Final Report on the Water Quality Monitoring Programme for Mussel Growers *

Prepared By

M. Brylinsky

Acadia Centre for Estuarine Research

May, 1989

*Supported By ERDA (Nova Scotia) and DSS (Gulf Region)

TABLE OF CONTENTS

INTRODUCTION

During the last several years culture of the blue mussel, *Mytilus edulis*, has been one of the fastest growing food-related industries in the Atlantic Maritime Provinces and is now rapidly reaching the point of becoming a major marine industry. As the industry grows it is becoming increasingly obvious that the successful culture of mussels, as well as the potential environmental impact of culture activities, is very much dependent on the nature of a number of key environmental conditions at growing sites. This has lead to the opinion, among both private mussel growers and government regulatory agencies, that orderly development of the industry could benefit from a programme in which environmental conditions at growing sites would be monitored on a routine basis. The need for an environmental monitoring programme became particularly evident in the late summer of 1986 when a large number of growers experienced severe summer-mortality of market-size mussels and were unable to determine or understand the cause of the mortality, largely because of the lack of basic data on environmental conditions or the condition of the mussels at the time of the mortality. A short while later events in Prince Edward Island associated with the presence of domoic acid further indicated the need for a routine monitoring programme that would provide base-line data useful in attempts to understand the causes of unusual and unexpected events. More recently, a growing concern among many individuals with regard to the potential environmental impact of mussel culture has further emphasised the need to document changes in environmental conditions that may be occurring at growing sites.

In response to the obvious need, and at the request of a number of practicing mussel growers and government agencies, the Acadia Centre for Estuarine Research (ACER) developed a proposal to implement a water quality monitoring programme at a number of growing sites located throughout the Atlantic Maritime provinces. A unique aspect of the proposed programme was that it required the active participation of private mussel growers in collecting data and samples. The participation of growers was considered not only desirable in terms of the training and general educational benefits they would receive, but necessary in order to develop a comprehensive programme at reasonable cost.

The major objectives of the programme, as stated in the original proposal, were; (1) to introduce commercial mussel growers to the environmental factors critical to the successful culture of mussels; (2) to train growers in the techniques for monitoring these variables; (3) to create a facility that would provide expertise in monitoring techniques, sample analyses and data interpretation and; (4) to begin development of a long-term data base that would be useful in explaining seasonal and yearly variations in mussel settlement, growth, and survival and provide a record documenting changes that may be occurring in environmental conditions at growing sites.

The proposal was subsequently jointly funded in the late summer of 1987 by the Nova Scotia Department of Fisheries under the ERDA programme and by the Gulf Region of the Federal Department of Fisheries and Oceans as a Department of Supply and

Services contract. A total of twenty sites were scheduled to take part in the monitoring programme; eight in Nova Scotia, eight in Prince Edward Island, three in New Brunswick, and one in Newfoundland. The programme ended in March, 1989, having lasted approximately nineteen months. This report summarizes the development and results of the monitoring programme. It is divided into three sections. The first provides a brief overview of the design and development of the programme. The second section summarizes the final results and discusses the successes and shortcomings of the programme, and the third section makes suggestions and recommendations that should be considered in establishing future monitoring programmes.

II. PROGRAMME DESIGN AND DEVELOPMENT

A. Selection of Sites:

The mechanism used to select sites for participation in the monitoring programme differed among provinces. In Nova Scotia, the sites were selected by personnel of the Nova Scotia Department of Fisheries and were chosen to cover a wide geographic area. This also resulted in the representation of a diversity of site types with regard to physical characteristics. In Prince Edward Island a meeting of the province's major growers was arranged during which the general nature and objectives of the programme were presented. The growers were then asked to decide if the programme seemed appropiate to their needs and, if so, to select among themselves eight sites most appropriate for monitoring. After some private discussion the growers agreed to participate in the programme and chose eight sites for the programme each of which represented a major growing area of the Island.

For the remaining four sites, three in New Brunswick and one in Newfoundland, a meeting with potential participants, chosen by Department of Fisheries and Oceans personnel mainly on the basis of the extent of their involvement in the industry, was held in New Brunswick. As in Prince Edward Island, the programme was described and the growers were asked if they would be willing to participate. All agreed to take part in the programme.

Table 1 presents a listing of the growers originally selected to participate in the programme and Figure 1 shows the location of each growing site.

B. Selection of Variables for Monitoring:

In chosing the variables to be included in the monitioring programme, it was necessary to identify those environmental factors thought to be most important in influencing mussel growth and survival, as well as being most susceptable to change over both temporal and spatial scales. It was also important that only variables measured relatively easily and inexpensively be considered for monitoring.

The final choice of variables to include was based largely on current concepts of the major inputs and outputs of a mussel and the environmental factors thought most important in controlling the rate of these inputs and outputs. A hierarchial

TABLE 1. Original Participants and Site Locations.

Site #	Participant	Site Location
1	P. Budreski	Little Ship Harbour, N.S.
2	P. Marchand	Lennox Passage, N.S.
3	P. Darnell	Mahone Bay, N.S.
4	J. MacInnes	Port Hood, N.S.
5	K. MacLeod	St. Ann's Bay, N.S.
6	R. Maloney	Tatamagouche Bay, N.S.
7	Guysborough Aquatic Ventures	Marie Joseph, N.S.
8	J. Underwood	Little Harbour, N.S.
9	G. Arsenault	Hillsborough River, PEI
10	S. Stewart	New London Bay. PEI
11	R. Dockendorf, Jr.	Cardigan River, PEI
12	T. Farrell	St. Marys Bay, PEI
13	G. Keith	Brudnell River, PEI
14	R. MacPherson	Murray River, PEI
15	R. Townshend	Tracadie Bay, PEI
16	J. VandenBremdt	Boughton River, PEI
17	M. Daigle	Richibucto, N.B.
18	C. Lanteigne	Caraquet, N.B.
19	G. LeBlanc	Shediac, N.B.
20	A. Benoit	Stephenville, NFLD.

model illustrating these concepts is presented in Figure 2. Table 2 presents a list of the variables selected for monitoring, along with a brief description of the measurement technique employed for each.

C. Establishing the Time Scale for Monitoring:

The time scale most appropriate for a monitoring programme depends largely on the rates at which the variables being monitored change, and a major problem in all routine monitoring programmes is that the variables of interest often change over very different time scales. For example, water temperature varies mainly over a seasonal time scale and it is possible to characterize this variation by taking measurements at weekly or even monthly time intervals. Current velocity, however, usually varies over a time scale associated with the tidal cycle, i.e. hours, and its characterization requires very frequent measurement. Another important consideration in designing a sampling programme is the extent of resources available, in this case mainly time, for sampling and sample processing.

With these considerations in mind, it was suggested to growers that they try to monitor their sites on at least a biweekly basis. They were, however, encouraged to monitor more

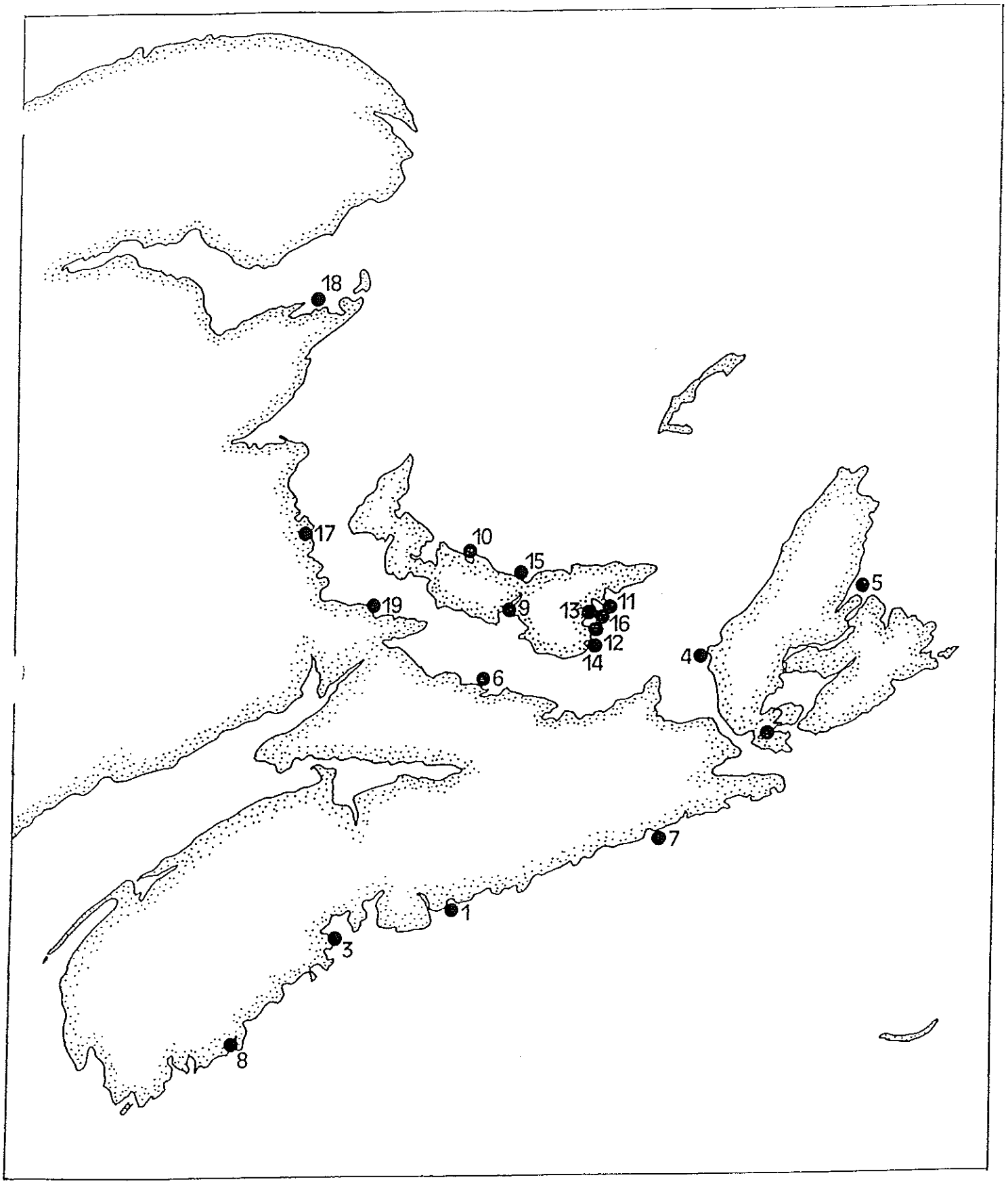


Figure 1. Location of sites originally selected for the monitoring programme.

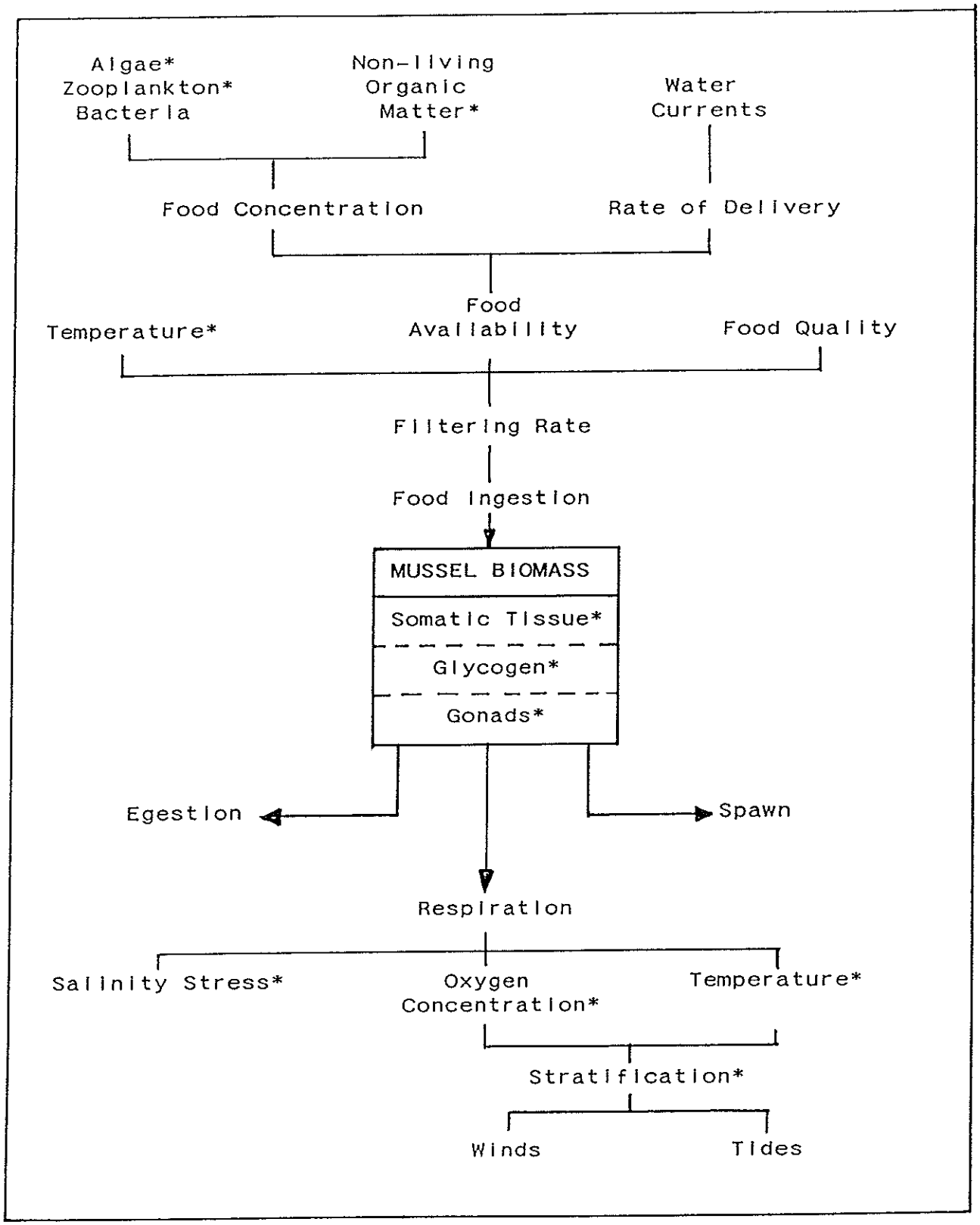


Figure 2. Hierarchal model illustrating major environmental factors influencing the growth of mussels. * Indicates factors on which information is collected in the monitoring programme.

