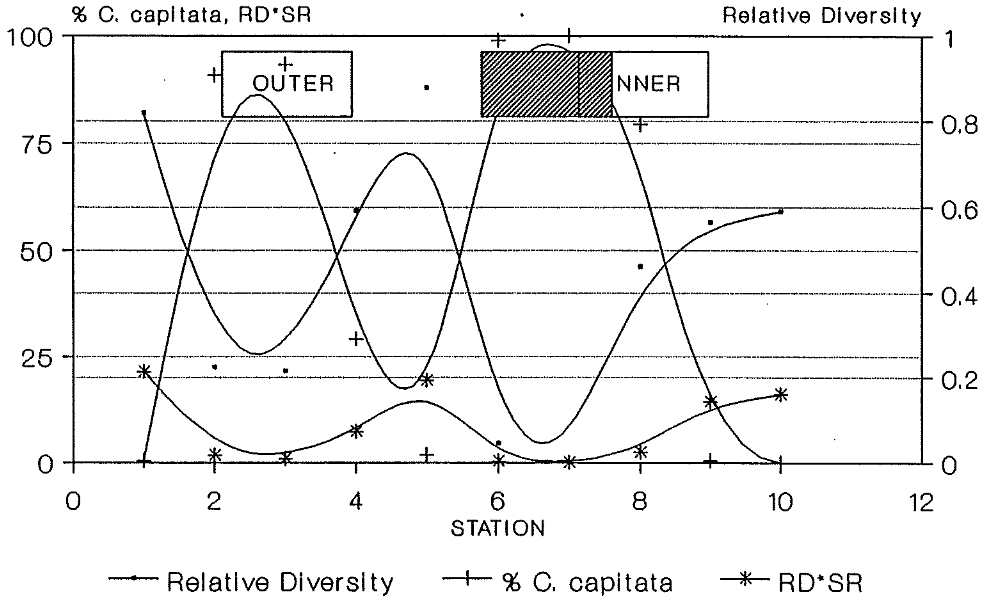


**FIGURE 4.6.
BENTHIC MACROFAUNA ANALYSIS RESULTS
INDICES COMPARISON**



SFML JB 1992
Box indicates cage location

MER ASSESSMENT CORPORATION
BENTHIC ANALYSIS REPORT
PAGE 7 OF 7

DATE	10-08-92
LOCATION	SFML JB
NO. SAMPLES	10

TABLE 4.5. BENTHIC MACROFAUNA ANALYSES RESULTS SUMMARY

	1	2	3	4	5	6	7	8	9	10	Total	Mean
Total organisms	234	745	163	216	57	614	144	58	279	274	2784	278
Abundance as No. organisms/0.1 m²	1283	4085	894	1184	313	3367	790	318	1530	1502	15265	1526
Species richness (No. species)	26	7	4	12	22	6	1	5	25	27		13.5
Distance in meters	30	0	0	0	30	30	0	0	0	30		
Rel. Diversity	0.819	0.224	0.215	0.591	0.877	0.044	0.000	0.462	0.564	0.589		0.438
% Capitella capitata	0.4	90.7	93.3	29.2	1.8	98.9	100.0	79.3	0.4	0.0		60.7
RD*SR	21.3	1.6	0.9	7.1	19.3	0.3	0.0	2.3	14.1	15.9		5.9

	Site	Outer	Inner	Inner Pre-shift
Impact Index	3.76			
Expert Rating	2.75			
Abundance/0.1 m²	1526	2054	879	1491
Species richness	1.4	7.7	10.3	4.0
Mean Rel. Div.	0.438	0.343	0.342	0.169
% C. capitata	60.7	71.1	59.9	92.7
Mean RD*SR	5.9	3.2	5.5	0.9

TABLE 4.6. SEDIMENT ANALYSES RESULTS SUMMARY

		1	2	3	4	5	6	7	8	9	10	Mean
Core Depth (cm)		10.5	11.0	11.0	10.5	7.0	8.0	9.5	8.0	9.0	10.0	9.5
UOML Depth (cm)		0.5	0.5	1.5	1.0	0.0	1.0	0.8	0.5	0.5	1.0	0.7
RPDL Depth (cm)		0.5	1.5	3.0	3.5	2.0	1.5	2.0	4.0	3.0	3.5	2.5
TOC		2.40	0.90	0.90	0.50	—	—	—	—	—	—	0.5
Grain Size	**Screen**											
Coarse gravel 1	**3.0 "**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coarse gravel 2	**2.0 "**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coarse gravel3	**1.50 "**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Medium gravel	**0.75 "**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fine gravel 1	**0.50 "**	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Fine gravel 2	**0.38 "**	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Coarse sand	**# 4**	1.7	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Cr/med sand	**# 10**	5.7	0.0	1.5	6.5	0.8	1.9	5.9	4.0	2.1	2.9	3.1
Med. sand	**# 20**	3.6	1.5	2.6	7.1	1.6	1.5	6.6	6.1	2.5	4.0	3.7
Med/fine sand	**# 40**	2.2	5.9	10.3	5.4	2.4	2.3	4.5	4.6	5.4	3.7	4.7
Fine sand 1	**# 60**	1.6	5.5	23.9	6.2	3.4	3.0	3.8	5.6	9.2	5.2	6.7
Fine sand 2	**# 100**	1.7	5.4	12.9	6.2	4.7	3.7	3.8	5.1	6.8	6.0	5.6
Very fine sand	**# 200**	8.8	18.2	10.5	9.3	16.4	16.8	12.6	8.1	9.3	14.6	12.5
Silt	**# 250**	2.5	5.7	1.5	2.0	5.4	6.0	3.3	2.6	2.0	3.7	3.5
Clay	**<# 250**	72.2	57.8	27.5	57.3	65.3	64.8	59.5	63.9	62.7	59.9	59.1
Gravel	**> # 4**	0.0	0.0	5.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
Sand	**<# 4 - ># 40**	11.0	1.5	7.7	13.6	2.4	3.4	12.5	10.1	4.6	6.9	7.4
Fine sand	**#40 - >#200**	5.5	16.8	47.1	17.8	10.5	9.0	12.1	15.3	21.4	14.9	17.0
Silt/Clay	**<# 200**	83.5	81.7	39.5	68.6	87.1	87.6	75.4	74.6	74.0	78.2	75.0
		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	

