Mussel Seed Quality Workshop Proceedings

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Cover photo: PEI mussel site at sunset - Courtesy Kevin Heasmen

Report Contents

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SECTION ONE – BACKGROUND

Background

Unexplained cultured mussel seed mortalities have been reported by Maritime mussel growers at an increasing rate over the last five years. Seed purchased and transferred from northern New Brunswick in the fall 2001, for grow out on PEI mussel leases, did not survived its second summer in the water, with reported mortalities in 2003 ranging from 90 to 100%. In 2003, individual losses ranged from $10,000 to $100,000 per lease. Possible explanations have included mussel fitness, genetic variations (*Mytilus trossulus* versus *M. edulis*) and environmental/physiological stress (e.g. the transplanted mussel seed cannot adapt to the new environmental conditions – temperature, salinity, etc.). Prince Edward Island mussel farmers have experienced a shortage in native mussel seed in recent years and hence have looked to off-Island sources of seed. As a result of the 2003 mass NB seed mortalities, most Maritime mussel growers faced not only a shortage of seed, but increased seed prices while NB seed growers experienced decreased demand from Island mussel growers during the 2003 fall socking season.

Fouling organisms and invasive species (tunicates, green algae, green crab, etc.) have also increased in severity over recent years. In 2003, a number of PEI growers reported finding massive amounts of a green, filamentous algae (*Cladophora* sp. and *Enteromorpha* sp.) on mussel seed collectors on the north shore of the Island. The macroalgae caused two problems. On some mussel lease areas the algae set on the collectors, clogging the collectors and preventing mussel spat settlement. At other locations, the macroalgae species intertwined with the mussel seed allowing the mussel byssal threads to attach to the algae rather than the collector material. As a result, when the collectors were lifted out of the water for routine inspection in the summer and fall, the algae slipped off the collectors to the ocean floor taking the mussel seed with them. In addition, during late summer (early fall) of 2003 some algae died creating anoxic conditions leading to physiological stressful environments and associated mortalities of mussel seed. Green algae (slime) is considered a serious fouling agent on PEI mussel collectors and estimated losses per individual effected leaseholder were in the $100,000 range.

On March 10, 2004 the Prince Edward Island Aquaculture Alliance and the Prince Edward Island Department of Agriculture, Fisheries, Aquaculture and Forestry co-sponsored the Mussel Seed Quality Workshop in the Avonlea Room of the Holiday Inn Express and Suites, Charlottetown, PE. The objectives of the workshop were multiple including:

- Address and discuss issues relevant to the quality of mussel seed in Atlantic Canada
- Identify research and development priorities for the cultured mussel industry specifically for mussel seed collection, growout, husbandry and treatment of fouling organisms, and
- Draft a plan of action (potential research projects funding sources, etc.) to help solve the issues and priorities facing the Atlantic Canadian mussel seed industry.

The Mussel Seed Quality Workshop was held between 8:30 am and 5:30 pm, allowing each guest speaker sufficient time to present his/her area of knowledge/expertise and workshop participants' ample opportunity to engage these individuals (and others in the audience) in thought provoking and resolution seeking discussions. Guest speakers were brought in from Gaspé and Magdalene Islands, Quebec and Mahone Bay, Nova Scotia (NS) to discuss mussel seed quality while a fourth guest speaker was brought in from the Bedford Institute of Oceanography, Dartmouth, NS to discuss fouling algae. Originally, a guest

speaker from France, Dr. Jean-Francois Samain, was invited to present the development of a comprehensible program on bivalve mortality in France. However, he could not attend at last minute, therefore, Thomas Landry (DFO-Gulf Region), gave his prepared talk in his absence. In addition, growers or aquaculture association representatives from Nova Scotia, New Brunswick and PEI gave overviews of issues facing the Maritime mussel seed industry.

Over 80 individuals from across Atlantic Canada participated in the workshop, including industry representatives (growers, employees, manufactures, processors), the research community and several levels of government participating in the discussions.

Sponsors & Supporters

The workshop was financially supported by the Aquaculture Collaborative Research and Development Program (ACRDP) of Fisheries and Oceans Canada and though the registration fees collected at the venue. A steering-organizing committee for the workshop (i.e. draft agenda, contact of guest speakers, etc.) was made up of representatives from the Prince Edward Island Department of Agriculture, Fisheries, Aquaculture and Forestry (PEIDFAF), Fisheries and Oceans Canada (Gulf-Region) and the Prince Edward Island Aquaculture Alliance (PEIAA). The Holiday Inn Express and Suites, Charlottetown, provided the venue and audio equipment. An in-kind donation of the visual services was provided by the PEIDFAF. The PEIAA provided administration services (i.e. mail-outs, telephone, organizational, etc) with help at the registration desk from the PEIDFAF.

Presentations

On March 10, 2004 the Mussel Seed Quality Workshop posed the following questions to help lead researchers and individuals with front line experience in an effort to better understand the issues facing mussel seed quality in the Maritimes:

Panel Discussion for Section Two – Mussel Seed Quality

- What are the costs and benefits of improving mussel seed quality?

Panel Discussion for Section Three – Optimizing Mussel Collection

- What are the costs and benefits of improving mussel seed production?