Table 2. Variables selected for monitoring.

VARIABLE	TECHNIQUE
Physical Factors	
Wave Conditions	Field Observations
Temperature	YSI S-C-T Meter
Water Transparency	Secchi Disc
Suspended Particulate Matter	Filtration, Gravimetric
Particulate Inorganic Matter	Filtration, Gravimetric
Chemical Factors	
Salinity	YSI S-C-T Meter
Dissolved Oxygen	Winkler Titration
Biological Factors	
Phytoplankton (Chlorophyll)	Spectrophotometric
Zooplankton	Gravimetric
Particulate Organic Matter	Filtration, Gravimetric
Mussel Growth Rates	Gravimetric and Meristic
Mussel Mortality	Field Observations
Condition Indices	% Glycogen and Meat Weight
Fecundity	Gravimetric (Gonad Weight)
Spawning Times	Gravimetric (Gonad Weight)
Spatfall Times and Densities	Spat Collectors
Predators	Field Observations
Fouling Organisms	Field Observations

often if they had time, particularly those variables, such as temperature and salinity, that require a minimum amount of time and effort to measure.

As the programme progressed it became apparent that at certain times of the year growers are especially busy and it is difficult for them to find much time for monitoring. Rather than collect no data at all during these times, which would leave serious gaps in the data base, it was suggested that they alter their monitoring activities to suit the time available for monitoring. A list of monitoring priorities was established (see letter of 23 June 1988 in Appendix B) to aid the growers in deciding what information would be most useful when there was insufficient time available to carry out all of the monitoring tasks.

D. Monitoring Techniques and Equipment:

There exists a great diversity of techniques and equipment available for monitoring water quality. The primary criteria used to select the most appropriate techniques for routine monitoring were simplicity to persons having little prior experience in scientific measurement procedures, potential for obtaining

Table 3. Equipment supplied to each grower.

Polyethylene Box to Hold Field Equipment
Water Sampler - 2 liter Van Dorn Bottle
YSI Portable S-C-T Meter with 15 Meter Probe
Secchi Disc - 30 cm Diameter
Zooplankton Net - 30 cm Diameter - 160 um Mesh
Dissolved Oxygen Apparatus:
6, 300 ml BOD Bottles
3, 250 ml Reagent Bottles
6, 2 ml Pipetes
1 Burette Stand and Clamp
1, 50 ml Burette
1 Funnel
1, 200 ml Titration Flask
1, 200 ml Graduated Cylinder
Filtration Apparatus:
1, 1000 ml Graduated Cylinder
6, 1000 ml Polyethylene Sample Bottles
1, 1000 ml Filtration Flask
1 Filter Holder
1 Hand Operated Vacuum Pump with Gauge
1 Filter Tweezers
100 Filter Containers
50 Watman GF/C Filters
25 Millipore HA Filters
Reagents:
500 ml Manganous Sulfate Solution
500 ml Sodium Azide/Sodium Iodide Solution
500 ml Conc Sulfuric Acid
1000 ml PAO Solution
100 ml Saturated Starch Solution
Miscellaneous:
6 Marking Pens
100 Data Sheets
50, 30 ml Sample Bottles
50, 500 ml Sample Bottles
1 liter Formalin
50 ml Lugol's Iodide Solution

consistent and comparable as opposed to precise or scientifically accurate results, and time required for measurement. In selecting the equipment for monitoring the important criteria were ease of use, longevity, and reasonable cost. Table 3 presents a list of equipment distributed to each grower. With the exception of the YSI S-C-T meter, which requires periodic calibration, all items listed require little maintenance, are readily available, and require a minimum amount of instruction for proper operation.

E. Training of Growers:

The initial training of growers was carried out in August, 1987 at a two-day workshop held at Acadia University. At the beginning of the workshop growers were introduced to the rationale behind the monitoring programme with particular emphasis being paid to the reasons why each variable was chosen and how to properly interpret the results of each measurement. Most of the workshop, however, was devoted to providing participants with hands-on experience in each monitoring technique. In addition to classroom demonstration and practice of the laboratory techniques, growers were taken to a nearby waterbody where each of the field techniques was demonstrated and practiced.

In addition to the growers, the workshop was attended by a number of other individuals, mainly government employees that have frequent contact with growers and who expressed an interest in learning about the programme and a desire to aid growers in carrying out the monitoring tasks. Appendix A lists all participants of the workshop along with their position and affiliation.

F. Manuals:

A major objective of the programme was to produce a manual, oriented to non-scientists, describing the need for and objectives of a monitoring programme as well as general information on mussel biology and instructions on monitoring techniques. Two manuals were produced for the programme. Initially, in preparation for the training workshop, a techniques manual was prepared describing, in brief cookbook fashion, step-by-step details of each monitoring procedure. This manual provided all the information necessary for a grower to perform the field and laboratory procedures and to properly preserve and prepare samples for shipment to ACER. Although some information on the importance and relevance of the variables being monitored was incuded, this was not covered in detail. The latter was the subject of a second more comprehensive manual dealing with the general biology of *Mytilus* and how its settlement, growth and survival is affected by various environmental factors. In addition, a section of this manual discusses the theory behind each field procedure and the general techniques used at ACER in analyzing data and samples collected by growers.

The two manuals were prepared with the idea that together they would provide all the information necessary to understand and master the monitoring techniques, as well as interpret the resulting data, making them useful to growers other than those officially participating in the monitoring programme.

Since the programme was novel, the initial design sometimes required changes and periodic updates were sent to growers. These are collected in Appendix B.

G. Site Visits:

As a follow-up to the training workshop, a site visit was made to each of the monitoring sites. The intent of the site visit was to have each grower perform the monitoring tasks in the presence of someone well-trained in the techniques to insure

that the procedures were understood and properly carried out. This also provided a chance to briefly survey sites and address any unusual conditions that might require some departure from the monitoring procedures discussed at the workshop or described in the manual.

For the Gulf Region, site visits were made in early November, 1987 and again in late May, 1988. In Nova Scotia, site visits were made in early May, 1988.

H. Sample and Data Analyses:

Although some of the information collected by growers, such as water temperature and salinity, could be interpreted directly, most required further analyses and this was one of the major responsibilities of ACER. Growers were given instructions as to proper processing and preservation of samples and these were sent to ACER by courier. At ACER samples were analyzed upon receipt and the resulting information immediately sent to growers. All data received were tabulated and stored in readily accessible data files. Periodically, this information was collated into a simple report listing all the data collected at each site which, by way of simple averages, allowed each grower to compare their site with other sites.

The analyses performed by ACER are listed in Table 4. Appendix C provides details of the laboratory techniques used in the analyses of samples.

Table 4. Analyses performed by ACER.

Shell Size (Length and Width)
Shell Weight
Meat Weight (Wet and Dry)
% Glycogen Content
% Gonad Weight (Fecundity)
Shell Growth Rate
Condition Indices
Chlorophyll Concentration
Total Particulate Matter
Total Particulate Inorganic Matter
Total Particulate Organic Matter
Suspended Particulate Matter
Spawning Times
Spatfall Densities
Stability of Stratification

III. RESULTS

Evaluation of the monitoring programme is best made in reference to the extent to which the major objectives of the programme, as listed in Section I, have been met.

With regard to the objectives of educating mussel growers

about the environmental factors important in determining the rate at which mussels grow and die, and the techniques available to measure these factors, the programm has been quite successful. This was most strongly evidenced by comments made by growers at the workshop and in conversation during site visits. Few, if any, felt that the monitoring techniques were too complex for them to master, and there was little indication that they did not understand the rationale behind the choice of variables being monitored. Some, in fact, felt confident enough to tailor certain aspects of the monitoring programme to provide information more specific to their particular growing site or to address questions they were especially interested in answering. The only persons ever expressing doubts about the ability of growers to carry out the monitoring procedures were individuals not directly involved in the programme and unfamiliar with the training received by growers.

The programme has also been successful in terms of establishing an efficient set of procedures for forwarding samples to ACER, processing the samples within a reasonable time period, and returning the resulting information to growers in an intelligible form. The use of local courier services to ship samples from growers to ACER worked very well. In most cases samples were received at ACER within twenty-four hours of being shipped, and in no instance did a sample arrive at ACER in a condition poor enough to preclude analysis. The procedures used at ACER for analysis of samples provided consistent results that could easily be duplicated at other laboratories. Data collation using SPSS and the report generation facility of this programme provided a versatile means of generating the reports issued to growers and allows easy transfer of data files to other computers. As the programme progressed, however, it became increasingly evident that if all twenty growers had participated to the full extent and had sampled their sites on a biweekly basis, sample analysis and data processing by ACER would have required considerably more time than that available to a half-time laboratory technician.

The greatest shortcoming of the monitoring programme was the relatively poor response by growers in terms of either their ability or willingness to participate in the programme. Of the twenty original growers, only four participated to the extent that a reasonably significant data base was developed for their sites. The response was particularly poor for the Gulf Region where only two of the original twelve growers participated to any real extent. In Nova Scotia only three of the original eight growers remained in the programme, but because of a much higher awareness of the programme among Nova Scotia growers, it was possible to replace those not participating with others having expressed a desire to be included in the programme. As a result there were five growers in Nova Scotia committed to monitoring at the termination of the programme.

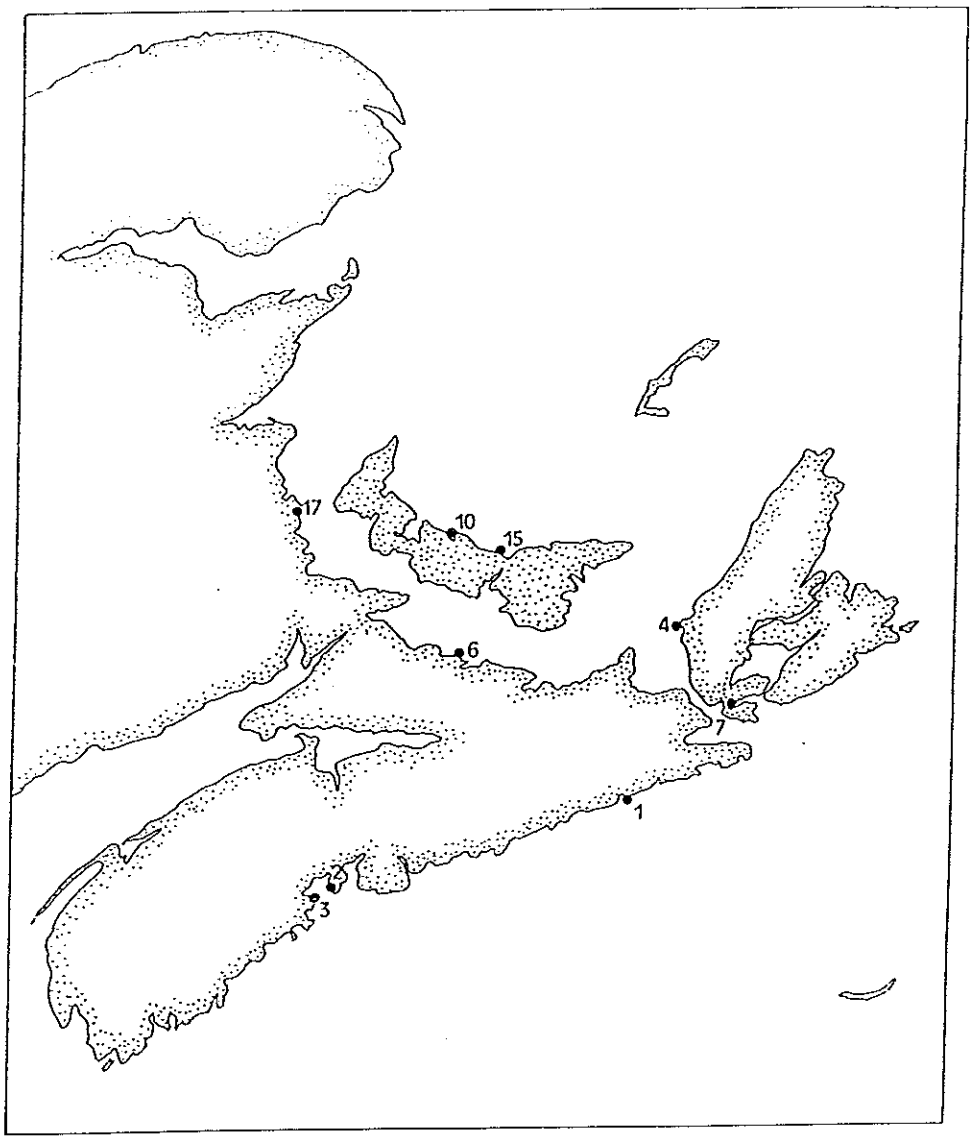
The reasons for this relatively poor response, particularly for the Gulf Region, are numerous and complex and, in many cases, not simply the result of an unwillingness among growers to participate in the programme. The status of each original participant at the termination of the programme is given in Table

5. Of the twenty original growers, seven were never able to participate in the programme as a result of either loss of their mussel crop, failure to obtain a lease site, or having their site closed as a result of pollution problems. Eight participants, five of which were from Prince Edward Island, failed to ever begin monitoring. In one instance a grower declined to agree to the condition that the monitoring equipment would have to be returned if it was not being used or if the programme was terminated for some reason. Five of the original growers, two in Prince Edward Island and three in Nova Scotia, monitored their sites faithfully and, in Nova Scotia, two additional participants were found to replace growers originally selected but who failed to participate after the first year, giving a total of seven growers that were committed to the programme at its termination.