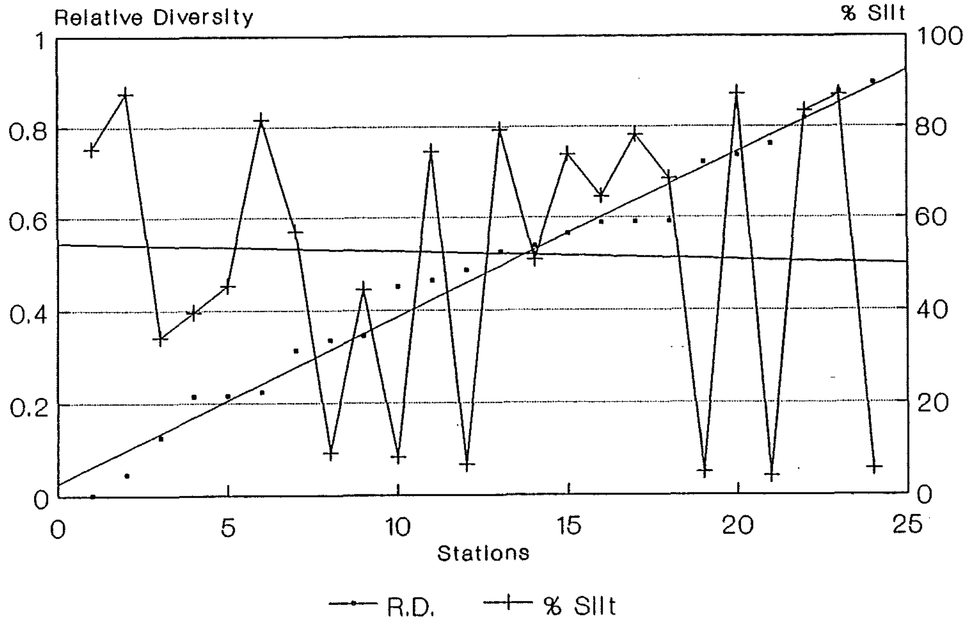
As with the CONA BC, the relative diversity values drop sharply in the vicinity of the cages, but here the effect is more pronounced and the inverse relationship between relative diversity and % *C. capitata* more clearly defined. As before, the results show the affected area to be confined to the immediate area beneath and adjacent to the cages. Such confinement is expected at this site, for the currents are too weak to disperse the deposition beyond the immediate vicinity of the cages. As a consequence, the affect to the "shadow" of the system is more severe than that seen beneath CONA BC Unit 6000 where swifter currents succeed in spreading the deposition over a larger area, thus reducing the impact in the immediate area.

Particularly noteworthy, however, is the "shift" in all indices beneath the inner system towards the system's previous position. The deep relative diversity valley (R.D. = 0), coupled with the complete dominance of *C. capitata* (100%), indicates that the shift was timely.

4.2. Relationships between Parameters

The foregoing examples show the usefulness of certain parameters in describing conditions under and around cage systems. However, the relationships between many of the parameters are less strong than expected, and in some cases defy intuition. Figure 4.7. below shows a comparison of the relative diversity and sediment silt content results for 24 of the stations sampled.

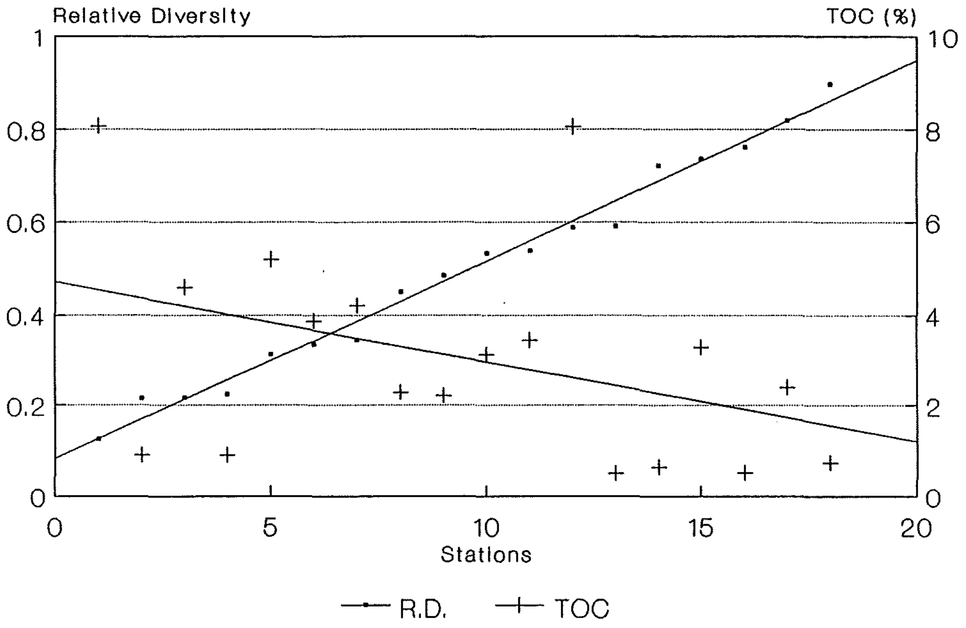
FIGURE 4.7.
RELATIVE DIVERSITY/% SILT
1992 AQUACULTURE MONITORING RESULTS



It is generally believed that softer sediment bottoms are more prone to pen-related impacts than coarser sediment bottoms. If true, one would expect to find an inverse relationship between increased silt content and indicators of environmental quality, such as relative diversity. As Figure 4.7. shows, however, relative diversity and silt content are poorly correlated with an R^2 value of 0.009 for these two parameters over 24 samples.