Discussion of Issues, Setting R&D Priorities for Section Six– Industry Perspective:

- What are the major concerns over seed supply in the Maritimes (quantity, quality, fellow travelers/fouling agents, others)?
- What are the main mechanisms that can address these concerns (I&T, record keeping, others)?
- What are the top five research and development priorities dealing with mussel seed quality?

These questions and the responses that were garnered by the presentations and ensuing discussion have been provided in this report. The organizers of the workshop have complied a brief summary of their notes for each presentation and, where available, a hard copy of the actual presentation, including speaker notes, is included.

Guest Speakers

The Mussel Seed Quality Workshop organizing-steering committee invited world-renowned researchers:

- Dr. Bruno Myrand, Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ), Îles-de-la-Madeleine, Québec;
- Dr. Réjean Tremblay, Institut des Sceinces de la mer, Université du Quebec à Rimouski, Quebec;
- Mr. Bob Semple, Bedford Institute of Oceanography, Dartmouth, NS; and
- Mr. Peter Darnell, NS industry representative, Mahone Bay, NS

Each invited speaker brought their expertise and experience with mussel seed mortality and fouling organisms to the workshop

Local researchers from the Atlantic Veterinary College (AVC), the PEIDAFAF, DFO Gulf-Region (Moncton) gave presentations on mussel seed quality, diseases, genetics, physiology, algae fouling, *Styela clava* fouling and impact of competitors on mussel productivity. Federal government representatives outlined policy and management of mussel seed production and growers or association representatives gave overviews of the issues facing mussel seed quality from their respective provinces.

Discussion between presenters and the workshop participants was encouraged throughout the day (including the health breaks and meals) leading to valuable input from all interested participants and a successful event.

SECTION TWO – INTRODUCTION & OVERVIEW OF ISSUES FACING MARITIME MUSSEL SEED INDUSTRY – *Moderator Crystal McDonald (PEIAA)*

Introduction and Welcome, *Crystal McDonald, Executive Director, Prince Edward Island Aquaculture Alliance (PEIAA)*

PEI Estuary – Courtesy Matt Smith

Prince Edward Island Aquaculture Alliance Executive Director, Crystal McDonald, welcomed the participants to the Mussel Seed Quality Workshop. Ms McDonald moderated the introductory session in which representatives from New Brunswick (NB), Nova Scotia (NS) and Prince Edward Island (PEI) aquaculture associations gave overviews on the issues facing the mussel seed industry in their respective provinces. She introduced the three speakers and explained the objectives of the workshop and outlined the agenda for the participants.

New Brunswick Perspective, *Florence Albert, Executive Director, Profession Shellfish Growers Association of New Brunswick (PSGANB)*

Florence Albert began her presentation with a general overview of the mussel seed industry in NB. She indicated the NB mussel industry is relatively small with 8 growers (4 mussel spat growers and 4 fresh mussel growers). Commercial harvest has risen from 181,000 kg in 1997 to over 440,00 kg in 2001, while the see harvest has risen from 22,500 kg to 160,000 kg during the same time period. In 2003, the NB spat production capacity was estimated at 200 MT of which 1790 MT were sold to out of province growers with the balance (210 MT) being used locally. As a result of this high demand, spat collection has become a significant activity for most of the NB growers.

Albert mentioned that there have been a number of considerations in recent years including the threat of tunicates (*Styela clava* and *Ciona intestinalis*), predators (e.g. star fish, green crab) and algae fouling on mussel collectors. Lately, issues have included varying levels of summer mussel seed mortality, spat collection problems and mortalities experienced in PEI with NB mussel seed. In relation to this recent seed mortality, particularly in PEI, the NB growers have met with the PEI Aquaculture Alliance, DFO, PEIDFAF and mussel growers in both provinces to help resolve this problem. The NB members see a need for increased seed health checks, a commitment to a mussel seed certification program and have submitted a project proposal with DFO-Gulf Region to ACRDP to study the mussel seed mortality problem further.

Nova Scotia Perspective, *Peter Darnell, Indian Point Marine Farms Ltd., Mahone Bay, NS*
Peter Darnell, Nova Scotian mussel farmer, followed Florence with an emphasis on how dependant Nova Scotia growers are on NB mussel seed. He mentioned that NS has a shortage of native seed and NB, not PEI, has been the major seed supplier for NS. He touched a few problems facing the NS mussel seed industry and the inter-provincial movement of seed:

- Fear of moving exotic species with mussel seed (e.g. tunicates, MSX, etc.)
- Introduction and Transfer permits need to be flexible and reactive, yet effective.
- I&T requirements require soaking seed in fresh water for 24 hrs prior to movement. There is no science to show what the effect of soaking is doing to the shelf-life of the seed.

- MSX – when MSX hit NS the mussel industry was shut down, yet lobsters moved freely into and out of the province. This needs to be addressed.
- Sea Ducks – duck predation is seriously impacting mussel seed supply in spring
- Seed quality issues have never been adequately addressed. Appearance, *M. trossulus* versus *M. edulis*, shell length, etc, needs to be further studied.
- Winter overset – a second spat or set is affecting seed quality

Darnell then explained what he felt might be some recommendations to these issues:

- Eliminating the exotic species and fellow travelers in mussel seed will require sound science.
- The solution or treatment must be cost effective.
- Seed producers, not the buyer, must issue a certificate that states the seed is "clean" and meets all I&T requirements
- I&T regulations must be reactive, flexible and effective.
- Areas/bays that can produce seed within NS must be found and identified so that NS growers are not completely relying on out of province seed.
- I&T permits will become move flexible when seed suppliers are certified
- Free movement of lobster must be addressed by Provincial and Federal I&T committees
- Hatchery seed and broodstock development as a seed source should be looked into for NS.