During the course of the programme, those growers not having exhibited any monitoring activity, and not having experienced problems with their lease site or mussel crop, were periodically contacted in order to determine the reasons for their inactivity. In almost all cases their response was that they simply had not been able to find the time to begin monitoring, but that they were still interested. Few were willing to return the monitoring equipment and instead gave assurances that they would soon begin monitoring. It was not until the latter part of the second year of the programme that these growers were willing to concede that they would probably never find the time to monitor and agreed to return their equipment. Suprisingly, many of these growers were disappointed to learn that the programme was terminated.

It would appear that, on the basis of the level of committment shown by different individuals in the programme, it should be possible to make some generalisations about the characteristics of growers most likely to contribute to a programme of this sort. This does not appear to be the case, however. Those who did participate included smaller as well as larger growers, both part-time and full-time growers, and growers having a strong background in biology as well as those having little or no background in biology. About the only generalisation that does seem evident is that most growers just starting on a full-time scale are very busy trying to make their operations financially viable and as a consequence have little spare time available making them poor choices for a monitoring programme.

Of the original twenty sites selected for the programme, at least some data was collected on seven sites. The replacement of two original participants in Nova Scotia makes a total of nine sites for which some data was obtained (six in Nova Scotia, two in Prince Edward Island, and one in New Brunswick). Figure 3 illustrates the location of these sites. However, of these nine sites only five were monitored often enough to produce a useful data base. Appendix D presents a listing of all data collected for all sites. Appendix E presents summaries of how those sites having sufficient data compare with each other, and Appendix F presents time series plots for a number of selected variables at each site.



Site Number	Grower/Location
1	Clearwater/ Marie Joseph, NS
2	S.F.T. Venture/ Blandford, NS
3	P. Darnell/ Mahone Bay, NS
4	J. MacInnes/ Port Hood, NS
6	R. Maloney/ Tatamagouche Bay, NS
7	P. Marchand/ Lennox Passage, NS
10	S. Stewart/ New London Bay, PEI
15	R. Townshend/ Tracacadie Bay, PEI
17	M. Daigle/ Richibucto, NB

Figure 3. Location of sites for which data was recorded.

Table 5. Status of original participants at termination of the programme.

NOVA SCOTIA

1. P. Budreski	Never began monitoring. Eventually returned monitoring equipment which was then transferred to Clearwater.
2. P. Marchand	Performed routine monitoring throughout the programme and was perhaps the most reliable of all participants.
3. P. Darnell	Performed routine monitoring during the first year of the programme. Discontinued monitoring during the second year as a result of problems associated with the destruction of his processing plant by fire and consequent lack of time for monitoring while rebuilding.
4. J. MacInnes	Performed routine monitoring at start of programme, but eventually lost site due to pollution problems.
5. K. MacLeod	Never began monitoring despite continued assurances that he would.
6. R. Maloney	Performed some monitoring during early part of the programme, but lost mussel crop after the first winter.
7. Guysborough Aquatic Ventures	This company ceased operations during the early stages of the programme. It was replaced by SFT Ventures who monitored throughout the programme on a regular basis.
8. J. Underwood	Performed some monitoring at the beginning of the programme, but financial problems and difficulties in obtaining a permanent lease resulted in his leaving the programme. The monitoring equipment was eventually given to R. McFarlane, but at too late a date to participate in the programme.

Table 5 (Continued)

GULF REGION	
9. G Arsenault	Never obtained a growing site.
10. S. Stewart	Performed routine monitoring throughout the programme.
11. R. Dockendorf	Never began monitoring.
12. T. Farrell	Never began monitoring.
13. G. Keith	Never began monitoring.
14. R. MacPherson	Never began monitoring.
15. R. Townshend	Performed routine monitoring throughout the programme.
16. J. VandenBremdt	Refused to agree to conditions of the equipment loan and therefore never entered the programme.
17. M. Dalgle	Monitored site once.
18. C. Lanteigne	Never began monitoring.
19. G. LeBlanc	Lost mussel crop in early stage of the programme and therefore never began monitoring.
20. A. Benoit	Growing site was closed as a result of pollution problems at early stage of the programme.

III. RECOMMENDATIONS AND SUGGESTIONS

During the course of the programme, a number of discussions were held with both growers and others having various levels of involvement in the monitoring project. This section summarises a number of ideas and suggestions in regard to changes that might be made to improve the programme.

A. Selection of Participants

The most obvious result of the monitoring programme has been the realisation that the single most important and difficult task in establishing a successful monitoring programme is being able to select participants that are both committed to routinely monitoring their sites and have the stability to remain with the programme on a long-term time scale. Although most growers

realise the potential value of monitoring environmental conditions at their growing sites, only a select few are really in a position to commit themselves to performing this task routinely. The success of any future monitoring programme involving the active participation of growers will depend largely on establishing a procedure to identify those growers most able to make this committment, and to quickly remove and replace those who do not meet their obligations.

Perhaps the best means of accomplishing this is to limit the programme to growers that specifically request to take part, as opposed to approaching growers and asking for their voluntary participation. This would insure that appreciation of the value of the programme and a certain level of committment are present at the outset. Availability of the programme could be advertised through notices in the numerous publications dealing with aquaculture.

A further assurance that only sincere participants take part in the programme is to require a financial committment on the part of the grower. This could take the form of an annual rental fee and could perhaps be set at a rate to cover the cost of equipment maintenance (particularly the YSI S-C-T meter) and the cost of consumable supplies. In addition to insuring that only those with a real intent take part in the programme, this arrangement would also help to offset some of the costs, an important consideration in any programme involving long term funding.

B. Simplification of Monitoring Tasks

The monitoring chores require about one-half to one hour of field work, and about one hour for preparation and preservation of samples. These tasks could be made a bit simpler, but not to any great extent since the information collected is really minimal in terms of documenting the most important environmental factors. Two changes that might be made to shorten the time required for monitoring without resulting in a great loss in information are elimination of routine dissolved oxygen determinations and collection of zooplankton samples.

When the monitoring programme was being formulated, there was little information available on the extent to which dissolved oxygen may become depleted at growing sites. Based on what has been learned during the programme, it is doubtful that this ever becomes a serious problem at most growing sites and constant monitoring of this factor is probably not necessary. However, because of the severe consequences of low dissolved oxygen levels, growers should retain the capability of measuring it in those instances where there is reason to believe it may be a problem.

The collection of zooplankton samples was included in the programme to provide information on the amounts of coarse particulate material, especially organic detrital material, that can potentially be an important food item of mussels. It has, however, been difficult to evaluate this easily and quickly at ACER and has not provided much useful information. In addition, the collection procedure involves considerable time relative to other monitoring tasks, as well as the handling of formalin in

the field. As a result both collection by growers and analysis by ACER involve a disproportionate amount of effort in terms of the information obtained and their inclusion in a routine monitoring programme is questionable.

C. Monitoring Performed by Others

During the course of the programme, it was often suggested that the best way to insure sites are monitored on a routine basis is to have this done by individuals employed specifically for this purpose. Although this would certainly result in a more reliable programme, it would essentially defeat the major advantages of a programme involving growers, i.e. reasonable cost and training of growers. The additional salaries and travel expenses that would be required to employ persons other than growers would at least double the cost of the programme, and the educational aspects of the programme would be largely lost.

D. Localisation of Coordinating Centre

The more favorable response to the monitoring programme in Nova Scotia as opposed to the Gulf Region suggests that there is some benefit to having the monitoring programme coordinated on a somewhat smaller scale and in closer proximity to growing sites. The fact that ACER is located in Nova Scotia has had certain benefits for Nova Scotia growers, not only in terms of being closer to the sites being monitored, but also in terms of more frequent contact with growers and a greater awareness among growers of the kinds of resouces available for the programme.

Likely candidates for coordinating centres located in the Gulf Region are the Veterinary College in Prince Edward Island and the University of Moncton in New Brunswick.

V. CONCLUSIONS

As a whole, for the amount of effort and expense involved, the monitoring programme has not been especially successful. This is more so for the Gulf Region than Nova Scotia. Although it is unrealistic to suppose that all of the original participants would have faithfully committed themselves to the programme, it was hoped that at least half would have shown a committment during the first year, and that in the second year those who did not respond would be replaced by others expressing an interest in being part of the programme. This did happen to some extent in Nova Scotia, but not at all in the Gulf Region. The major problem in establishing a programme of the kind attempted here lies not in logistics, but in identifying growers who appreciate the potential value of monitoring their sites and who realise that, because of the expense involved in having university or government agencies do this for them, it is unlikely that this will be done by anyone but themselves.

In retrospect, it appears that the monitoring programme may have been somewhat ahead of its time. For the most part the mussel aquaculture industry is still in the early stages of its growth and the problems of most concern to growers centre around competition in the marketplace, insuring the financial security of their operation, setting up adequate systems to insure the

public receives a safe toxin-free product, prolonging the harvest season, and numerous other logistic problems involved in the growing and processing of mussels. Monitoring environmental conditions at growing sites often assumes a low priority in view of these other concerns. However, as the industry grows and problems more biological in nature, such as carrying capacity limitations and the environmental impact of culture operations, assume a greater importance, some sort of monitoring programme will be required. It is not unrealistic to believe that before too long, monitoring water quality as a means of assessing the impact of culture operations may become a condition for obtaining a site lease. Hopefully, the experience gained in this programme will be of value in insuring the development of a workable programme in the future.