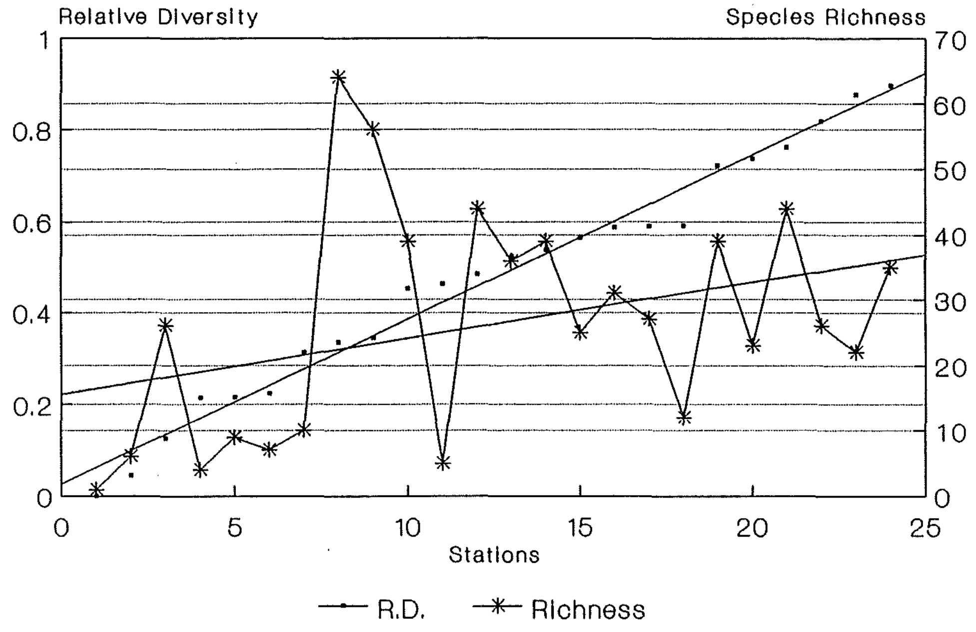
Similarly, it would be expected that, as a general trend, as organic enrichment increases (as indicated by increased TOC), the environmental quality diminishes. Figure 4.8. below shows that this general trend is found, but there is a wide range of data points around the trend and the relationship is weak (R^2 = 0.168). It should be noted that this regression analysis is based on only 18 samples and the inclusion of more samples may reinforce the trend and improve the R^2 value.

FIGURE 4.8.
TOTAL ORGANIC CARBON/RELATIVE DIVERSITY
1992 AQUACULTURE MONITORING RESULTS



Another example is the relationship between species richness and relative diversity. Intuitively one would expect to find a strong positive relationship between the two. As shown in Figure 4.9., there is a general trend towards increased species richness with increased relative diversity, but again, the relationship is weak with an R^2 value of 0.147 for these two parameters over 24 samples.

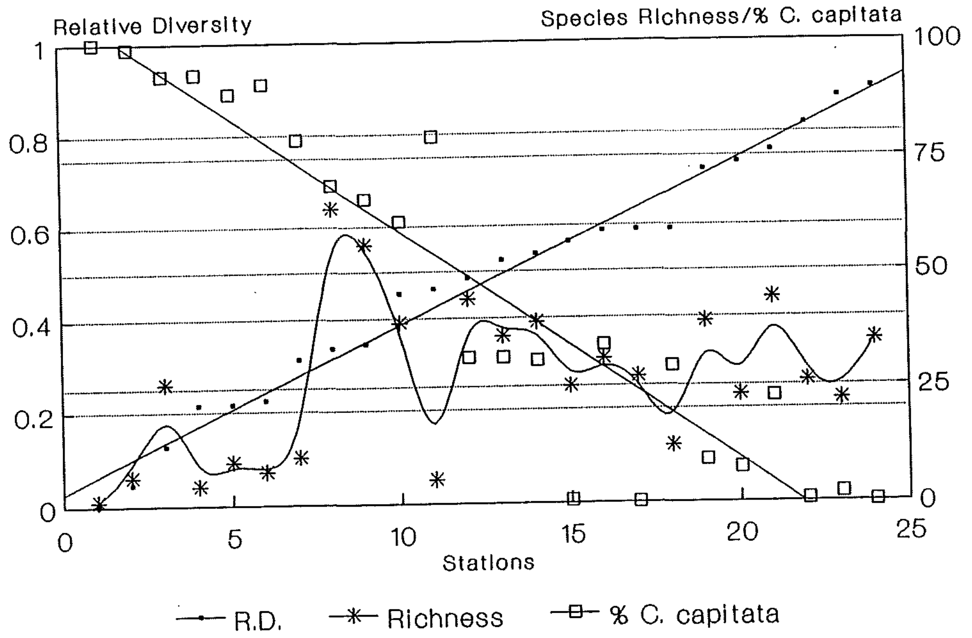
FIGURE 4.9.
SPECIES RICHNESS/RELATIVE DIVERSITY
1992 AQUACULTURE MONITORING RESULTS



24 STATION AT 3 SITES

Although it is difficult to show a strong relationship between most of the parameters, a clear inverse relationship exist between relative diversity and the abundance of *C. capitata*. Figure 4.10. below shows this relationship as the crossed trend lines of the two parameters. This relationship is relatively strong with R^2 = 0.853.

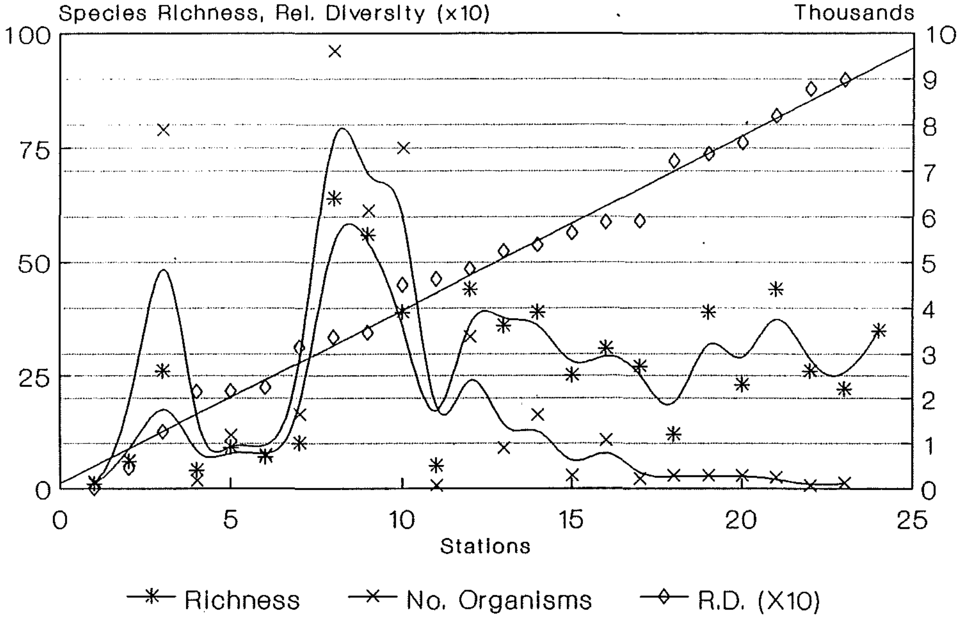
FIGURE 4.10.
SPECIES RICHNESS/REL. DIVER./C. capitata
1992 AQUACULTURE MONITORING RESULTS