Prince Edward Island Perspective, *Dr. Greg MacCallum, Research and Development Coordinator, PEI Aquaculture Alliance*

Dr. MacCallum gave a brief overview of the mussel seed industry on PEI. He explained that there are 120 companies/individuals producing seed and growout with currently eight processing plants in operation. The average size of mussel leases ranges from 50-150 acres, with an annual production rate ranging from 30-90,000 lbs per year. The 2002 total was over 17,000 MT (37 million lbs) of mussel with a value of approximately $23 million. The PEI mussel industry currently employs 1500 Islanders. Based on these figures he estimated that the mussel seed requirements for PEI would be 9 million pounds per year (37 million lbs = 150,000 pans of seed @ 60 lbs per pan).

MacCallum broke down the issues facing the PEI mussel seed industry into two categories: Management Issues and Ecological/physical Issues.

Management issues and questions include:

- Seed shortages
- Seed movement (is there any negative long term, genetic impacts?)
- Spat Collection - questions
  - Are there gaps in seed collection capacity?
  - Is the current collection method the best?
  - Can we improve our efficiency in collecting/grading/socking?
  - Should growout and seed collection be done at the same location?
  - Seed certification – do we need this?
  - Should we also harvest wild seed?

Mussel Lines on PEI
Courtesy Matt Smith

Ecological/Physical issues included:

- Predation – sea ducks, starfish, green crab
- Parasites and diseases – Digenean castrator
- Fouling Organisms – Clubbed tunicate & green algae
- Summer mortalities (on & off Island seed)
- Physical – wind, nutrient loading, anoxia

Styela attached to mussel
Courtesy Garth Arsenault

MacCallum mentioned that wild seed has played, and continues to play, an

important role in the PEI industry. Wild seed was the first source of seed and tends to be hardier than cultured variety. Depending on the year, wild seed can make up a significant portion of the total Island seed. MacCallum felt that the PEI Aquaculture Alliance needs to maintain:

- A licence to harvest wild seed
- Timely I&T permits to allow disease free and fouling free seed transfers
- A supportive policy framework for both wild an cultured seed and,
- Shellfish health expertise

MacCallum explained that PEI has an important provincially funded program in place, The Mussel Monitoring Program. This program goal is spat collection and it has proven to be a great service to the industry. The Alliance needs to continue to support this program because it helps take the guesswork out of spat fall prediction.

MacCallum stated that PEI has a long history of moving native and non-native seed around the Island. Unfortunately, there have been some cases reported where some seed transfers from certain areas on PEI did not perform well. This was the case for both native and off Island seed. Recently, NB seed transferred in 2001 did not survive its second summer in PEI. Interestingly, some NB seed did not survive in NB either, but did well in NS. The question arose as to why – was it related to genetics, fitness, disease/parasites and/or the environment?

MacCallum concluded with a take home message outlined as follows:

- Healthy quality mussel seed is the basis for our industry – we cannot take our on and off Island seed for granted
- There will always be a risk associated with moving seed from one area to the nest
- Issues that may come into play when transferring seed may include: genetics, fitness, disease/parasites, fouling organisms and the environment
- Mortalities are unfortunately going to happen and when losses are substantial, then it becomes a problem.
- Without high quality mussel seed – there is no crop for growout, no product to seed that may lead to eventual loss of jobs and the resultant loss of the entire industry itself.

SECTION THREE – MUSSEL SEED QUALITY – *Moderator Thomas Landry, DFO Gulf Region*

Disease issues in the blue mussel *Mytilus edulis, Anne Veniot, Shellfish Health Unit, Fisheries and Ocean Canada, Gulf-Region*

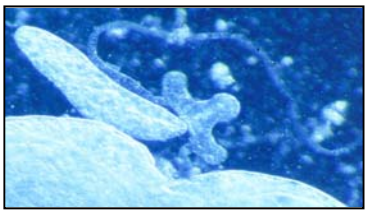
Anne Veniot, Shellfish Pathologist with the DFO Shellfish Health Unit in Moncton, gave an overview of the current activities with the Unit on Maritime mussels. Veniot and her colleagues are currently working on an ACRDP funded project survey of a digenean worm, *Prosorhyncus squamatus*, which potentially castrates mussels, implications of MSX on Maritime mussels and summer seed mortality investigations. She gave an overview of the life cycle of *P. squamatus* explaining that it lives in three hosts during its lifetime. The mussel is the first intermediate host for the worm with fish being the second and final host in the life cycle.