APPENDIX A

Workshop Participants

Workshop Participants

Prince Edward Island

Gerald Arsenault (mussel grower)
Box 45, Wellington Bay
P.E.I. C0B 2E0
902-854-2710
902-854-2610

Russel Dockandorff (mussel grower)
St. Peter's Bay Mussel Farms Inc.
P.O. Box 43, St. Peter's Bay
P.E.I. C0A 2A0

Terry Farrell (mussel grower)
St. Mary's Road
Montague, R.R. #2
P.E.I. C0A 1R0

Greg Keith (mussel grower)
Musselmen Inc.
R.R. #4, Lower Montague
P.E.I. C0A 1R0

Ralph MacPherson (mussel grower)
Orwell
P.E.I. C0A 2E0
902-651-2876

Stephen Stewart (mussel grower)
Kensington, R.R. #5
Spring Valley
P.E.I. C0B 1M0
902-836-5534

Roger Townshend (mussel grower)
Blooming Point Road
Mt. Stewart, R.R. #1
P.E.I. C0A 1T0

Henri VanDenBremt (mussel grower)
P.O. Box 75, Cardigan
P.E.I. C0A 1G0
902-583-2202

George Vessey (President, PEI Mussel Growers Association)
32 Hillside Dr.
Charlottetown
P.E.I. C1A 6H7

Nova Scotia

Zachery Green (mussel grower, employed by P. Darnell)
R.R. #2, Mahone Bay
N.S. B0J 2E0
902-624-8097

John F. MacInnes (mussel grower)
R.R. #1, Port Hood
N.S. B0E 2W0

Ken MacLeod (mussel grower)
Marine Farming Ltd.
Jersey Cove
R.R. #1, Englishtown
N.S. B0C 1H0

John Mahtab (mussel grower, employed by P. Budreski)
Little Harbour Fisheries
5233 Prince St., Halifax
N.S. B3J 1L8
902-423-6610

Ralph Maloney (mussel grower)
P.O. Box 166
Tatamagouche
N.S. B0K 1V0
902-657-2973
902-895-3640

David L. Underwood (mussel grower)
Blue Mussel Aquaculture Ltd.
R.R. #1, Sable River
N.S. B0T 1V0
902-656-2419

New Brunswick

Maurice Daigle (mussel grower)
57 Mathieu Cr., Moncton
N.B. E1A 6C1
506-854-4541

Cecile Lanteigne (mussel grower)
C.P. 835, Caraquet
N.B. E0B 1K0
506-727-2777

Gilles Leblanc (mussel grower)
C.P. 120, Cap Pele
N.B. E0A 1J0
506-577-4325

Newfoundland

Alton Benoit (mussel grower)
P.O. Box 465, Stephenville
Nfld. A2N 3A3
709-643-5014

Administrators

Andrew Bagnall (Biologist)
N.S. Dept. of Fisheries
Box 84, Musquodoboit Hbr.
N.S. B0J 2L0
902-889-2923

Stephen Lanteigne (Biologist)
N.B. Dept. of Fisheries
C.P. 1390, Shediac
N.B. E0A 3G0
506-532-2461

Claude Leger (Biologist)
D.F.O.
P.O. Box 5030, Moncton
N.B. E1C 9B6

Marcel Leger (Biologist)
N.B. Dept. of Fisheries
C.P. 1390, Shediac
N.B. E0A 3G0
506-532-2461

Maurice Mallet (Development Officier, D.F.O., Gulf Region)
D.F.O.
P.O. Box 5030, Moncton
N.B. E1C 9B6

Richard McDormand (Fisheries Officier)
N.S. Dept. of Fisheries
Box 56, Granville Ferry
N.S. B0S 1K0
902-532-7039

Gerald Mossman (Fisheries Officier)
N.S. Dept. of Fisheries
P.O. Box 31, Riverport
N.S. B0J 2W0
902-766-4749

Appendix B

Periodic Updates To Growers

July 31, 1987

Letter to: Mr. Maurice Mallet, Mr. Lincoln MacLeod, Mr. Irwin Judson, Mr. Peter Darnell, Mr. Paul Budreski, Mr. Ralph Maloney, Mr. David Underwood, Mr. Ken MacLeod, Mr. John MacInnes, Mr. Perry Marchand, Mr. Mark Conway, Mr. Wayne Somers, Mr. Russel Dockandorff, Mr. Gerald Arsenault, Mr. Roger Townshend, Mr. Joe VandenBremt, Mr. David Cole, Mr. Greg Keith, Mr. Terry Farrell, Mrs. Cécile Lanteigne, Mr. Maurice Daigle, Mr. Alton Benoit

Dear...:

The techniques workshop for the mussel growers' water quality monitoring programme is scheduled to take place at Acadia University on August 20-21. An agenda, general information sheet and map of the Acadia campus is enclosed. Registration is scheduled for 9 to 10 a.m., August 20, so you should plan to arrive early that morning or the night before (rooms will be available for the night of August 19--see the general information sheet for details).

All materials required for the workshop will be provided by ACER. You should, however, bring rain gear in the event of bad weather since an important part of the workshop will involve demonstrations and practice in the field. In addition, for the session on selection of sampling sites, you should bring whatever charts, maps, and aerial photos of your growing sites that you have available.

If you have any questions please do not hesitate to contact me at 902-542-2201 (extension 509). I look forward to seeing you in the next few weeks.

Sincerely,

Mike Brylinsky

df
Enclosures

ACADIA CENTRE FOR ESTUARINE RESEARCH

TEL: 1-902-542-2201

A G E N D A

Mussel Water Quality Monitoring Workshop
Acadia Centre for Estuarine Research
Acadia University, Wolfville, Nova Scotia
August 20-21, 1987

Thursday August 20	9:00 - 10:00	Registration
	10:00 - 10:15	Coffee Break
	10:15 - 12:00	Introductory Comments Monitoring Programme Rationale and Goals
	12:00 - 1:00	Lunch
	1:00 - 3:00	Laboratory Demonstration of Monitoring Techniques
	3:00 - 3:15	Coffee Break
	3:15 - 5:00	Laboratory Demonstrations Continued - Data Reporting and Interpretation
	5:00 - 7:00	Dinner
	7:00 - 9:00	Discussion on Selection of Sampling Sites
Friday August 21	9:00 - 5:00	Hands-on Practice of Field and Laboratory Techniques by Mussel Growers (Part of this session will be held at a nearby field site).

P.O. Box 115
Acadia University, Wolfville, Nova Scotia

ACADIA CENTRE FOR ESTUARINE RESEARCH

TEL: 1-902-542-2201

October 5, 1987

After considerable delay, we have finally managed to accumulate most of the equipment for the monitoring programme. We are presently assemblying these materials into kits that will be delivered to you within the next week or two. The items we have not yet received are the BOD bottles necessary for analysis of dissolved oxygen and some of the probes for the YSI salinometers. Although you will not be able to make dissolved oxygen measurements immediately, this should not be a problem since this is probably not a critical factor at this time of year for most sites. For those of you who do not receive a probe for the YSI salinometer, we will try to make arrangements with local government biologists to have them monitor salinity and temperature for you or, alternatively, you may be asked to temporarily share a probe with a nearby participant.

With regard to ownership of the equipment you will be receiving, I have been asked by the funding agencies to inform participants that formally the equipment remains the property of the government, but that for all practical purposes can be considered to belong to the participant as long as the monitoring programme is in effect and as long as the participant continues to record and provide data on his/her site.

Arrangements for returning samples to us are being made and you will be informed of the procedure to follow when you receive your monitoring equipment.

At our workshop there were some techniques for which we had not worked out the details, primarily those dealing with the use of water current clods and spat collectors. We have since defined these techniques and are enclosing write-ups for them. Please remove the original instructions from your manual and replace them with the revised instructions.

P.O. Box 115
Acadia University, Wolfville, Nova Scotia
CANADA B0P 1X0

Sometime soon, hopefully before the end of October, I will be contacting each participant with regard to a site visit. These will probably occur after you have had a chance to make some measurements at your site and will give us a chance to discuss any problems you may be experiencing.

If you have questions about any of the above, please feel free to call us.

Sincerely,

Mike Brylinsky

df

Enclosures

ACADIA ESTUARINE CENTRE FOR RESEARCH

TEL: 1-902-542-2201

12 January 1988

Dear Grower:

It has now been nearly three months since the equipment needed for the monitoring programme was distributed to the growers involved in the Water Quality Monitoring Programme. Thus far, the response to this programme has been very disappointing : of the 20 original participants, only 4 have actually done any monitoring of the water on their leases at all, and most of these have only obtained one or two sets of samples.

We realise that the past few months have been busy ones for all growers--lines have to be sunk, boats taken out of the water, and other preparations for winter have to be made--and by comparison it may seem that the need to monitor the lease at this time is of rather less importance. This certainly seems to be the attitude of most of you.

The events of the past few weeks in PEI should be enough to convince you that the monitoring programme that you agreed to participate in should receive a much higher priority in your work than it is apparently receiving. All growers had received their equipment before the appearance of the toxicity problem in eastern PEI. If everyone had commenced their monitoring programme in October, there would have been collected a great deal of valuable information on phytoplankton, salinity, temperature, and chlorophyll in the various estuaries of the region, including some of those affected by the toxicity, and many that were not. A set of consistent samples taken as the toxicity problem was beginning to manifest itself would have proved invaluable in discovering the possible involvement of diatoms and dinoflagellates in the affected waters, and in providing insight into the set of environmental factors responsible for the onset of the toxic conditions. It is probably necessary now to wait until the conditions repeat themselves (which one hopes will not happen) before the important questions can be addressed. And even a recurrence will not help unless the water being used for cultivation is being monitored on a consistent basis. The data that you were instructed to collect regularly included a number of important factors that would help explain the origin and occurrence of the toxicity : phytoplankton samples would be invaluable in determining whether diatoms are correlated with the toxicity, as has been suggested; suspended sediment concentrations (SPM) would have indicated whether dredging

P.O. Box 115
Acadia University, Wolfville, Nova Scotia
CANADA B0P 1X0

activities or storms were important in increasing the sediment loads in each estuary, and we could have determined whether increased sediment loads were associated with toxicity; the mussel samples that were to be sent in for condition analyses could have been examined for the presence of the small seaweed (*Chondria*) that the National Research Council at first thought might be involved.

There are obviously other examples that could be quoted to show how valuable the results of this monitoring programme could have been. What is more important, however, is to ensure that we do not miss out again in the future. We are aware that most of you recognise the importance of monitoring water quality on your leases -- after all, the programme came about because many of you requested it. It appears, however, that some of the participants have to reassess the obligation they made when agreeing to be part of the programme. The success of any monitoring programme depends upon analysis of samples obtained from a consistent sampling schedule. Obtaining information of this kind requires a commitment to accord a high priority to the work, so that the schedule is followed despite the demands of other activities. Two to three hours each two weeks might seem a lot of commitment (it might be a great deal less when combined with other necessary activities), but if you carefully consider the potential returns, it is a wise investment of time. After all, being able to answer the kinds of questions raised by this recent scare with domoic acid will contribute a lot to the survival of this industry in the region.

Another important consideration is the funding of this programme. Before long the government agencies responsible for its support will be considering whether or not it should be continued. If response to the programme, measured in terms of the number of samples collected and analysed, continues at the present level, it will be hard to argue that the programme should be continued, despite the fact that we have had an experience that should convince anybody of the value of the effort.

If, as a result of reconsidering your own obligation to the programme, you decide you do not wish to commit the effort required, or are still not convinced of its value, please return the equipment to us as soon as possible so that it can be given to someone else.

We regret the negative tone of this letter, but we are concerned that unless something is done soon, the future of the programme does not look very good. Please give this your serious and urgent consideration.

Yours sincerely,

Mike Brylinsky

ACADIA ESTUARINE CENTRE FOR RESEARCH

TEL: 1-902-542-2201

23 June 1988

To All Participants In Monitoring Programme

Dear

Over the last few months I have had occasion to speak with many of the mussel growers involved in the water quality monitoring programme. Based on numerous discussions, it has become obvious to me that, at certain times of the year, the workload involved in growing mussels is very high and it is unreasonable to expect that water quality monitoring activities will be given much of a priority during these periods. Unfortunately, the development of a good, useful data base ideally requires consistent data collection to insure that seasonal trends and the presence of unfavorable growing conditions are adequately recorded. In order to achieve this objective without asking you to give monitoring a high priority during those busy times, I would like to suggest that you alter the extent of your monitoring activities to coincide with the amount of time you feel you have available for this task. For example, during busy times you could decide to do only the bare minimum, perhaps a temperature-salinity profile, a chlorophyll sample and a mussel sample. This should only require a half-hour or less in the field and 15 minutes or so in the lab, but would allow continual monitoring of the most important environmental factors affecting your mussels.

If you have a bit more time, you may add a secchi disc reading and a phytoplankton or SPM sample. The main point is that it is better to do some monitoring on a frequent basis rather than all monitoring infrequently.

In order to help you decide what to include and what to omit when pressed for time, I have listed on the attached page the various sampling activities according to what I consider the greatest priority. I have also grouped these into a number of "levels" of varying activity, level I being the tasks carried out when busy and level IV being the tasks carried out when you have more time available. These are only guidelines and you can work up your own "levels" depending on your interests.