24 STATIONS AT 3 SITES

It is interesting to note the peak in species richness (*), represented by the curve at the left of the intersection of the trend lines. Figure 4.11. below shows that this "spike" in species richness is also seen in the number of organisms (**x**) represented in samples. These "spikes", have been observed elsewhere in benthic community analyses and appear to represent a zone of biostimulation, a condition where the organic load offers increased opportunities for colonization without creating adverse conditions which would favor selected species. Pearson and Rosenberg (1978) reported similar finding regarding benthic community responses to organic enrichment.

FIGURE 4.11.
RICHNESS/REL. DIVER./NO. ORGANISMS
1992 AQUACULTURE MONITORING RESULTS



24 STATIONS AT 3 SITES

Table 4.7. below shows the extent of relationship between the various parameters used in the Aquaculture Monitoring Program.

Table 4.7.
Compararive Analysis of Parameters
Regression R^2 Matrix of Parameters

	RD	% SILT	SR	% Cap.	TOC	RPD
RD		.009080	.147299	**.852958**	.168230	.194562
% SILT	.009080		.356566	.000022	.043159	.121959
SR	.147299	.356566		.154733	.031355	.010271
% Cap.	**.852958**	.000022	.154733		.125645	.154278
TOC	.168230	.043159	.031355	.125645		.435237
RPD	.194562	.121959	.010271	.154278	.435237	

The only two parameters which show a strong relationship between them are relative diversity and % *C. capitata*. As stated earlier, this is no surprise, 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". Although % *C. capitata* may be a good indicator, reliance on the relative abundance of *C. capitata* as a <u>sole</u> indicator may be an oversimplification. This can again be illustrated using the example of stations 3 and 8 at CONA BC. Here, the two stations have relative diversity values of 0.335 and 0.314 and % *C. capitata* values of 68.5 and 79.0, respectively. Based on these relatively close values one might assume that the two stations are similar. However, a review of the species richness values shows station 3 supports 64 species while station 8 supports only 10. The situations are clearly not at all similar, for a review of the RPD layer depths shows station 8 to be severely hypoxic, with anoxic surface sediments, compared to a 3 cm oxic layer at station 3.

Obviously, no single parameter by itself can fully reflect the conditions beneath and adjacent to cage systems and a broader understanding of the sites is required to facilitate and improve interpretation.

5. Critique and Recommendations

5.1. Video Monitoring

The value of underwater video recordings has already been proven, however, their usefulness depends greatly on the quality of the image. Several factors contribute to image quality, including the quality of equipment, type of film, and operator experience, but two have the greatest affect: 1) amount of light, and 2) speed of the diver along the bottom.

During the first season of filming, artificial light was only used beneath the cages and not along the approach to and departure from the cage systems. In 1993 artificial lighting was used throughout the dive and significantly improved the quality of the images. The use of a single 50W light appears to be sufficient, for the use of increased light up to 150W has no appreciable affect on image quality enhancement. Further, the use of light provides greater definition to both the flora and fauna, thus facilitating identification. It is therefore recommended that light continue to be used throughout the video recording, even when ambient light appears to be sufficient.

The speed of travel across the bottom is critical to image quality and proper interpretation of the footage. Where speed is excessive, images are blurred, particularly in frame-by-frame analysis, often making identification of individual organisms and specific impact assessment impossible. It is therefore recommended that the filming swim rate not exceed 0.3m/sec or ~60m every 3 to 4 minutes.

Finally, although video recording is already useful as a "stand alone" tool, its usefulness will be greatly enhanced by coupling specific video images with quantitative results of sediment granulometry and benthic macrofauna community analyses. A preliminary attempt has already been made at such a coupling by taking "still" video recordings of the bottom at the location of benthic coring sites prior to the cores being taken. The results of the benthic cores will be compared to the recorded images. Interpretation of the comparison of these two monitoring tools will remain highly subjective, but through experience should lead to improved interpretation of the visual images.

5.2. Benthic Monitoring

The difficulties encountered in measuring the depth of the unconsolidated organic material (UOM) and redox discontinuity (RPD) layers have already been discussed. Some of these problems are related to the methods used while others are related to site-specific conditions.

When monitoring first began in Maine, it was anticipated that the UOM layer would be several centimeters deep based on reports of up to 2-3 meters of accumulation beneath pens in Norway and Washington State. In cases of heavy accumulation, measurement errors of centimeters are insignificant, but when the layer is very thin, as is usually the case in Maine where it rarely exceeds 2-3 cm, the possibility of erroneous measurement is rather high and their effects on accuracy magnified. Therefore, if the parameter is to be retained as part of the program, other methods of differentiating UOM from fine sediments should be investigated.

The difficulties with the RPD measurements have already been mentioned. Recently we have found bands of dark anoxic sediments sandwiched between lighter colored sediments. This is being attributed to burial of anoxic surface sediments under oxic sediments deposited over the bottom after being resuspended by local dragging activities. These high sediment deposition rates may also be affecting the determination of UOM by compacting the organic material under a layer of fine inorganic sediment. Similarly, the total organic carbon results may be affected by having much of the carbon buried below the 2 cm level which is used as the standard sample depth. Further, where dragging is occurring adjacent to the cages, much of the deposited carbon is undoubtedly being resuspended and redeposited elsewhere.

A possible solution to the problem of TOC source identification may be the simultaneous presentation of **total nitrogen (TN)** in the samples and the ratios of TOC to TN. Since this ratio varies with the source of carbon, the **TOC:TN** may provide some clues as to the source of the carbon. Preliminary results including TN and TOC:TN ratios have been received, but insufficient information is currently available on the conditions where the samples were taken to allow any conclusions to be drawn regarding the applicability of these data. Additional work on the relationship between TOC and TN in sediments around cage sites is currently underway and more information should be available within the next six (6) months.