Historically, in Atlantic Canada, *P. squamatus* was first recorded in mussels from Caraquet Bay, NB and the Magdalene Islands, Quebec in 1990. In 1997 it was discovered in mussels from Eastern shore, NS for the first time in North America. There have been no associated mussel mortalities to date in Atlantic Canada, however, European sites have experienced heavy mussel infections with significant reported mortalities. Since then, extensive Atlantic Canada surveys have found the parasite on the southern shore of

NS. Veniot stated there has been no human health implications associated with the presence of this parasite in Atlantic Canadian mussels.

Veniot also mentioned that the benefits of the *P. squamatus* survey and ACRDP project has been:

- Full health screening now available for industry
- Regular sampling leading to decreased reaction time when unexplored events occur
- Addressing implications of MSX for mussel transfers, and
- Proactively addressing emerging mussel health issues



Prosorhyncus squamatus
Courtesy of Ann Veniot

Veniot has also been addressing the 2003 summer mortalities in NB mussels, which occurred in NB and PEI. Samples collected during the 2003 incident and examined histopathologiacally revealed no disease agent. Veniot and her colleagues feel that an alternative cause of mortality might be a linked environmental parameter, husbandry or possibly genetics. Veniot mentioned that the Shellfish Health Unit would be involved with a possible ACRDP funded project examining NB mussel seed quality and the unexplained summer seed mortalities. The Units role will be to:

- Assess/monitor mussel diseases/parasites
- Examine mussel condition index/productivity
- Determine the mussel biochemical and genetic profiles
- Conduct genomic sequencing and,
- Develop practical methods to assess mussel fitness

Veniot mentioned that in addition to participating in mussel mortality issues, the Shellfish Health Unit will be finishing the *P. squamatus* project in the spring of 2005 and a final report will be provided to interested industry growers.

Summer mortality of blue mussels in the Magdalen Islands*, Dr. Bruno Myrand, Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ), Iles-de-la-Madeleine, Québec*

Dr. Bruno Myrand, a researcher with MAPAQ, Magdalen Islands, Québec, gave an overview of past research conducted on summer mortalities in blue mussel on the Magdalen Islands. Myrand stated in his introduction that mussel summer mortalities first occurred in 1975 and were considered an irregular event. The reported losses were up to 80% in mainly 2-year-old mussels (> 50 mm shell length). The mortalities occurred in early August when water temperature is at its highest. Myrand also mentioned that their were no specific cues or indications of weakness in the mussels and that the mortalities occurred over a two week period. Interestingly the mussels that survived were in good condition.

Between 1989 and 1990 Myrand and his colleagues conducted an intra-Island transfer study. Four different local mussel stocks were transferred to different sites to assess possible mortality. There were no physical/environmental differences (e.g. water temperature, salinity, etc.) between the four sites, however, after two years, significant differences were noted in the transferred mussels. Myrand concluded that the unexplained mortality was related to mussel genetics rather than to environmental factors. Myrand then studied the genetic characteristics of the mussels from theses sites. He found that there was a low abundance of Mytilus trossulus (< 4% of the populations). He did find that there were significant differences in **heterozygosity** between three of the mussel populations/sites.

***Heterozygosity** is the measurement of genetic variability in an animal. It is determined by examining the animals' allelic enzymes. Allelic enzymes are analysed biochemically using a process called electrophoresis. Electrophoresis is a laboratory procedure that allows various macromolecules, including*

DNA and proteins, to separate out based on size. If electrophoresis analysis shows two bands for a certain enzyme, then the animal is ***heterozygous*** *at that genetic site or locus. One band means that the animal is* ***homozygous****. In theory, animals with higher heterozygosity will survive extreme conditions (e.g. temperature stress, starvation, etc.) more easily than homozygous animals. In other words a heterozygous animal is considered "more fit." An animals' survival is directly related to its fitness. The higher an animal's heterozygosity, the more physiologically fit it is. Physiological fitness may result in a higher survival rate.*

Myrand found that mussels from Amherst Basin (southern tip of Magdalen Islands) had a higher heterozygosity than mussels from three other sites. In addition, he noted that at the individual population levels, higher heterozygosity meant the mussels had lower maintenance metabolism (vital functions) and thus had an energetic advantage over the homozygous mussels. In laboratory and field tests, Myrand found that Amherst Basin mussels showed better performances (e.g. lower stress, better survival under stressful conditions and no summer mortalities). Myrand observed that Amherst Basin mussels' maintenance metabolism was low enough to allow the mussels to survive stressful conditions and thus avoid summer mortalities.

PEI Mussel Sock – Courtesy of PEIDAFAF

He and his colleagues also related reproduction costs to summer mortality. They noted that summer mortalities occurred only after a complete spawning in late July (when mussels' reserves were depleted). This mortality was concurrent with stressful high water temperatures (> 20^{o}C) and decreases in food quality. They observed no summer mortalities after partial spawning in mussels. They theorized that even though temperature was high (stressful) the partial reabsorption of gametes by the mussels provide enough energy help them survive. Summer mortality, therefore, is probably a reproductive cost paid only under stressful conditions after the mussels' energy reserves had been depleted by a complete spawning event.