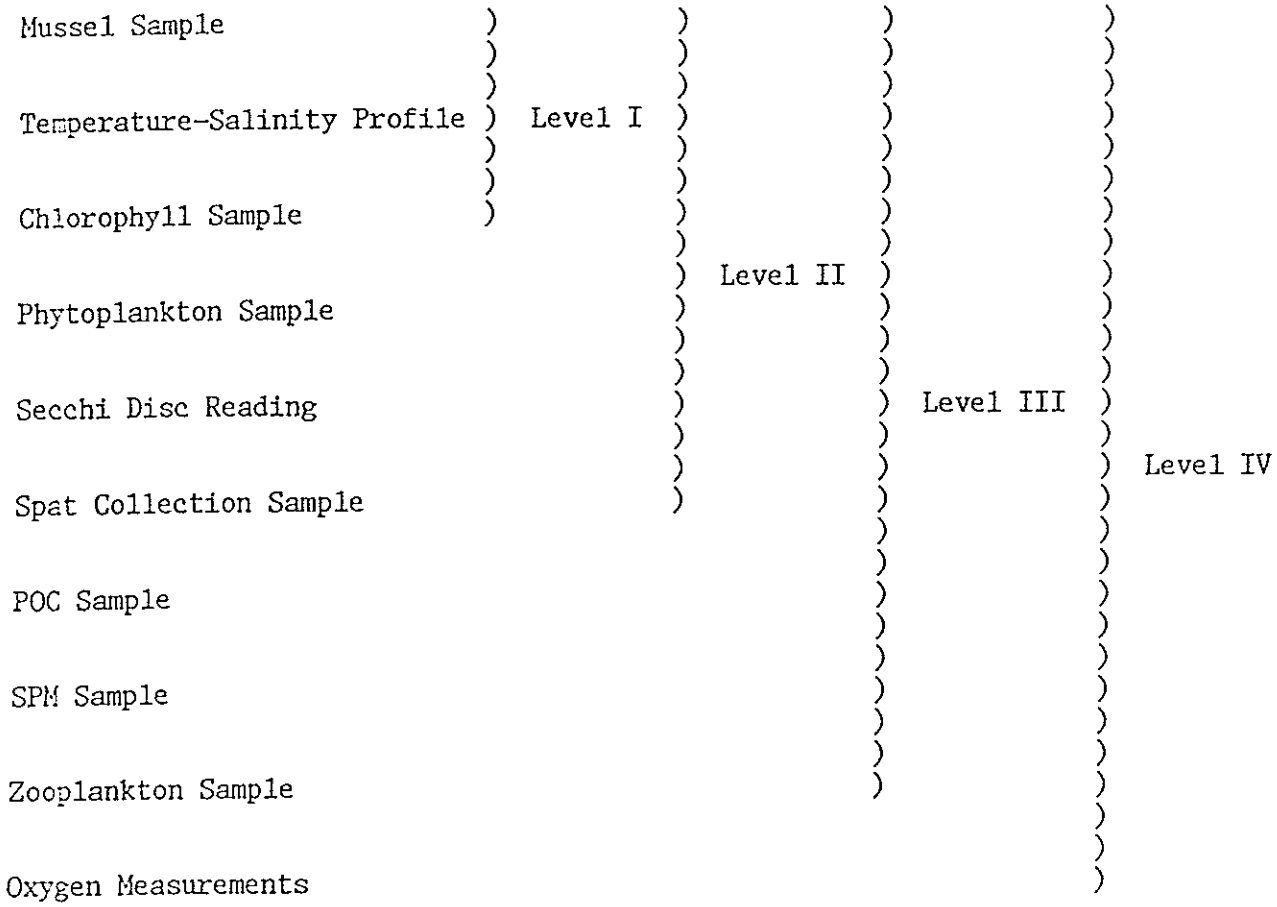
Sincerely,

Mike Brylinsky

df
Enclosure

P.S. This approach, hopefully, will make participation in the monitoring programme a bit less demanding during busy periods, yet still allow some data collection.

P.O. Box 115
Acadia University, Wolfville, Nova Scotia
CANADA B0P 1X0


Mussel Sample
Temperature-Salinity Profile
Chlorophyll Sample
Phytoplankton Sample
Secchi Disc Reading
Spat Collection Sample
POC Sample
SPM Sample
Zooplankton Sample
Oxygen Measurements
Level I
Level II
Level III
Level IV

ACADIA CENTRE FOR ESTUARINE RESEARCH

TEL: 1-902-542-2201

November 18, 1988

letter to growers

Dear

Please find enclosed summaries of the data that have been recorded thus far for your growing sites. Three types of summary are provided. One simply lists all the data for your site as it has been recorded. Another summary plots the data against time to give you an indication of the seasonal variation in each variable. Finally, the range and mean of each variable for the time period April 1 to September 30, 1988 for all sites as well as for your particular sites have been tabulated and listed together to give you an idea of how your site compares with all other sites.

In the latter summary, it should be kept in mind that some caution is required in comparing the mussel data since different sites have mussels of different ages. We have tried to partially correct for this by providing separate summaries for young (less than one year old) and old (greater than one year old) mussels, but even so, if the values for your mussels are either very low or very high it may simply mean that your mussels are at the low or high end of the age scale. You can easily check this by comparing the mean age for all sites with the mean age for your sites.

If you have any problems understanding or interpreting the results, or questions of any kind, please call us anytime.

Sincerely,

Mike Brylinsky

df

Enclosures

APPENDIX C

Details of Techniques Used at ACER

SAMPLE ANALYSIS PROCEDURES USED AT ACER

A. Morphometrics:

1. Frozen mussel samples were thawed and randomly subsampled to produce a representative sample of either six (> 12 months old) or ten (< 12 months old) mussels.
2. Total shell length and width was measured using a vernier caliper and recorded to the nearest 0.5 mm.
3. Shells were opened, the soft parts removed and, if gonads were present, somatic tissue and gonads were separated from each other.
4. All mussel tissue was then weighed to determine the wet weight.
5. Both shell and mussel tissue were oven dried for 24 hours at 90-100 C and reweighed to determine dry weight.
6. A condition index was calculated as follows:

$$C.I. = \frac{\text{Total Dry Tissue Weight}}{\text{Dry Shell Weight}} \times 100$$

7. Fecundity was calulated as percent gonad weight as follows:

$$\text{Fecundity} = \frac{\text{Dry Gonad Weight}}{\text{Total Dry Tissue Weight}} \times 100$$

B. Glycogen Content:

1. Frozen mussel samples were thawed and subsampled to produce a representative sample of three to six mussels.
2. All meats were removed from the subsample and combined into one sample.
3. The volume of the combined sample was determined by measuring the volume of water displaced by the sample.
4. The sample was then homogenised to a thick slurry in 4 ml of YSI buffer solution.
5. The resulting slurry was made up to a volume of 12 ml using YSI buffer and mixed by hand shaking.
6. Two ml of the slurry was incubated at room temperature for 3 hr in the presence of 200 ul of amyloglucosidase enzyme solution (made by dissolving 500 mg of enzyme in 100 ml citrate buffer).
7. After incubation the sample was centrifuged for 30 min at 2200 rpm.
8. Twenty-five ul of the resulting supernatant was then analysed for glucose using a YSI Industrial Analyser. (Standards were run using a glucose solution containing 12.5 mg glucose in 5 ml of citrate buffer.)
9. Results were reported as percent glycogen calculated as follows:

$$\% \text{ glycogen} = \frac{\text{mg glucose}}{\text{Dry Tissue Weight}} \times 100$$

C. Chlorophyll:

1. Frozen Watman GF/C filters were added to 8 ml of 90% acetone and homogenized for 1 min.

2. The resulting solution was then filtered through a Watman GF/C filter to remove glass fibers and the filtrate made up to a volume of 15 ml.

3. The filtrate was analysed for absorbance in a narrow-band spectrophotometer using a 5 cm pathlength.

4. Phaeophytin was determined by remeasuring absorption after acidification of the sample with two drops of 10N hydochloric acid.

5. Total chlorophyll and phaeophytin concentrations were calculated using the equations presented in Strickland and Parsons (1972, A Practical Handbook of Seawater Analysis. Fish. Res. Bd. Canada, Bull. 167).

D. Suspended Particulate Matter:

1. Frozen 0.45 um Millipore filters were oven dried for 24 hr at 60-70 C.

2. The dried filters were then weighed on a microbalance and the weight recorded to the nearest milligram.

3. SPM concentration was calculated as the total weight of the filter minus the dry filter weight and corrected for the volume of water filtered and the results reported as mg SPM per liter.

E. Total Particulate Matter (TPM), Total Particulate Inorganic Matter (TPIM), and Total Particulate Organic Matter (TPOM)

1. Frozen pre-tared Watman GF/C filters were oven dried for 24 hr at 60-70 C.

2. The dried filters were reweighed on a microbalance to the nearest mg.

3. The filters were then combusted at 450 C for 24 hr in a muffel furnace.

4. The filters were then reweighed and the following calculations made:

$$TPM = \frac{\text{net weight dry residue}}{\text{ml water filtered}} \times 1000$$

$$TPIM = \frac{\text{net weight after combustion}}{\text{ml water filtered}} \times 1000$$

$$TPOM = TPM - TPIM$$

F. Spatfall Density

1. Collector samples, previously preserved in formalin, were divided into four equal sized squares one of which was chosen as a representative subsample.

2. Subsamples were then further divided into 72 sampling fields using an ocular micrometer and a total of four fields enumerated for spat. If densities were very low, a total of sixteen fields were enumerated, and in those cases where no spat could be found, another of the initial subsamples was examined as a check.

G. Stability of Stratification

1. For those sites that exhibited stratification, stability of stratification was calculated as follows:

$$\text{Stab of Strat} = \frac{(\text{Dbot} - \text{Dsur}) \times (\text{Ztot} - \text{Zsur})}{(\text{Zsur} / 2)}$$

where,

Dbot = Density of Lower Water Layer
Dsur = Density of Upper Water Layer
Ztot = Total Water Depth
Zsur = Depth of Surface Layer

APPENDIX D

Data Base: Data Recorded for Each Site

SITE #1

LOCATION: MARIE JOSEPH, NS

GROWER: CLEARWATER

SUMMARY OF ENVIRONMENTAL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	STABILITY OF STRATIFICATION (G/CM3)	SURFACE TEMPERATURE (C)	BOTTOM TEMPERATURE (C)	SURFACE SALINITY (MG/L)	BOTTOM SALINITY (MG/L)	PARTICULATE ORGANIC CARBON (MG/L)	PARTICULATE INORGANIC CARBON (MG/L)
1	141088		9.0	10.0	29.0	29.0	2.7	14.9
1	171088		7.2	8.5	29.0	29.0	2.3	10.3
1	241088		10.0	9.9	25.2	26.9		
1	311088		8.0	9.0	28.0	28.0	4.2	10.5
1	71188		10.0	9.0	26.0	26.8	4.9	12.2
1	151188						5.4	10.8
2	141088		10.0	10.0	28.5	29.0	6.7	16.7
2	191088							
3	141088		9.0	10.5	28.9	28.7		
3	171088		8.5	9.8	28.2	28.0	3.3	12.0
3	241088		9.9	9.9	27.0	27.1		
3	311088		8.0	9.0	28.0	28.0	4.0	13.3
3	71188		10.2	9.2	25.1	26.5	4.2	9.4
3	151188						2.7	14.1
4	261088		10.9	10.0	11.2	26.7	4.0	9.0
4	71188						3.3	12.0
4	91188		9.0	9.2	20.0	26.5		
4	161188						4.6	9.2
5	191088		10.5	9.5	24.0	26.5	3.0	10.0
5	261088		10.5	10.0	12.5	16.0	2.2	9.9
5	91188		9.0	9.9	12.0	25.0	4.5	11.2
5	161188						4.2	8.4

SITE #1

LOCATION: MARIE JOSEPH, NS

GROWER: CLEARWATER

SUMMARY OF ENVIRONMENTAL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	SUSPENDED PARTICULATE MATTER (MG/L)	SURFACE DISSOLVED OXYGEN (MG/L)	BOTTOM DISSOLVED OXYGEN (MG/L)	SURFACE OXYGEN SATURATION (PERCENT)	BOTTOM OXYGEN SATURATION (PERCENT)	TOTAL CHLOROPHYLL (UG/L)	PHAO PIGMENTS (UG/L)	ZOOPLANKTON (MG/SAMPLE)	SPAT DENSITY (#/SAMPLE)
1	141088	17.8								
1	171088						1.9	.7		
1	241088	21.8					.9	.2	22	
1	311088	13.8					2.9	1.3	19	
1	71188	6.9					1.4	.7	7	
1	151188	6.7					1.7	.7	36	
2	141088	25.0					.8	.5	21	
2	191088	7.1					2.1	.7		
3	141088	11.8					2.6	.8	11	
3	171088	9.7							10	
3	241088	14.5					1.9	.7	9	
3	311088	14.5					1.8	.9	25	
3	71188	15.0					1.0	.6	17	
3	151188	1.8					1.7	.8	28	
4	261088	22.2					1.2	.9	51	
4	71188						3.5	1.4	22	
4	91188	6.2					1.2	1.1		
4	161188	6.0							64	
5	191088	13.8					1.8	.6	36	
5	261088	14.5					2.5	1.1	23	
5	91188	12.3					3.8	1.6	17	
5	161188	4.1					1.6	.6	10	
							1.8	.7	11	

SITE #1

LOCATION: MARIE JOSEPH, NS

GROWER: CLEARWATER

SUMMARY OF MUSSEL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	AGE IN MONTHS	AVERAGE SHELL LENGTH (MM)	STANDARD DEVIATION SHELL LENGTH	AVERAGE SHELL WIDTH (MM)	STANDARD DEVIATION SHELL WIDTH	AVERAGE SHELL WEIGHT (MM)	STANDARD DEVIATION SHELL WEIGHT	PERCENT GLYCOGEN CONTENT
1	141088	-	45.4	5.4	15.9	3.0	2794	1120	7.1
1	171088	-	44.7	7.1	17.3	1.9	2415	1091	12.0
1	151188	-	46.8	5.0	17.8	1.0	2213	785	4.8
3	141088	12.0	36.9	5.1	12.7	1.1	1137	347	4.9
3	171088	12.0	38.8	5.9	13.7	2.8	1265	612	3.9
3	311088	-	45.4	5.2	16.9	1.7	2335	660	6.5
3	151188	-	41.7	3.9	14.7	2.0	1578	358	5.9
4	161188	18.0	40.7	3.9	14.5	2.4	1772	585	8.6
5	161188	24.0	55.3	5.3	21.1	1.9	4126	1167	7.3