The benthic macrofauna analyses are extremely time- and labor-consuming, but provide a depth of understanding unattainable through physical and chemical analyses alone. Although the program requires identification only to the "lowest practical taxonomic" level, every effort has been made to identify organisms to the species level. This has been done in large part to allow evaluation of indices such as species richness and relative diversity. Now that the data is available at the species level, the species will be grouped by Family and the indices recalculated and the difference between the results compared. Due to the predominance of members of the Family Capitellidae in samples taken from beneath the cages, the difference between the two calculations may be relatively insignificant, in which case the level of identification could be reduced to Family, thus significantly reducing the labor intensity and consequently the cost of benthic monitoring.

Finally, certain sites have shown little evidence of affect from the cage system operation, either in the video or benthic monitoring. Reduction in the level of scrutiny received by these sites may be justifiable based on the lack of observed impact. Monitoring could be reduced to an annual video survey in the Fall with benthic sediment and macrofauna monitoring carried out only every fourth year. The level of monitoring could, of course, be intensified at any time if the results of the video survey indicated increased degradation of the bottom.

6. Related Work

6.1 Predictive Model

The work carried out in Maine over the past two years has provided information useful in related research efforts. Sowles, Churchill, and Silvert (1993) have recently developed a predictive model for penculture-related benthic loading. In its current form, the model attempts to predict benthic impacts based on production levels, feeding efficiency (feed conversion rates), depth, and current velocity. These variables have been mathematically manipulated to arrive at an equation which yields a "prediction" for individual systems comparable to the "expert" scores reported here in Section 3.1.2. for the same systems.

The results thus far are encouraging, but before being of use, the model must be validated in the same way that the arbitrary "expert" scores upon which it is based must be validated. This can be accomplished by having the model accurately predict real impacts as described by the data generated through the Aquaculture Monitoring Program. The model has been developed on information from 23 sites in Maine, but complete monitoring data is currently available for only 12 of these sites. Once the samples collected in 1993 are analyzed, complete benthic information will be available for 22 of the 23 selected sites.

It must be emphasized, however, that the model is not intended as a tool for site selection, but has been designed to assist regulators in determining the appropriate level of monitoring for a particular site.

6.2. Species Sensitivity Classification

The work of Chang *et al.* (1992) and its application to the aquaculture monitoring effort in Maine have already been mentioned. As pointed out, one difficulty encountered with applying this classification approach is the disproportionate number of species classified as "most insensitive" (Category IV), thus shifting the overall site rating higher. To alleviate this problem, species assemblages normally found in Maine under different environmental conditions need to be classified in the same manner as Chang *et al.* have done for the New York Bight.

One approach is to pass the macrofauna data developed through the aquaculture monitoring program and other similar studies through the statistical "sieve" employed by Chang *et al.* to produce ratings for local species. Unfortunately, Chang *et al.* included sensitivity to lead and chromium, in addition to grain size and total organic carbon, in their selection process. While the latter two have direct applicability to the work presented here, heavy metal sensitivity is not of concern in this case. Nevertheless, although both costly and time-consuming, species sensitivity classification may provide a useful quantitative tool for analyzing environmental quality through benthic macrofauna analysis, not only as applied to aquaculture, but to all forms of marine environmental degradation through enrichment.

6.3. "Recovery"

As the graph on the first page of this report shows, the number of pens in operation in Maine has been steadily increasing over the last 5-6 years. Today, all of the ideal sites, and most if not all of the good sites (for salmon culture), have been leased. Consequently, for continued expansion to occur, sites will have to be located in increasingly marginal areas (greater distance from shore, greater exposure, etc.) or existing sites will have to be utilized more intensively. If the latter is the case, pens will have to be rotated around sites to avoid excessive degradation of the bottom.

The aquaculture monitoring program has been successful in detecting and tracking the degradation process, but little is known about the recovery process once organic enrichment ceases. Knowledge of this process, however, will become critical in the future as operators are faced with decisions on when and where to locate pens on their sites.

A preliminary effort has been initiated to investigate the rate of benthic recovery after pen removal. This effort, however, is restricted to only one site which would not be considered to represent the average or normal situation in Maine. An effort to develop information on the recovery rate applicable across the State would require investigation of several sites representing various environmental conditions and production levels.

The current project is being funded at a minimal level at this time, but additional funding is being sought.

References

Chang, et al., 1992. Association of benthic macrofauna with habitat types and quality in the New York Bight. *Mar. Ecol. Prog. Ser.*, Vol. 89:237-251.

Grassle, J.P., and J.F. Grassle, 1976. Sibling species in the marine pollution indicator *Capitella* (Polychaeta). *Science* 192:567-569.

Hedges, J.I., and J.H. Stern, 1984. Carbon and nitrogen determinations of carbonate-containing solids. *Limnol. Oceanogr.*, 29(3):657-663.

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

Shannon, C.E., 1948. A mathematical theory of communication. In: *Biostatistical Analysis*, Ed. J.H. Zar, Prentice-Hall, Inc. Englewood Cliffs, N.J., 617 pp.

Sowles, J.W., L. Churchill, and W. Silvert, 1993. The effects of benthic carbon loading on the degradation of bottom conditions under farm sites. In: *Modelling Benthic Impacts of Organic Enrichment from Marine Aquaculture*, Ed. B.T. Hargrave, Can. Tech. Rep. Fish. Aq. Sci. (not numbered).