Myrand's take home message was that:

- Resistant mussel stocks have higher heterozygosity and thus lower vital needs (e.g. enough energy to survive stressful conditions such as high water temperature, low food, etc.)
- Susceptible stocks have lower heterozygosity and thus higher vital needs
- As vital needs increase in stressful conditions so does the mortality rate
- Summer mortality will occur under stressful conditions when maintenance needs are at there highest but spawning depletes energy reserves

As a result of the research and studies, Myrand and his colleagues have developed a strategy to help avoid summer mussel mortalities on Magdalen Islands:

- Spat is collected only from Amherst Basin
- No mussel culture occurs in Amherst Basin
- Spat is transferred to growout sites in other lagoons, and
- As a result – no summer mortalities have been reported to date.

Reproductive variation between wild and cultured stocks of mussels, Mytilus edulis, *Thomas Landry, Head, Molluscan Productivity & Health Section, DFO Gulf-Region, Moncton, NB*

Thomas Landry followed Dr. Myrand giving a presentation on the variation between wild and cultured mussel seed on PEI. Landry and his colleagues have conducted research and surveys in Tracadie Bay, PEI since 1996. The Bay is divided into two populations of mussels. A small arm of Tracadie Bay, Winter Bay,

on the western side is primarily made up of wild mussels while the bulk of Tracadie bay is composed of cultured mussel stocks. The objectives of their research was to:

- Identify the onset of spawning of wild and cultured mussels
- Determine their respective contribution for seed production.

Landry and his colleagues recorded water temperature, conducted benthic biomass surveys and calculated spawning effort of these populations between 1996 and 2002. They found that wild mussels only constituted only 3% of the total estimated biomass of mussel in Tracadie Bay. In addition, they examined dried meat yields and histology sections of gonads and concluded that cultured mussels had significantly higher densities of gametes versus wild stocks.

They summarized their findings by concluded the following:

- Timing of reproduction was consistently earlier (by about one week) in cultured stock versus wild stock mussels.
- There was no indication that temperature was the triggering factor
- Cultured stock seemed to be self-sufficient in spat production
- Wild stock may not play an important role in the quantitative contribution of spat production in Tracadie Bay.

Research Divers with mussel sock
Courtesy Thomas Landry

Landry mentioned that he and his colleagues would be evaluating genetic characteristics of wild and cultured stock to help determine the qualitative contribution of wild stock in spat production on PEI.

Mussel Seed Quality & Genetics, *Dr. Réjean Tremblay, Canadian Research Chair in Aquaculture, Insitut des Sciences de la Mer, Université du Québec à Rimouski, Québec.*

Dr. Réjean Tremblay, Canadian Research Chair in Aquaculture, Université du Québec à Rimouski, followed Thomas Landry's talk with his presentation relating mussel seed quality to genetics. Tremblay mentioned in his introduction that many mussel stock/sites in the Gulf of St. Lawrence have shown differences in mussel fitness within stocks. This fitness was indicated through mortality (Magdalen Islands – see Bruno Myrand above) and in growth rate.

Tremblay hypothesized that mussels are genetically different on a small geographic scale (between bays) in spite of mussels having a large dispersal potential as larvae. He feels that these genetic differences have a significant impact on mussel farm production. One of the questions he is trying to answer in his research is – can you easily identify a genetic component of fitness survival to stress events and best growth?

Tremblay and his colleagues surveyed mussel populations throughout Atlantic Canada and Québec and found that PEI and Magdalen Island (MI) mussel are relatively "pure" *Mytilus edulis* with very little *Mytilus trossulus*. They also found that any differences in fitness between PEI and MI mussels were not related to the presence of *M. trossulus* or *M. edulis.* Tremblay further examined the genetic variability of PEI and MI mussel stocks and found a large difference in the heterozygosity between mussel stocks (see Myrand presentation for definition of heterozygosity). He noted that wild *M. edulis* populations had more heterozygosity (and thus were more fit) than culture *M. edulis* populations on PEI and MI. Wild mussels therefore were more capable of handling stress than their cultured counterparts.

Tremblay major hypothesis in his research is determine if you can use genetic characteristics as fitness tools in commercial seed on a large

Québec Mussels
Courtesy Réjean Tremblay

geographic scale. In 2000, Tremblay and his colleagues sampled mussels from Atlantic Canada and Québec. They measured metabolic rate, species identification (DNA), characterized the mussels' genetic variability and ran laboratory growth and survival experiments on the mussels. They found:

- Large differences in mortality levels (10-50%) and growth rates (0.5-1.7 cm in 10 months) between mussel populations/stocks.
- The mussel stocks with the higher mortality had lower growth rates
- No differences between physiological parameters, survival and growth in M. edulis versus M. trossulus
- Mussel stocks with low-level heterozygosity had 26% less energy available to resist stress than mussel stocks with higher levels of heterozygosity
- These same differences twice as obvious when scope for growth, growth rates and survival levels were examined

Tremblay concluded by stating that the different mussel stocks in Atlantic Canada showed variable levels of fitness (expressed by growth and survival) in laboratory conditions which could be explained by their metabolic rates and genetic characteristics. He further mentioned that until now, the only genetic characteristic related to fitness has been the level of heterozygosity in mussels.