SITE #1

LOCATION: MARIE JOSEPH, NS

GROWER: CLEARWATER

SUMMARY OF MUSSEL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	AVERAGE MEAT WEIGHT (MG)	STANDARD DEVIATION MEAT WEIGHT	AVERAGE GONAD WEIGHT (MG)	STANDARD DEVIATION GONAD WEIGHT	AVERAGE CONDITION INDEX	STANDARD DEVIATION CONDITION INDEX	AVERAGE PERCENT GONAD WEIGHT	STANDARD DEVIATION PERCENT GONAD WT
1	141088	577	242	128	53	20.7	2.3	23.3	8.3
1	171088	590	339	124	89	23.7	6.2	20.0	7.8
1	151188	436	162	70	32	20.0	4.1	16.0	2.0
3	141088	242	79	24	28	21.5	3.9	7.8	8.8
3	171088	268	126	44	34	22.0	6.0	13.6	10.0
3	311088	255	112	35	26	11.2	2.8	14.9	5.6
3	151188	267	64	29	22	17.3	3.4	10.0	7.3
4	161188	329	88	50	33	18.7	4.1	12.6	8.5
5	161188	895	136	184	38	22.9	5.2	20.7	3.7

ITE #2

LOCATION: BLANDFORD, NS

GROWER: S.F.T. VENTURE

SUMMARY OF ENVIRONMENTAL DATA PART
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	STABILITY OF STRATIFICATION (G/CM3)	SURFACE TEMPERATURE (C)	BOTTOM TEMPERATURE (C)	SURFACE SALINITY (MG/L)	BOTTOM SALINITY (MG/L)	PARTICULATE ORGANIC CARBON (MG/L)	PARTICULATE INORGANIC CARBON (MG/L)
1	151287	12.6	4.0	5.0	25.9	26.5	2.7	14.1
1	80188	13.7	0.0	1.2	28.0	29.0		
1	30288	0.0	.5	.9	32.0	32.0	4.3	13.6
1	130488	0.0	2.2	2.2	28.0	28.0	7.8	9.0
1	120588	0.0	6.4	6.3	27.0	27.0	5.0	9.0
1	30688		5.3	5.0	34.0		5.0	11.3
1	220688		13.5				9.0	7.0
1	70788		14.8	8.9			5.7	12.9
1	250788		16.0	11.7			4.5	11.1
1	10988		15.8				4.0	11.0
1	190988		9.7				3.7	12.2
2	101287	14.0	4.9	5.0	20.5	20.9		
2	231287	0.0	4.0	4.3	25.9	26.0		
2	80188	13.7	1.0	1.2	29.0	29.0		
2	30288		.9		32.0		4.0	10.0
2	130488	0.0	2.2	2.2	28.0	28.0	7.0	6.0
2	120588	0.0	6.4	6.4	27.0	27.0	5.0	7.0
2	30688						10.0	7.5
2	220688		13.5				9.0	7.0
2	70788		14.8	8.9			6.7	10.0
2	250788						5.0	9.0
2	10988						7.0	8.0
2	190988						12.2	19.2

ITE #2

LOCATION: BLANDFORD, NS

GROWER: S.F.T VENTURE

SUMMARY OF ENVIRONMENTAL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	SUSPENDED PARTICULATE MATTER (MG/L)	SURFACE DISSOLVED OXYGEN (MG/L)	BOTTOM DISSOLVED OXYGEN (MG/L)	SURFACE OXYGEN SATURATION (PERCENT)	BOTTOM OXYGEN SATURATION (PERCENT)	TOTAL CHLOROPHYLL (UG/L)	PHAO PIGMENTS (UG/L)	ZOOPLANKTON (MG/SAMPLE)	SPAT DENSITY (#/SAMPLE)
1	101287	12.6					5.0	.2	11	
1	231287	7.8					0.0	0.0	14	
1	80188	6.7					.5	0.0	6	
1	30288	11.6					1.3	0.0	2	
1	130488	12.0					1.5	.6	28	
1	120588	10.0					.9	0.0	7	
1	30688	24.0					1.2	0.0	41	
1	220688	21.3					.7	.2		
1	70788	27.7					1.1	0.0	4	0
1	250788	21.3					1.6	0.0	29	0
1	10988	22.6					1.5	.3	11	
1	190988	30.6					1.8	.4		
2	101287	5.4					3.9	19.4	4	
2	231287	7.8					0.0	0.0	30	
2	80188	10.0					.9	0.0	3	
2	30288	11.2					1.8	0.0	11	
2	130488	12.0					2.5	.7	24	
2	120588	11.0					.9	0.0	17	
2	30688	14.3					1.8	.3	39	
2	220688	21.3					.6	0.0		
2	70788	36.0					1.1	0.0	6	0
2	250788	18.8					2.2	0.0	43	144
2	10988	34.1					1.6	.3	29	1584
2	190988	31.6					3.2	.5		

ITE ...

LOCATION: BL ...FORD, NS

GROWER: S.' ... VENTURE

SUMMARY OF MUSSEL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	AGE IN MONTHS	AVERAGE SHELL LENGTH (MM)	STANDARD DEVIATION SHELL LENGTH	AVERAGE SHELL WIDTH (MM)	STANDARD DEVIATION SHELL WIDTH	AVERAGE SHELL WEIGHT (MM)	STANDARD DEVIATION SHELL WEIGHT	PERCENT GLYCOGEN CONTENT
1	101287	4.0	26.0	3.4	9.0	1.7	375	158	2.8
1	231287	4.3	26.8	3.3	9.4	1.3	380	129	2.3
1	80188	4.9	25.8	4.5	9.1	1.9	474	224	1.3
1	30288	5.8	27.0	3.8	9.2	1.4	414	156	1.5
1	130488	8.1	24.8	3.4	9.0	1.3	452	160	4.4
1	120588	9.1	34.5	4.2	12.5	2.1	724	251	5.2
1	30688	9.9	34.2	4.3	11.6	2.1	626	271	3.5
1	160688	10.3	31.7	6.2	10.7	2.0	439	222	1.8
1	70788	10.9	38.4	5.5	12.8	1.6	706	232	1.3
1	250788	11.6	29.6	7.0	10.4	2.7	416	278	.5
1	10988	12.8	37.6	7.2	14.4	2.2	944	316	1.4
1	190988	13.4	38.4	8.0	14.0	2.7	1193	528	3.2
1	71088	14.0	50.2	3.5	18.7	2.3	2530	924	2.8
1	261088	14.7	39.5	5.9	14.1	2.4	1462	704	4.1
2	101287	12.0	52.8	10.9	19.9	4.8	5469	3844	5.6
2	231287	12.4	47.4	10.0	17.6	4.8	4191	3445	5.6
2	80188	12.9	53.1	10.8	20.0	3.3	5353	3369	2.9
2	30288	13.8	52.7	6.8	20.6	2.5	4670	2157	3.4
2	130488	16.1	52.9	6.4	19.8	2.3	4391	1712	3.6
2	120588	17.1	47.8	9.0	18.5	2.7	4567	2692	5.0
2	60688	17.9	57.0	8.3	21.3	4.4	5494	3206	1.2
2	160688	18.3	54.9	6.7	20.5	2.4	4260	1705	3.4
2	70788	19.0	57.5	8.1	21.1	3.0	4880	2672	2.6
2	250788	19.6	56.5	7.7	20.3	3.3	4876	3179	1.7
2	10988	20.8	59.6	7.3	23.0	2.8	5193	3200	2.0
2	190988	21.4	58.6	5.3	21.7	2.5	5264	2448	2.3
2	71088	22.0	47.4	4.9	17.1	1.5	2162	645	4.5

SITE #2

LOCATION: BLA__ORD, NS

GROWER: S.F.__VENTURE

SUMMARY OF MUSSEL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	AVERAGE MEAT WEIGHT (MG)	STANDARD DEVIATION MEAT WEIGHT	AVERAGE GONAD WEIGHT (MG)	STANDARD DEVIATION GONAD WEIGHT	AVERAGE CONDITION INDEX	STANDARD DEVIATION CONDITION INDEX	AVERAGE PERCENT GONAD WEIGHT	STANDARD DEVIATION PERCENT GONAD WT
1	101287	65	25	0	0	17.6	2.2	0.0	0.0
1	231287	67	36	0	0	16.9	3.9	0.0	0.0
1	80188	68	29	0	0	15.0	2.6	0.0	0.0
1	30288	57	25	0	0	13.7	2.8	0.0	0.0
1	130488	115	40	6	10	25.7	2.5	4.2	7.1
1	120588	210	72	40	32	29.3	3.2	19.6	14.4
1	30688	138	61	28	28	22.5	3.6	17.4	13.6
1	160688	116	63	16	17	26.0	5.1	11.5	10.3
1	70788	147	51	25	22	20.9	1.9	15.6	11.1
1	250788	94	67	19	25	22.2	4.8	13.1	14.2
1	10988	190	75	59	40	20.7	6.3	26.7	12.7
1	190988	233	100	54	31	21.6	8.0	21.4	7.0
1	71088	320	78	58	20	13.7	3.6	18.7	6.9
1	261088	227	142	42	61	15.4	3.9	13.8	8.9
2	101287	702	517	162	209	13.3	2.8	15.6	17.1
2	231287	536	429	55	67	15.8	6.6	6.7	7.4
2	80188	693	481	122	123	13.1	1.8	15.6	8.3
2	30288	576	243	121	67	13.0	4.1	20.1	5.6
2	130488	775	304	268	143	17.6	1.7	33.6	12.6
2	120588	556	275	118	84	12.6	1.7	17.8	9.7
2	60688	558	160	124	33	11.7	3.5	23.4	4.2
2	160688	377	151	106	58	9.3	3.0	26.8	10.1
2	70788	369	87	83	14	8.7	2.9	23.5	6.9
2	250788	385	206	82	46	8.6	2.8	21.2	3.2
2	10988	572	229	167	96	8.0	1.2	28.0	10.7
2	190988	524	222	148	82	10.4	3.6	26.5	6.4
2	71088	332	158	71	76	14.8	2.9	17.5	9.1

SITE #3

LOCATION: MAHONE BAY, NS

GROWER: P. DARNELL

SUMMARY OF ENVIRONMENTAL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	STABILITY OF STRATIFICATION (G/CM3)	SURFACE TEMPERATURE (C)	BOTTOM TEMPERATURE (C)	SURFACE SALINITY (MG/L)	BOTTOM SALINITY (MG/L)	PARTICULATE ORGANIC CARBON (MG/L)	PARTICULATE INORGANIC CARBON (MG/L)
1	221187	37.2	7.0	7.8	29.1	30.5		
1	81287	0.0	5.0	5.0	29.1	29.1		
1	100188			-.5		28.9	5.3	11.2
1	290288		0.0					
1	90488	2.0	5.0	3.0	24.8	29.1	10.0	15.7
1	240488						9.0	9.9
1	110588						6.1	8.9
1	220688						11.1	14.4
2	221187	-3.6	7.0	8.0	29.8	30.1		
2	210288	9.8	1.0	.1	27.0	29.0		

SITE #3

LOCATION: MAHONE BAY, NS

GROWER: P. DARNELL

SUMMARY OF ENVIRONMENTAL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	SUSPENDED PARTICULATE MATTER (MG/L)	SURFACE DISSOLVED OXYGEN (MG/L)	BOTTOM DISSOLVED OXYGEN (MG/L)	SURFACE OXYGEN SATURATION (PERCENT)	BOTTOM OXYGEN SATURATION (PERCENT)	TOTAL CHLOROPHYLL (UG/L)	PHAO PIGMENTS (UG/L)	ZOOPLANKTON (MG/SAMPLE)	SPAT DENSITY (#/SAMPLE)
1	221187									
1	81287	10.9							0	
1	100188								2	
1	290288	0.0					0.0	0.0	8	
1	90488	70.0					.9	0.0	10	
1	240488	30.0					.9	.1		
1	110588	31.7					.5	.8	4	
1	220688	40.0					.9	.1		0
2	221187	0.0								
2	210288	10.0					.9	.4	5	

SITE #3

LOCATION: MAHONE BAY, NS

GROWER: P. DARNELL

SUMMARY OF MUSSEL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	AGE IN MONTHS	AVERAGE SHELL LENGTH (MM)	STANDARD DEVIATION SHELL LENGTH	AVERAGE SHELL WIDTH (MM)	STANDARD DEVIATION SHELL WIDTH	AVERAGE SHELL WEIGHT (MM)	STANDARD DEVIATION SHELL WEIGHT	PERCENT GLYCOGEN CONTENT
1	81287	5.0	24.5	3.2	8.4	1.1	469	157	4.2
1	290288	8.0	35.4	3.9	12.1	1.7	1133	376	3.3
1	81287	17.0	42.8	4.5	15.3	2.2	1381	301	8.0
1	90488	8.0	35.2	2.9	12.9	1.3	1090	200	16.6
1	90488	20.0	53.6	2.8	19.0	.7	3417	880	10.3
1	220688	22.5	44.3	3.9	15.8	1.4	1751	544	4.6