Appendix I Example Spreadsheet

MER ASSESSMENT CORPORATION
BENTHIC ANALYSIS REPORT
PAGE 1 OF 7
DATE 10-08-92
LOCATION SFML JB
NO. SAMPLES 10

	Sp. Cat.	SAMPLING STATIONS											
		1	2	3	4	5	6	7	8	9	10	Total	Mean
ANNELIDA													
POLYCHAETA													
Ampharetidae													
Ampharete arctica		0	0	0	0	0	0	0	0	0	0	0	0.000
Ampharete acutifrons		5	0	0	0	0	0	0	0	2	1	8	0.800
Ampharete sp.		0	0	0	0	0	0	0	0	0	0	0	0.000
Asabellides sp.	1.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Melinna cristata		0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	1	1	0.100
Apistobranchidae													
Apistobranchus tullbergi		0	0	0	0	0	0	0	0	0	0	0	0.000
Arenicolidae													
Arenicola marina		0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Capitellidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Capitella capitata	4.00	1	676	152	63	1	607	144	46	1	0	1691	169.100
Capitella sp.	4.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Mediomastus ambiseta	4.00	2	0	0	0	0	0	0	0	0	0	2	0.200
Heteromastus filiformis		0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Cirratulidae	1.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Cirratulus cirratus	1.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Chaetozone sp.		0	0	0	0	0	0	0	0	0	0	0	0.000
Tharyx spp.	3.00	4	12	0	101	1	0	0	0	0	1	119	11.900
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Cossuridae		0	0	0	0	0	0	0	0	0	0	0	0.000
Cossura longicirrata	4.00	2	0	0	0	1	0	0	0	1	0	4	0.400
Dorvilleidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Flabelligeridae		0	0	0	0	0	0	0	0	0	0	0	0.000
Brada spp		0	0	0	0	0	0	0	0	0	1	1	0.100
Pherusa spp	4.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Diplocirrus hirsutus		0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Hesionidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Microphthalmus aberrans		0	1	8	0	0	1	0	1	0	0	11	1.100
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Lumbrineridae		0	0	0	0	0	0	0	0	0	0	0	0.000
Lumbrineris spp.		0	0	0	0	4	0	0	0	1	1	6	0.600
Ninoe nigripes	4.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Maldanidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Clymenella torquata	4.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Clymenella sp	4.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Praxillela spp		0	0	0	0	0	0	0	0	0	0	0	0.000
Rhodine sp.		0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000

MER ASSESSMENT CORPORATION
BENTHIC ANALYSIS REPORT
PAGE 2 OF 7
DATE 10-08-92
LOCATION SFML JB
NO. SAMPLES 10

SAMPLING STATION

		1	2	3	4	5	6	7	8	9	10	Total	Mean
POLYCHAETA		0	0	0	0	0	0	0	0	0	0	0	0.000
Nephtyidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Aglaophamus neotenus		0	0	0	0	1	0	0	0	0	0	1	0.100
Nephtys sp	3.50	4	0	0	6	0	0	0	0	1	0	11	1.100
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Nereidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Nereis spp.	2.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Opheliidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Ophelina acuminata		6	0	0	0	0	0	0	0	1	1	8	0.800
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Orbiniidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Naineris quadricuspida		0	0	0	0	0	0	0	0	0	0	0	0.000
Scoloplos sp.		0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Oweniidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Paraonidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Aricidea spp.	1.00	0	0	0	0	1	0	0	0	1	0	2	0.200
Paraonis sp.		0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Pectinaridae		0	0	0	0	0	0	0	0	0	0	0	0.000
Cistena granulata		0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Phyllodocidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Eteone spp.	4.00	1	33	0	0	0	1	0	6	0	0	41	4.100
E. longa	4.00	0	2	0	0	0	0	0	0	0	0	2	0.200
E. trileneata.		0	0	0	0	0	0	0	0	0	0	0	0.000
Phyllodoce groenlandica		0	0	0	0	0	0	0	0	0	0	0	0.000
Phyllodoce mucosa		3	0	0	0	0	0	0	0	0	0	3	0.300
Phyllodoce sp.		0	0	0	0	0	0	0	0	0	1	1	0.100
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Polynoidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Harmathoe extenuata	2.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Harmathoe imbricata		0	0	0	0	0	0	0	0	0	0	0	0.000
Lepidonotus squamatus		0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Sabellidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Chone infundibuliformis	3.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Euchone rubrocincta	3.50	0	0	0	0	0	0	0	0	0	0	0	0.000
Myxicola infundibulum		0	0	0	0	0	0	0	0	0	0	0	0.000
Potamilla spp		0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Scalibregmidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Scalibregma inflatum	2.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Serpulidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Spirorbis spp		0	0	0	0	0	0	0	0	0	0	0	0.000

MER ASSESSMENT CORPORATION
BENTHIC ANALYSIS REPORT
PAGE 3 OF 7
DATE 10-08-92
LOCATION SFML JB
NO. SAMPLES 10

SAMPLING STATION

		1	2	3	4	5	6	7	8	9	10	Total	Mean
POLYCHAETA		0	0	0	0	0	0	0	0	0	0	0	0.000
Sigalionidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Pholoe minuta	4.00	0	0	0	0	1	0	0	0	0	2	3	0.300
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Spionidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Polydora spp		0	0	0	0	3	0	0	0	0	0	3	0.300
Prionospio steenstrupi	4.00	11	0	0	0	1	0	0	0	0	1	13	1.300
Scolecolepedis viridis		0	0	0	0	2	0	0	0	0	0	2	0.200
Spio sp	3.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Spiophanes bombyx	2.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Sternaspidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Sternaspis scutata		0	0	0	0	0	0	0	0	1	2	3	0.300
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Syllidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Eusyllis sp		0	0	0	0	0	0	0	0	0	0	0	0.000
Exogone spp	1.50	0	0	0	0	0	0	0	0	0	0	0	0.000
Syllis sp.		0	0	0	0	0	0	0	0	0	0	0	0.000
Syllis gracilis		0	0	0	0	0	0	0	0	0	0	0	0.000
Syllis cornuta		0	0	0	0	0	0	0	0	0	0	0	0.000
Sphaerosyllis erinaceus		0	0	0	0	0	0	0	0	0	0	0	0.000
Paraprionosyllis longicirrata	1.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Terebellidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Amphitrite cirrata		0	0	0	0	0	0	0	0	0	0	0	0.000
Amphitrite sp		0	0	0	0	0	0	0	0	0	0	0	0.000
Nicolea venustula		0	0	0	0	0	0	0	0	0	0	0	0.000
Polycirrus sp		0	0	0	0	0	0	0	0	0	0	0	0.000
P. eximius		0	0	0	0	0	0	0	0	0	0	0	0.000
Streblosoma spiralis		0	0	0	0	0	0	0	0	0	0	0	0.000
Terebellides stroemi	2.00	4	0	0	0	1	0	0	0	3	5	13	1.300
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Unidentified Polychaeta		36	0	0	0	0	0	0	0	0	0	36	3.600
OLIGOCHAETA		0	0	0	0	6	1	0	0	0	0	7	0.700
CHORDATA		0	0	0	0	0	0	0	0	0	0	0	0.000
Ascidiacea		0	0	0	0	0	0	0	0	0	0	0	0.000
Boltenia sp		0	0	0	0	0	0	0	0	0	0	0	0.000
Halocynthia pyriformis		0	0	0	0	0	0	0	0	0	0	0	0.000
Molgula sp		0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
CNIDARIA		0	0	0	0	0	0	0	0	0	0	0	0.000
Edwardsiidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Edwardsia elegans	4.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Metridiidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Metridium senile		0	0	0	0	0	0	0	0	0	0	0	0.000