Growth, survival and heterozygosity in the blue mussel Mytilus edulis, *Neil LeBlanc, PhD Candidate, Atlantic Veterinary College, Charlottetown, PEI.*

Neil LeBlanc, a PHD student working at the Atlantic Veterinary College, gave a presentation on his work on PEI mussel growth, survival and heterozygosity. The main objectives of his study are to:

- Examine growth, survival and genetic factors through the lifecycle of mussel seed
- Determine the genetic factors required to predict good seed stock
- Determine if selection techniques such as culling can improve the fitness of mussel seed

LeBlanc collected mussel seed from St. Peter's Bay. Three Bays were used in the study (St. Peter's, New London, and Tracadie). He treated mussel seed either by exposing them to extreme high water temperature (33^{o}C for 6 hours) or air exposure (for 11 hours). He found mortality rates as high as 75% in mussels exposed to high water temperature and 50% in those exposed to air. Of the mussels tested, over 4000 seed were deployed in cages attached to mussel longlines in three PEI bays (New London, St. Peter's and Tracadie Bay). He followed the progress of the mussel over 10 months and determined the heterozygosity of the seed. Survival of the mussel seed after the 10 months ranged from 28% in the controls to 43% in seed initially exposed to air. There did appear to be a difference in survival between the three bays but variation in the cages prevented statistically significant results (New London – 45% survival; St. Peter's – 40%; Tracadie Bay – 31%).

Cage containing mussels attached to longline –Courtesy Neil LeBlanc

Leblanc was able to conclude the following from his study:

- Growth - air exposed mussels grew longer than any other mussel seed (treated or controls)
- Survival – treated mussels had better survival versus controls
- Heterozygosity – initially, treatments did affect heterozygosity, but it still not clear whether there is a genetic advantage in the field trials
- Difference among Bays tested – New London Bay appeared to be more productive, followed by St. Peter's and Tracadie Bay.

A project on *Crassostrea gigas* summer mortalities in France, *Dr. Jean-Francois Samain, French Institute for the Exploration of the Sea (IFREMER), Issy-les-Moulineaux Cedex, France. Proxy presenter, Thomas Landry (DFO-Gulf Region)*

Originally, Dr. Jean-Francois Samain, IFREMER, France was to present on a project dealing with summer oyster mortalities in France. He was unable to attend at last minute but sent a copy of his presentation to us. Thomas Landry, DFO Gulf-Region, who is familiar with the French program, gave his presentation on his behalf. The French project funded by IFREMER is called MOREST, which stands for MORtalités ESTivales (bivalve mortalities in English).

Thomas Landry began by giving a small background on the project. Although the MOREST project deals with oysters he felt that it would be appropriate to present the French project to possibly see how some of their work might be applicable to the Maritime mussel seed mortalities. In his introduction, Landry mentioned that massive seasonal oyster mortalities were first reported in Japan in 1940's. This was followed by mortalities in North America in 1950's and then by France in the 1990's. In France the mortalities ranged from 30-60% and were reported in a variety of different sites in patchy areas throughout the country. The mortalities have been associated with high summer water temperatures and the oysters' reproductive period. Affected oysters have been juveniles and 1-2 year olds. In addition, the mortalities have not been associated completely with a single pathogen (e.g. virus or bacteria).

The MOREST researchers' standpoint is to realize that summer mortalities may be a result of a complex interaction between the oyster (or bivalve), a pathogen and the surrounding environment. In other words there is a distinct interaction occurring between the bivalve (its genetics, age, physiology, defence mechanisms, nutrition, etc.), the environment (temperature, salinity, oxygen content, food conditions, stress, pollution, etc.) and a pathogen (its virulence, genetics, nutrition, etc.). This interaction is the main focus of the work conducted by the MOREST researchers.

The MOREST researchers have examined the associations between oyster mortality dynamics and:

- temperature extremes in different ecosystems,
- long term climatic changes over 30 years,
- oyster reproduction
- juvenile mortality
- triploids and survival (genetic effects),

and have come to the following baseline conclusions:

- Temperatures over 19^{o}C can initiates oyster mortality
- Reproduction period seems associated with mortality, even for juveniles
- Disease/pathogen sensitive and resistant oysters can be observed in bi-parental crosses and have a different reproductive strategy and
- Trophic conditions (food) could control reproductive effort

Through their research, MOREST biologists have noticed that as food levels (phytoplankton) increases, so does the reproductive effort. This in turn leads to a decrease in the bivalves' immune system and thus increases the risk of infection from a pathogen. Further research into scope for growth (net growth after metabolic waste is accounted for) and the association with mortality has lead to the following observations in French oysters:

- Primary production (phytoplankton) influences reproductive effort
- Reproductive effort and temperature can affect energy balance, therefore weakening the oyster and making it more susceptible to disease/infections
- A low trophic condition in spring can lower the reproductive effort and thus the mortality rate.

- However, this is not always sufficient for mortality induction

The final point from the MOREST presentation was that the strong interaction between the environment-oyster-pathogen cannot be overlooked or underestimated. In laboratory studies conducted by MOREST biologists, oysters were stressed with temperature and bacteria (vibrio). They noticed a strong increase in bacteria in the blood (hemolymph) of the oysters just before death.