SITE #3

LOCATION: MAHONE BAY, NS

GROWER: P. DARNELL

SUMMARY OF MUSSEL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	AVERAGE MEAT WEIGHT (MG)	STANDARD DEVIATION MEAT WEIGHT	AVERAGE GONAD WEIGHT (MG)	STANDARD DEVIATION GONAD WEIGHT	AVERAGE CONDITION INDEX	STANDARD DEVIATION CONDITION INDEX	AVERAGE PERCENT GONAD WEIGHT	STANDARD DEVIATION PERCENT GONAD WT
1	81287	55	22	0	0	11.8	2.4	0.0	0.0
1	290288	180	64	0	0	16.0	3.2	0.0	0.0
1	81287	307	77	10	25	21.8	2.2	2.3	5.7
1	90488	337	53	23	31	31.1	2.7	6.7	8.9
1	90488	998	301	220	44	29.0	3.3	23.1	6.5
1	220688	281	99	21	31	16.3	4.3	12.7	14.4

SITE #4

LOCATION: PORT HOOD, NS

GROWER: J. MACINNES

SUMMARY OF ENVIRONMENTAL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	STABILITY OF STRATIFICATION (G/CM3)	SURFACE TEMPERATURE (C)	BOTTOM TEMPERATURE (C)	SURFACE SALINITY (MG/L)	BOTTOM SALINITY (MG/L)	PARTICULATE ORGANIC CARBON (MG/L)	PARTICULATE INORGANIC CARBON (MG/L)
1	130588	72.0	11.0	1.5	21.0	28.7	6.0	4.8
1	140688	21.2	13.0	8.0	22.0	28.0	7.8	6.0
1	200788							

SITE #4

LOCATION: PORT HOOD, NS

GROWER: J. MACINNES

SUMMARY OF ENVIRONMENTAL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	SUSPENDED PARTICULATE MATTER (MG/L)	SURFACE DISSOLVED OXYGEN (MG/L)	BOTTOM DISSOLVED OXYGEN (MG/L)	SURFACE OXYGEN SATURATION (PERCENT)	BOTTOM OXYGEN SATURATION (PERCENT)	TOTAL CHLOROPHYLL (UG/L)	PHAO PIGMENTS (UG/L)	ZOOPLANKTON (MG/SAMPLE)	SPAT DENSITY (#/SAMPLE)
1	130588	59.7					1.1	.1		
1	140688	55.0					1.7	1.7	47	0
1	200788	13.8					2.3	.3	67	

SITE #4

LOCATION: PORT HOOD, NS

GROWER: J. MACINNES

SUMMARY OF MUSSEL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	AGE IN MONTHS	AVERAGE SHELL LENGTH (MM)	STANDARD DEVIATION SHELL LENGTH	AVERAGE SHELL WIDTH (MM)	STANDARD DEVIATION SHELL WIDTH	AVERAGE SHELL WEIGHT (MM)	STANDARD DEVIATION SHELL WEIGHT	PERCENT GLYCOGEN CONTENT
1	130588	10.0	25.5	3.7	9.9	1.7	464	202	4.2
1	140688	11.0	29.7	5.3	11.6	2.3	616	283	3.9
1	200788	12.2	29.2	7.1	10.8	2.1	792	361	1.0

SITE #4

LOCATION: PORT HOOD, NS

GROWER: J. MACINNES

SUMMARY OF MUSSEL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	AVERAGE MEAT WEIGHT (MG)	STANDARD DEVIATION MEAT WEIGHT	AVERAGE GONAD WEIGHT (MG)	STANDARD DEVIATION GONAD WEIGHT	AVERAGE CONDITION INDEX	STANDARD DEVIATION CONDITION INDEX	AVERAGE PERCENT GONAD WEIGHT	STANDARD DEVIATION PERCENT GONAD WT
1	130588	104	40	0	0	23.0	3.6	0.0	0.0
1	140688	145	78	28	35	23.1	4.2	14.1	15.2
1	200788	58	28	0	0	7.4	1.5	0.0	0.0

SITE #6

LOCATION: TATAMAGOUCHE BAY, NS

GROWER: R. MALONEY

SUMMARY OF ENVIRONMENTAL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	STABILITY OF STRATIFICATION (G/CM3)	SURFACE TEMPERATURE (C)	BOTTOM TEMPERATURE (C)	SURFACE SALINITY (MG/L)	BOTTOM SALINITY (MG/L)	PARTICULATE ORGANIC CARBON (MG/L)	PARTICULATE INORGANIC CARBON (MG/L)
1	20588	8.0	6.0	5.0	15.0	18.0	6.6	12.0

SITE #6

LOCATION: TATAMAGOUCHE BAY, NS

GROWER: R. MALONEY

SUMMARY OF ENVIRONMENTAL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	SUSPENDED PARTICULATE MATTER (MG/L)	SURFACE DISSOLVED OXYGEN (MG/L)	BOTTOM DISSOLVED OXYGEN (MG/L)	SURFACE OXYGEN SATURATION (PERCENT)	BOTTOM OXYGEN SATURATION (PERCENT)	TOTAL CHLOROPHYLL (UG/L)	PHAO PIGMENTS (UG/L)	ZOOPLANKTON (MG/SAMPLE)	SPAT DENSITY (#/SAMPLE)
1	20588	5.0					0.0	0.0	11	

SITE #6

LOCATION: TATAMAGOUCHE BAY, NS

GROWER: R. MALONEY

SUMMARY OF MUSSEL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	AGE IN MONTHS	AVERAGE SHELL LENGTH (MM)	STANDARD DEVIATION SHELL LENGTH	AVERAGE SHELL WIDTH (MM)	STANDARD DEVIATION SHELL WIDTH	AVERAGE SHELL WEIGHT (MM)	STANDARD DEVIATION SHELL WEIGHT	PERCENT GLYCOGEN CONTENT
1	20588	8.0	31.2	4.8	12.0	2.1	1279	488	4.8
1	20588	12.0	55.2	5.3	21.5	2.2	6102	1895	2.5
1	141088	3.5	21.3	2.8	7.9	2.1	395	132	6.1

SITE #6

LOCATION: TATAMAGOUCHE BAY, NS

GROWER: R. MALONEY

SUMMARY OF MUSSEL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	AVERAGE MEAT WEIGHT (MG)	STANDARD DEVIATION MEAT WEIGHT	AVERAGE GONAD WEIGHT (MG)	STANDARD DEVIATION GONAD WEIGHT	AVERAGE CONDITION INDEX	STANDARD DEVIATION CONDITION INDEX	AVERAGE PERCENT GONAD WEIGHT	STANDARD DEVIATION PERCENT GONAD WT
1	20588	190	89	29	28	14.5	1.9	13.5	11.0
1	20588	1103	484	354	260	17.8	4.9	29.3	19.7
1	141088	58	23	2	3	13.0	4.1	2.3	4.8

SITE #7

LOCATION: LENNOX PASSAGE, NS

GROWER: P. MARCHAND

SUMMARY OF ENVIRONMENTAL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	STABILITY OF STRATIFICATION (G/CM3)	SURFACE TEMPERATURE (C)	BOTTOM TEMPERATURE (C)	SURFACE SALINITY (MG/L)	BOTTOM SALINITY (MG/L)	PARTICULATE ORGANIC CARBON (MG/L)	PARTICULATE INORGANIC CARBON (MG/L)
1	150588	15.4	9.1	3.5	28.0	32.9	3.0	9.0
1	290588	26.0	13.9	3.5	23.9	33.5	2.0	9.8
1	120688	1.9	10.9	8.0	29.0	28.7	7.9	8.8
1	280688						6.4	14.7
1	90788	5.9	17.0	7.5	27.6	29.9	7.8	7.8
1	240788	7.5	16.5	12.2	29.0	31.0	9.2	7.1
1	210888		20.0	18.5	26.0	26.1	6.2	9.9
1	250988		13.2	13.2	29.0	29.0	5.2	11.3
1	250988		13.2	13.2	29.0	29.0	6.9	15.3

SITE #7

LOCATION: LENNOX PASSAGE, NS

GROWER: P. MARCHAND

SUMMARY OF ENVIRONMENTAL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	SUSPENDED PARTICULATE MATTER (MG/L)	SURFACE DISSOLVED OXYGEN (MG/L)	BOTTOM DISSOLVED OXYGEN (MG/L)	SURFACE OXYGEN SATURATION (PERCENT)	BOTTOM OXYGEN SATURATION (PERCENT)	TOTAL CHLOROPHYLL (UG/L)	PHAO PIGMENTS (UG/L)	ZOOPLANKTON (MG/SAMPLE)	SPAT DENSITY (#/SAMPLE)
1	150588	32.3								
1	290588	29.2					.6	0.0		
1	120688	20.0					1.1	.3	20	
1	280688	33.3					1.1	0.0	15	
1	90788	33.3					3.5	.5	68	
1	240788	36.7					3.6	.9	29	
1	210888	30.0					2.9	.1	32	
1	250988	23.3					4.0	0.0	43	720
1	250988	8.1					2.4	0.7		
							2.0	1.1	24	

SITE #7

LOCATION: LENNOX PASSAGE, NS

GROWER: P. MARCHAND

SUMMARY OF MUSSEL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	AGE IN MONTHS	AVERAGE SHELL LENGTH (MM)	STANDARD DEVIATION SHELL LENGTH	AVERAGE SHELL WIDTH (MM)	STANDARD DEVIATION SHELL WIDTH	AVERAGE SHELL WEIGHT (MM)	STANDARD DEVIATION SHELL WEIGHT	PERCENT GLYCOGEN CONTENT
1	150588	9.0	39.5	7.0	15.1	3.0	1485	565	9.9
1	290588	9.5	38.9	4.3	14.1	1.6	1411	508	9.4
1	120688	9.9	41.6	4.6	15.5	1.9	1500	396	6.1
1	90788	10.8	43.7	3.0	16.9	1.6	1989	389	2.8
1	90788	10.8	49.5	3.3	18.9	2.4	2428	855	2.0
1	240788	11.3	46.5	4.7	16.9	1.6	2280	809	1.8
1	210888	12.3	52.6	5.5	18.6	1.7	2193	759	1.6
1	210888	12.3	43.3	7.6	16.4	3.9	2090	1030	4.3
1	250988	13.3	52.3	4.2	21.4	2.0	3603	1485	3.6

SITE #7

LOCATION: LENNOX PASSAGE, NS

GROWER: P. MARCHAND

SUMMARY OF MUSSEL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	AVERAGE MEAT WEIGHT (MG)	STANDARD DEVIATION MEAT WEIGHT	AVERAGE GONAD WEIGHT (MG)	STANDARD DEVIATION GONAD WEIGHT	AVERAGE CONDITION INDEX	STANDARD DEVIATION CONDITION INDEX	AVERAGE PERCENT GONAD WEIGHT	STANDARD DEVIATION PERCENT GONAD WT
1	150588	459	180	107	60	31.1	4.4	22.4	5.8
1	290588	504	163	77	47	36.3	6.1	14.4	7.1
1	120688	485	115	139	52	33.0	6.7	28.1	4.4
1	90788	352	68	73	30	18.1	4.2	20.2	4.6
1	90788	666	189	209	135	29.0	6.8	31.0	16.9
1	240788	386	211	119	102	16.7	5.3	27.8	10.0
1	210888	300	115	61	51	13.7	2.7	16.7	13.2
1	210888	235	67	51	28	13.3	6.6	20.0	10.8
1	250988	466	297	116	86	12.4	4.7	23.1	4.6

SITE #10

LOCATION: NEW LONDON BAY, PEI

GROWER: S.STEWART

SUMMARY OF ENVIRONMENTAL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	STABILITY OF STRATIFICATION (G/CM3)	SURFACE TEMPERATURE (C)	BOTTOM TEMPERATURE (C)	SURFACE SALINITY (MG/L)	BOTTOM SALINITY (MG/L)	PARTICULATE ORGANIC CARBON (MG/L)	PARTICULATE INORGANIC CARBON (MG/L)
1	201187	4.9	6.5	9.0	22.2	25.0		
1	90588	2.9	6.0	2.0	23.8	26.7		
1	250588	0.0	13.0	11.2	25.8	25.3	4.9	8.1
1	130688	.4	13.9	11.0	28.3	27.8	3.8	9.8
1	270688						5.0	11.0
1	150788						8.0	9.1
1	260788						7.0	7.0
1	180888		18.9	21.5	28.7	27.1		
2	90588	.5	6.0	1.9	26.0	26.3	7.3	9.7
2	250588	0.0	12.5	11.5	25.8	26.0		
2	130688		14.6	10.9	26.2	22.0	6.3	15.2
2	270688						4.0	12.0
2	150788						11.6	9.5
2	260788						8.0	7.0
2	180888		19.5	21.2	28.4	27.0		