DATE 10-08-92
LOCATION SFML JB
NO. SAMPLES 10

SAMPLING STATION

		1	2	3	4	5	6	7	8	9	10	Total	Mean
CRUSTACEA		0	0	0	0	0	0	0	0	0	0	0	0.000
Amphipoda		0	0	0	0	0	0	0	0	0	0	0	0.000
Aeginella longicornis		0	0	0	0	0	0	0	0	0	1	1	0.100
Ampelisca spp	1.00	4	0	0	2	4	0	0	0	3	1	14	1.400
Antionella sarsi		0	0	0	0	0	0	0	0	0	0	0	0.000
Caprella linearis		0	0	0	0	0	0	0	0	0	0	0	0.000
Caprella sp		0	0	0	0	0	0	0	0	0	0	0	0.000
Corophium spp	1.00	30	0	0	2	1	0	0	0	11	10	54	5.400
Dexamine thea		1	0	0	0	0	0	0	0	0	0	1	0.100
Dulichia porrecta		0	0	0	0	0	0	0	0	0	0	0	0.000
Erichthonius sp.	1.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Gamaridae spp		0	0	0	0	0	0	0	0	0	0	0	0.000
Gammaropsis nitida		0	0	0	0	0	0	0	0	0	0	0	0.000
Gattyana cirrosa		0	0	0	0	0	0	0	0	0	0	0	0.000
Harpinia propinqua		11	0	0	0	0	0	0	0	16	5	32	3.200
Ilyannassa sp.		0	0	0	0	0	0	0	0	0	0	0	0.000
Leptocheirius pinguis	2.00	7	0	0	0	0	0	0	0	0	0	7	0.700
Monoculodes spp.		0	0	0	0	0	0	0	0	0	0	0	0.000
Orchomonella spp.		46	0	0	26	7	0	0	0	96	96	271	27.100
Photis sp.	4.00	9	0	1	2	2	0	0	0	105	86	205	20.500
Phoxocephalus holbolli	1.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Pleusymtes glaber		0	0	0	0	0	0	0	0	0	0	0	0.000
Unciola sp	1.50	0	0	0	1	0	0	0	0	0	0	1	0.100
Unid.		4	0	0	3	1	0	0	0	1	0	9	0.900
Cumacea		0	0	0	0	0	0	0	0	0	0	0	0.000
Dyastilis spp	2.00	8	6	0	6	11	0	0	0	14	35	80	8.000
Eudorella spp		26	0	0	3	5	0	0	0	5	5	44	4.400
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
DECAPODA		0	0	0	0	0	0	0	0	0	0	0	0.000
Portunidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Carcinus maenas		0	0	0	0	0	0	0	0	0	0	0	0.000
Crangonidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Crangon septemspinosa	2.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Isopoda		0	0	0	0	0	0	0	0	0	0	0	0.000
Edotea triloba	4.00	2	0	0	0	1	0	0	0	3	1	7	0.700
Edotea spp	4.00	1	0	0	0	0	0	0	0	0	1	2	0.200
Idotea balthica		0	0	0	0	0	0	0	0	0	0	0	0.000
Idotea sp		0	0	0	0	0	0	0	0	0	0	0	0.000
Munna fabricii		0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Tanaidacae		0	0	0	0	0	0	0	0	0	1	1	0.100
ECHINODERMATA		0	0	0	0	0	0	0	0	0	0	0	0.000
Holothuroidea		0	0	0	0	0	0	0	0	0	0	0	0.000
Chiridotidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Chiridota laevis		0	0	0	0	0	0	0	0	0	0	0	0.000
Cucumariidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Cucumaria frondosa		0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000