Landry concluded the presentation emphasizing the environment-oyster-pathogen interaction. MOREST researchers theorize that if there is a change in the environment (slight temperature increase), leading to an increase in nutrients in the water. This increase in nutrients leads to an increase in phytoplankton and bacteria abundance which may be interrelated or interdependent. This is followed by an increase in feeding and reproduction in the oysters. As long as the temperature remains below 19^{o}C the oysters seem physiologically capable of overcoming these changes in phytoplankton and bacteria loading. However, when the temperature exceeds 19^{o}C and the aforementioned environmental conditions occur, the oyster becomes too stressed, weakens and then dies. Landry concluded by mentioning that the MOREST model should be considered when examining mussel seed mortalities in our region, rather than developing specific investigations into each of these potential causes.

MUSSEL SEED QUALITY INDUSTRY PANEL - ***Industry perspective on cost & benefits of improving mussel seed quality, Florence Albert, Executive Director, Professional Shellfish Growers Association of New Brunswick; Crystal McDonald, Executive Director, PEI Aquaculture Alliance, Brian Muise, Executive Director, Nova Scotia Aquaculture Association***

What are the costs and benefits of improving mussel seed quality from an industry perspective?

The following are the key points raised in the Panel Discussion at the end of the Mussel Seed Quality section:

- Seed certification should be investigated, but need some science behind it
- Growers want a guaranteed supply of certified disease free-healthy seed
- The seed exporter should be the person who is certified not the importer
- Seed certification should be conducted by all provinces
- Seed certification should have the appropriate tracking methods attached to allow any undesirable characteristics of the seed to be identified
- Seed certification program should be industry lead
- Seed certification will require commitment and support of regulators, the science community and DFO to provide the sampling and monitoring in a cost effective way.
- There is a potential for mussel seed culling, but it must be cost effective on a commercial scale
- The benefits of culling weaker seed prior to socking include:
    - Lower input costs
    - Higher returns per sock if more of the sock remains through to harvest
- Hatchery production of mussel seed might be a future option – British Columbia is currently using hatchery reared mussel seed in some areas.

SECTION FOUR – OPTIMIZING MUSSEL COLLECTION – ***Moderator Neil MacNair (PEIDAFAF)***

Treatment of Fouling Pests in Mussel Seed, ***Neil MacNair, PEI Department of Agriculture, Fisheries, Aquaculture and Forestry (PEIDAFA), Charlottetown, PEI***

Neil MacNair, Shellfish Biologist with the PEIDAFAF, moderated the afternoon session on Optimizing Mussel Collection and also started the session by giving a presentation on results of treatment trials conducted on pests that foul PEI mussel seed. MacNair mentioned in his introduction that there are three major fouling organisms of mussel collectors on PEI, hydroids, the clubbed tunicate (*Styela clava*) and green algae species.

Hydroids (polyp-like organisms in the same family as sea anemones and jellyfish) often foul mussel seed collectors resulting in the loss of mussel seed. Hydroid fouling occurs frequently in several PEI estuaries. The degree of fouling varies greatly from year to year, and from location to location. MacNair and his colleagues conducted treatment mitigation trials in1996 on seed collectors located at the mouth of Montague River that were heavily fouled with hydroids. They experimented with lime and saturated brine as treatment agents and had moderate success with 4 % lime. To date, lime appears to the most effective treatment against hydroid fouling on mussel collectors.

Hydroids on mussel sock
Courtesy PEIDAFAF

Styela clava, the clubbed tunicate, has been a significant fouling organism to the PEI mussel industry since it was first reported in 1997. It was first found in Brudenell River in 1997 and by 2003 is now found in Montague River, Murray River, Orwell Bay, St. Mary's Bay, Cardigan River and as far west as the Marchwater area in Malpeque Bay. As a result of the infestation, restrictions on mussel seed movement are in place in PEI infested areas. Some areas such as Murray River experienced mussel seed shortages in 2002 as a direct result of *Styela* infestations.

MacNair and his colleagues have been conducting mitigation treatment trials on *Styela* since 2001. The objective of their work on treatment of infested mussel seed has been twofold; 1) to kill 100% of the *Styela* without harming the mussel seed for purposes of transferring the seed and, 2) to reduce the numbers of tunicates transferred with the seed to newly socked mussels.

Styela covering mussel sock
Courtesy PEIDAFAF

In 2001, they batch treated seed prior to socking with separate treatments of brine, lime, freshwater and vinegar. MacNair noticed that immersion in 5% vinegar solution resulted in close to 100% kill of *Styela*. Lime treatments also caused large numbers of tunicate mortalities, while brine and freshwater were not effective. There did not appear do be large numbers of mortalities in the mussel seed with vinegar or lime, however longer term studies are required. In 2003 they treated whole mussel lines with lime, vinegar and sodium hydroxide. The sodium hydroxide had the greatest effect on the tunicates, while in comparison vinegar and lime were slightly less effective. Sodium hydroxide is a very caustic chemical and careful investigation into the health and safety of mussel growers handling the product would be required prior to it's use in a commercial scale. As well sodium, hydroxide will degrade aluminium and may not be practical to use it around aluminium equipment and boats. MacNair mentioned that treatment trials utilizing several different agents are ongoing and that treatment trials with lime and vinegar will need to be repeated under a variety of environmental conditions to determine which chemical may be the most effective.