SITE #10

LOCATION: NEW LONDON BAY, PEI

GROWER: S. STEWART

SUMMARY OF ENVIRONMENTAL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	SUSPENDED PARTICULATE MATTER (MG/L)	SURFACE DISSOLVED OXYGEN (MG/L)	BOTTOM DISSOLVED OXYGEN (MG/L)	SURFACE OXYGEN SATURATION (PERCENT)	BOTTOM OXYGEN SATURATION (PERCENT)	TOTAL CHLOROPHYLL (UG/L)	PHAO PIGMENTS (UG/L)	ZOOPLANKTON (MG/SAMPLE)	SPAT DENSITY (#/SAMPLE)
1	201187	12.0	12.8		100		0.0	0.0	30	
1	90588	24.0	11.4	13.0	86	87	.4	.3	25	
1	250588	28.0	11.6	10.4	100	91	.5	.2	21	
1	130688	15.4	9.4	10.4	87	95	1.8	.4	31	
1	270688	28.6	12.0	12.0			8.6	1.3	55	
1	150788	38.2	8.4	9.6			6.8	1.7	298	2520
1	260788	36.7	8.4	7.8			5.7	2.5	131	2304
1	180888	43.3	10.2	9.8	105	105	12.8	0.0	43	1368
2	90588	32.1	68.2	14.0	99	96	1.6	.7	22	
2	250588	44.0	9.6	9.0	88	80	1.3	.4	27	
2	130688		8.8	10.4	85	96	1.5	.9	31	0
2	270688	40.0	10.0	11.0			6.6	2.9	59	
2	150788	50.0	9.2	10.2			6.6	3.0	315	
2	260788	40.0	7.8	8.0			6.7	2.5	113	
2	180888	50.0	9.0	9.2	95	98	9.2	0.0	84	

SITE #10

LOCATION: NEW LONDON BAY, PEI

GROWER: S. STEWART

SUMMARY OF MUSSEL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	AGE IN MONTHS	AVERAGE SHELL LENGTH (MM)	STANDARD DEVIATION SHELL LENGTH	AVERAGE SHELL WIDTH (MM)	STANDARD DEVIATION SHELL WIDTH	AVERAGE SHELL WEIGHT (MM)	STANDARD DEVIATION SHELL WEIGHT	PERCENT GLYCOGEN CONTENT
1	201187	4.5	27.2	3.8	9.9	1.8	577	261	8.7
1	90588	10.1	35.5	5.6	13.5	2.4	1302	578	14.3
1	250588	10.7	35.2	5.4	14.2	2.5	1316	427	9.5
1	130688	11.3	38.0	4.1	15.2	1.8	1548	464	-
1	270688	11.8	40.5	5.3	15.8	1.3	2068	580	-
1	150788	12.4	41.1	7.0	15.9	2.8	2285	993	4.3
1	260788	12.8	41.3	6.7	17.6	3.3	2692	952	2.7
1	180888	13.5	50.1	4.1	20.9	1.7	4448	705	2.8
2	90588	11.0	31.3	4.8	11.6	1.9	992	357	16.5
2	130688	12.3	33.8	3.5	13.5	1.9	1413	317	8.7
2	270688	12.6	41.6	6.4	16.3	2.7	2281	757	4.7
2	150788	13.2	43.8	6.0	17.4	2.2	2767	725	3.1
2	260788	13.6	45.0	3.7	19.0	1.2	3023	379	5.5
2	180888	14.4	46.9	2.7	20.2	1.4	3862	487	1.4

SITE #10

LOCATION: NEW LONDON BAY, PEI

GROWER: S. STEWART

SUMMARY OF MUSSEL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	AVERAGE MEAT WEIGHT (MG)	STANDARD DEVIATION MEAT WEIGHT	AVERAGE GONAD WEIGHT (MG)	STANDARD DEVIATION GONAD WEIGHT	AVERAGE CONDITION INDEX	STANDARD DEVIATION CONDITION INDEX	AVERAGE PERCENT GONAD WEIGHT	STANDARD DEVIATION PERCENT GONAD WT
1	201187	133	70	0	0	22.2	2.1	0.0	0.0
1	90588	634	315	119	107	47.9	6.4	16.3	10.2
1	250588	463	174	106	78	34.9	4.7	20.1	9.4
1	130688	468	163	121	62	30.0	3.8	30.9	7.7
1	270688	565	180	187	71	27.2	1.5	32.8	5.8
1	150788	327	153	82	62	14.8	3.7	24.3	7.8
1	260788	460	321	132	140	16.3	6.9	24.5	8.9
1	180888	722	345	267	204	16.0	6.5	34.0	11.4
2	90588	376	164	31	41	37.1	4.3	6.2	8.1
2	130688	386	112	106	52	27.1	4.3	26.5	6.4
2	270688	552	250	209	129	24.8	7.8	35.8	7.2
2	150788	450	134	129	48	16.9	4.7	28.3	6.7
2	260788	440	48	110	19	14.7	2.1	24.9	2.3
2	180888	411	28	100	16	10.8	1.7	24.3	3.8

SITE #15

LOCATION: TRACACADIE BAY, PEI

GROWER: R. TOWNSHEND

SUMMARY OF ENVIRONMENTAL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	STABILITY OF STRATIFICATION (G/CM3)	SURFACE TEMPERATURE (C)	BOTTOM TEMPERATURE (C)	SURFACE SALINITY (MG/L)	BOTTOM SALINITY (MG/L)	PARTICULATE ORGANIC CARBON (MG/L)	PARTICULATE INORGANIC CARBON (MG/L)
1	110188	91.7	-2.0	-.5	11.8	30.0	6.5	9.5
1	250188	4.0	0.0	0.0	10.3	30.2	4.8	10.2
1	80288	8.3	-.2	-.9	1.3	25.9	6.8	7.3
1	210288	68.8	.8	-.6	3.0	29.3	5.9	8.8
1	20588	6.0	5.0	3.8	23.0	27.2	5.7	12.5
1	150588	1.7	11.7	8.0	23.9	26.8	5.9	9.8
1	130688	2.8	13.2	11.9	28.5	29.5	2.9	11.8
1	30788	2.6	16.1	12.2	26.6	28.0	6.9	10.6
1	180788	6.6	22.2	18.5	26.2	27.0	5.0	12.0
1	310788	4.8	22.0	18.0	25.9	27.1	8.6	8.9
2	110187	60.1	-1.8	-.4	12.4	30.5	3.7	9.3
2	250188	88.5	.2	.8	4.5	30.9	5.1	9.5
2	80288	95.3	-.3	0.0	4.2	29.7	4.9	7.1
2	210288	21.2	.2	0.0	4.0	30.0	7.0	7.0
2	130388	19.4	-.2	-.9	3.9	28.8		
2	20588	4.3	6.0	3.9	20.0	26.2	6.0	7.0
2	150588	1.8	11.2	9.2	23.9	25.9	7.7	7.8
2	310588	7.2	13.2	11.1	25.0	26.8	6.8	8.7
2	130688	1.8	13.8	12.4	26.8	27.2	6.8	10.7
2	30788	.7	16.0	13.3	27.2	27.6	4.8	9.6
2	180788	6.0	22.5	18.5	26.8	26.8	7.0	7.9
2	310788	5.4	21.5	18.5	25.0	26.0	8.8	5.8

SITE #15

LOCATION: TRACACADIE BAY, PEI

GROWER: R. TOWNSHEND

SUMMARY OF ENVIRONMENTAL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	SUSPENDED PARTICULATE MATTER (MG/L)	SURFACE DISSOLVED OXYGEN (MG/L)	BOTTOM DISSOLVED OXYGEN (MG/L)	SURFACE OXYGEN SATURATION (PERCENT)	BOTTOM OXYGEN SATURATION (PERCENT)	TOTAL CHLOROPHYLL (UG/L)	PHAO PIGMENTS (UG/L)	ZOOPLANKTON (MG/SAMPLE)	SPAT DENSITY (#/SAMPLE)
1	110188	16.0		12.6		80	0.0	0.0	8	
1	250188	16.2		11.6		75	.6	0.0	5	
1	80288	14.0		11.2		72	1.2	0.0	0	
1	210288	16.8		10.8		70	1.4	0.0	2	
1	20588	27.3		10.7		84	2.4	0.0	64	
1	150588	29.1		10.2		89	2.4	0.0	35	
1	130688	31.9		9.4		86	.6	0.0		
1	30788	34.0		8.6		84	2.6	0.0		
1	180788	30.6		9.0		99				
1	310788	28.3		8.4		92	2.3	0.0		
2	110187	14.0		11.7		75	0.0	0.0	10	
2	250188	14.9		11.7		76	0.0	0.0	6	
2	80288	13.9		10.5		69	1.5	0.0		
2	210288	18.6		10.6		70	.9	0.0	12	
2	130388								40	
2	20588	24.1		12.7		97	2.4	0.0	32	
2	150588	35.7		10.6		93	5.3	0.0		
2	310588	27.6		9.3		85	3.4	0.0		
2	130688	32.7		9.4		86	1.0	0.0		0
2	30788	34.0		9.2		89	2.5	0.0		14336
2	180788	28.3		9.3		100	3.2	0.0		2628
2	310788	32.7		7.8		95	2.4	0.0		456

SITE #15

LOCATION: TRACADIE BAY, PEI

GROWER: R. TOWNSHEND

SUMMARY OF MUSSEL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	AGE IN MONTHS	AVERAGE SHELL LENGTH (MM)	STANDARD DEVIATION SHELL LENGTH	AVERAGE SHELL WIDTH (MM)	STANDARD DEVIATION SHELL WIDTH	AVERAGE SHELL WEIGHT (MM)	STANDARD DEVIATION SHELL WEIGHT	PERCENT GLYCOGEN CONTENT
1	181187	5.0	27.5	4.4	10.2	1.6	673	344	5.8
1	20588	10.5	36.2	3.7	13.7	1.6	1464	498	8.2
1	150588	10.9	37.7	4.5	14.8	1.8	1449	418	10.2
1	130688	11.9	43.0	4.4	17.3	1.6	2101	537	7.3
1	30788	12.6	45.2	5.6	17.7	1.4	2203	596	2.6
1	180788	13.1	47.0	4.6	18.0	1.0	2628	670	6.0
1	310788	13.5	48.4	2.1	18.5	1.1	2855	311	2.5
2	181187	17.0	58.1	7.1	22.6	2.8	5508	1347	5.8
2	110188	18.8	55.6	3.5	19.6	1.3	4836	849	8.8
2	20588	22.5	60.4	6.9	21.8	3.2	5431	1549	6.3
2	150588	22.9	60.9	8.5	23.0	3.0	6186	1761	5.8
2	310588	23.5	59.1	7.1	21.4	1.9	5976	1394	8.3
2	130688	23.9	57.6	8.8	21.8	1.8	5818	1555	4.8
2	30788	24.6	67.0	6.7	26.3	3.6	8765	2460	4.7
2	180788	25.1	64.6	5.4	23.3	2.5	7666	1559	5.0

SITE #15

LOCATION: TRACADIE BAY, PEI

GROWER: R. TOWNSHEND

SUMMARY OF MUSSEL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	AVERAGE MEAT WEIGHT (MG)	STANDARD DEVIATION MEAT WEIGHT	AVERAGE GONAD WEIGHT (MG)	STANDARD DEVIATION GONAD WEIGHT	AVERAGE CONDITION INDEX	STANDARD DEVIATION CONDITION INDEX	AVERAGE PERCENT GONAD WEIGHT	STANDARD DEVIATION PERCENT GONAD WT
1	181187	138	86	0	0	20.4	4.8	0.0	0.0
1	20588	328	135	61	52	22.1	4.6	15.9	11.3
1	150588	488	176	102	69	33.2	4.2	19.2	8.8
1	130688	334	144	69	36	15.8	4.3	20.3	2.3
1	30788	432	119	116	50	19.7	1.3	25.9	4.8
1	180788	421	90	113	50	16.3	3.1	26.1	7.5
1	310788	482	98	86	24	16.9	3.4	17.6	1.6
2	181187	1515	497	350	171	30.6	11.0	21.8	6.2
2	110188	829	255	112	84	16.9	3.4	12.9	8.4
2	20588	1579	593	491	278	28.6	4.7	29.1	6.7
2	150588	1355	415	379	178	21.8	1.7	26.8	5.3
2	310588	756	189	210	67	12.7	1.5	27.4	3.7
2	130688	654	131	162	46	11.7	2.5	24.9	6.5
2	30788	889	105	233	51	10.7	2.7	26.1	4.4
2	180788	1009	210	227	80	13.2	1.2	21.9	4.2

SITE #17

LOCATION: RICHIBUCTO, NB

GROWER: M. DAIGLE

SUMMARY OF ENVIRONMENTAL DATA
WATER QUALITY MONITORING PROGRAMME FOR MUSSEL GROWERS
ACADIA CENTRE FOR ESTUARINE RESEARCH

SUB SITE	DATE	STABILITY OF STRATIFICATION (G/CM3)	SURFACE TEMPERATURE (C)	BOTTOM TEMPERATURE (C)	SURFACE SALINITY (MG/L)	BOTTOM SALINITY (MG/L)	PARTICULATE ORGANIC CARBON (MG/L)	PARTICULATE INORGANIC CARBON (MG/L)
1	290688		16.1		19.5			
1	40788		16.2		23.0		6.0	8.0
1	110788	2.1	23.1	22.1	23.0	24.1	8.0	7.1
1	210788		22.0		24.2		6.0	7.8
2	40788						7.0	9.1