MER ASSESSMENT CORPORATION
BENTHIC ANALYSIS REPORT
PAGE 5 OF 7

DATE 10-08-92
LOCATION SFML JB
NO. SAMPLES 10

		SAMPLING STATION											
		1	2	3	4	5	6	7	8	9	10	Total	Mean
Molpadiidae		0	0	0	0	0	0	0	0	0	0	0	0.000
Molpadia sp		0	0	0	0	0	0	0	0	0	0	0	0.000
Echinoidea		0	0	0	0	0	0	0	0	0	0	0	0.000
Echinarachnius parma	1.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Strongylocentrotus droebachiensis		0	0	0	0	0	0	0	0	0	0	0	0.000
Stelleroidea		0	0	0	0	0	0	0	0	0	0	0	0.000
Amphipholis sp		0	0	0	0	0	0	0	0	0	0	0	0.000
Asterias forbesii		0	0	0	0	0	0	0	0	0	0	0	0.000
Asterias vulgaris		0	0	0	0	0	0	0	0	0	0	0	0.000
Opiuroidea		0	0	0	0	0	0	0	0	0	0	0	0.000
Ophiopholis sp		0	0	0	0	0	0	0	0	0	0	0	0.000
Solaster sp		0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
MOLLUSCA		0	0	0	0	0	0	0	0	0	0	0	0.000
Bivalvia		0	0	0	0	0	0	0	0	0	0	0	0.000
Astarte undata	1.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Cardita borealis		0	0	0	0	0	0	0	0	0	0	0	0.000
Cerastoderma pinnulatum	3.00	0	0	0	0	0	0	0	0	1	1	2	0.200
Crenella sp		1	0	0	0	0	0	0	0	0	0	1	0.100
Hiatella arctica		0	0	0	0	0	0	0	0	1	0	1	0.100
Modiolus modiolus		0	0	0	0	0	0	0	0	0	0	0	0.000
Musculus niger		0	0	0	0	0	0	0	0	0	0	0	0.000
Mya arenaria		0	0	0	0	0	0	0	0	0	0	0	0.000
Mya truncata		0	0	0	0	0	0	0	0	0	0	0	0.000
Mytilus edulis	3.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Nucula spp	4.00	0	0	0	0	0	1	0	1	4	2	8	0.800
Nuculana sp		0	0	0	0	0	0	0	0	0	0	0	0.000
Thyasira gouldii		0	0	0	0	0	0	0	0	4	2	6	0.600
Yoldia sp	4.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	1	1	0.100
Gastropoda		0	0	0	0	0	0	0	0	0	0	0	0.000
Acmea testudinalis		0	0	0	0	0	0	0	0	0	0	0	0.000
Buccinum spp		0	0	0	0	0	0	0	0	0	0	0	0.000
Colus sp		0	0	0	0	0	0	0	0	0	0	0	0.000
Coryphella spp		0	0	0	0	0	0	0	0	0	0	0	0.000
Crucibulum striatum		0	0	0	0	0	0	0	0	0	0	0	0.000
Cylichna alba		0	0	0	0	0	0	0	0	1	5	6	0.600
Dendronotus frondosus		0	0	0	0	0	0	0	0	0	0	0	0.000
Hydrobia minuta		0	0	0	0	0	0	0	0	0	0	0	0.000
Lacuna vincta		0	0	0	0	0	0	0	0	1	0	1	0.100
Margarites spp		0	0	0	0	0	0	0	0	0	0	0	0.000
Neptunea decemcostata		0	0	0	0	0	0	0	0	0	0	0	0.000
Polinices spp.		0	0	0	0	0	0	0	0	0	0	0	0.000
P. heros		0	0	0	0	0	0	0	0	0	0	0	0.000
P. triseriata		0	0	0	0	0	0	0	0	0	0	0	0.000
Urosalpinx cinereus		0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Polyplacophora		0	0	0	0	0	0	0	0	0	0	0	0.000
Ischnochiton alba	1.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Ischnochiton ruber	1.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.		0	0	0	0	0	0	0	0	0	0	0	0.000
Scaphopoda		0	0	0	0	0	0	0	0	0	0	0	0.000

MER ASSESSMENT CORPORATION
BENTHIC ANALYSIS REPORT
PAGE 6 OF 7
DATE 10-08-92
LOCATION SFML JB
NO. SAMPLES 10

SAMPLING STATION

			1	2	3	4	5	6	7	8	9	10	Total	Mean
NEMATODA			3	15	2	1	1	3	0	4	1	0	30	3.000
NEMERTINEA			0	0	0	0	0	0	0	0	0	0	0	0.000
Cerebratulus sp		3.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Micrura sp		3.00	0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.			0	0	0	0	0	0	0	0	0	0	0	0.000
PLATYHELMINTHES			0	0	0	0	0	0	0	0	0	0	0	0.000
Tubullaria			0	0	0	0	0	0	0	0	0	0	0	0.000
PRIAPULIDA			0	0	0	0	0	0	0	0	0	0	0	0.000
Priapulus caudatus			0	0	0	0	1	0	0	0	0	0	1	0.100
PYCNOGONIDA			0	0	0	0	0	0	0	0	0	0	0	0.000
Pycnogonum littorale			0	0	0	0	0	0	0	0	0	0	0	0.000
Unid.			0	0	0	0	0	0	0	0	0	0	0	0.000
SIPUNCULA			0	0	0	0	0	0	0	0	0	0	0	0.000
Golfingia sp			0	0	0	0	0	0	0	0	0	0	0	0.000
Phascolion strombi			0	0	0	0	0	0	0	0	0	0	0	0.000
Phascolopsis guoldii			2	0	0	0	0	0	0	0	0	4	6	0.600
Unid.			0	0	0	0	0	0	0	0	0	0	0	0.000

Salmon Aquaculture Monitoring and Research Fund

Financial Report
Fy 92 - Fy94

DEPARTMENT OF MARINE RESOURCES
FINFISH REPORT
AS OF 12-18-93

c:\qpw\data\monthly.rpt\94\finfish.cum

	FY 92	FY 93	FY 94 THRU JAN 94	TOTAL
REVENUES COLLECTED IN FY	82,643.63	134,699.96	53,306.97	270,650.56
EXPENDITURES: (ACTUAL PAYMENTS - DOES NOT REFLECT ENCUMBRANCES)				
CONTRACTUAL SERVICES		98,073.95	38,789.49	136,863.44
AUTO EXPENSES (INS., REPAIRS, MAINT.)		745.91	2,036.68	2,782.59
TELEPHONE		17.15		17.15
TRAVEL IN STATE (HOTEL & FOOD)	72.00	1,260.99	1,495.00	2,827.99
MAIL		31.77	60.50	92.27
COPYING/PRINTING		869.59	6.75	876.34
COMPUTER EXPENSES (MAINT. & SOFTWARE)	104.19	3,309.72	203.33	3,617.24
MISC OFFICE & LAB SUPPLIES		1,580.50	2,296.88	3,877.38
STATE CAP	2.47	1,020.95	1,267.30	2,290.72
EQUIP. NON CAPITAL		3,959.23	1,933.25	5,892.48
CAPITAL - COMPUTER EQUIP.		9,180.00		9,180.00
TOTAL SPENT	**178.66**	**120,049.76**	**48,089.18**	**168,317.60**

CONTRACTUAL SERVICES DETAIL:

	FY 92	FY 93	FY 94 THRU JAN 94	TOTAL
Intertide Corporation	17,018.00	82,884.19		99,902.19
WCTC Marine/Tom Duym		1,200.00	1,200.00	2,400.00
Todd Lajeunesse		1,200.00	1,200.00	2,400.00
MER Assessment Corporation			79,624.00	79,624.00
TOTAL ENCUMBERED IN FY	17,018.00	85,284.19	82,024.00	184,326.19

NOTE:

Income to the fund is generated through a one cent per pound assessment on whole fish harvested payable to the Department of Marine Resources.

The Department is recommending that the assessment remain at that rate in order to support continuation of the monitoring program.