The rest of MacNairs' presentation was dedicated to green algae species that foul mussel seed collectors. This algae forms a dense heavy matt on the collector and when lifted or shaken in a wind the algae will

slide off the collector stripping the mussel seed off with it. In 1998, *Enteromorpha* sp. and *Cladophora* sp., single-celled green filamentous algae species, caused significant fouling on mussel collectors and lines in Rustico Bay, and have since caused problems there on a yearly basis. By 2003, a number of PEI growers reported finding massive amounts of the green, filamentous algae species (*Cladophora* sp. and *Enteromorpha* sp.) on mussel seed collectors in many seed collection areas on PEI. Green algae fouling has lead to serious mussel seed losses in certain areas of PEI. MacNair mentioned that some growers have lost their entire years' production of mussel seed.

In 2003, MacNair and his colleagues conducted treatment trials on the fouling green algae species on mussel collector lines in Rustico Bay with vinegar and found that the vinegar application resulted in large amounts of algae mortality. They also treated algae fouled collectors in Covehead Bay with solutions of brine, lime and vinegar utilizing various exposure times. Unfortunately, all the algae and mussel seed was shaken off collectors as a result of the high winds from Hurricane Juan in late September 2003, so final conclusions of the treatment trials could not be determined. MacNair mentioned that there is a collaborative project proposal being submitted to AFRI from the Aquaculture Alliance, the Dept. of Fisheries and Oceans and the DAFAF to conduct a study of the fouling green algae in 2004. The study will include further treatment trials.


Green algae on mussel line
Courtesy PEIDAFAF

Styela clava*: Potential impact on mussel larvae, *Daniel Bourque, Shellfish Biologist, DFO- Gulf-Region, Moncton, NB

Daniel Bourque, Shellfish Biologist with DFO Gulf-Region Moncton, followed MacNairs' introductory presentation with a talk on the potential impact *Styela clava* is having on mussel seed recruitment on PEI. Bourque explained invertebrate larvae, such as tunicates and bivalves have similar life cycles in which separate sex adults release egg and sperm into the water column. Fertilization and metamorphosis occurs and larvae disperse based on water currents. Once mature the larvae settle on virtually any substrate and remain there in a sessile form until death. Bourque explained that invertebrate larvae have a number of mortality sources such as:

- Transportation into unsuitable habitats
- Physiological stress associated with metamorphosis
- Extreme temperature limits
- Starvation during plankton phases
- Predation


Styela clava

He mentioned that invertebrate larvae, as a result of these aforementioned stresses have adopted defence mechanisms against predation such as:

- Physiological structures (e.g. spines, setae, shells) to dissuade predators
- Chemical substances
- Behavioural patterns (e.g. larval migration, varying reproductive timing, and increasing their abundance)

One of the more successful reproductive strategies of invertebrates, including mussels and *Styela*, is to release millions of larvae into the water with the hope that some will survive.

In terms of predation, he stated that filter feeders such as mussels and tunicates could in fact remove larvae from the water by actively feeding (filtration). The


Mussel seed
Courtesy DFO

question arises then are tunicates (Styela) ingesting mussel larvae from the water and thus negatively impacting the mussel stocks?
Bourque stated that based on the basis biology/structure of *Styela* and they research that he and his colleagues have conducted Styela mostly likely could not ingest a significant portion of mussel larvae or kill larvae via their filtering mechanisms. However this needs to be investigated scientifically.

Bourque and his colleagues have conducted field observations in Murray River since 2002 and have noticed the following:

- There was a mussel seed shortage and failure in 2002
- However in there was an overall good set in 2003
- If the mussel seed sets first few tunicates will settle on the mussel seed
- However, if there space on the collector with no mussels, tunicates will fill it in.
- There is an interaction occurring between mussels and tunicates

Bourque concluded by stating that on an individual basis, adult mussels will most likely ingest new mussel larvae, not the tunicates. However, it is important to keep in mind that there are 4X more tunicates in Murray River than mussels. Further study on the interaction is required

Impact of competitors on mussel productivity, *Angeline LeBlanc, Shellfish Biologist, DFO- Gulf-Region, Moncton, NB*

Angeline LeBlanc, Shellfish Biologists with DFO Gulf-Region, followed up on Bourques' presentation and spoke on the effects that competition can have on mussel productivity in terms of fitness and reproduction. She started by explaining that in recent years, collection of mussel larvae has diminished in certain areas and to date we do not understand why. Many factors influence mussel fecundity and larvae abundance including water temperature and food availabilty. She stated that these factors have not changed much in recent years. What has, in some areas, is the species composition and abundance of competitors. The question arises therefore as to what impact these competitors can have on mussel productivity?

LeBlanc mentioned that she would be talking about experiments that the aquaculture division at DFO have done and from the literature, what they understand mussel reproduction and feeding.LeBlanc described the reproductive cycle of mussels stating that adult mussels release egg and sperm in the water column. Fertilization occurs and an embryo develops. Within 6-12 hours, this embryo develops into what is called a trochophore larvae. At this stage, the larvae have no feeding structures and therefore are not capable of feeding itself. The trocophore develops into a veliger larvae in about 24-26 hours. The veliger larvae has feeding structures. Thus, for the first 30-38 hours of its life, bivalve larvae depend on energy reserves from the egg for nutrients.


Mussel on the half-shell
Courtesy Angeline LeBlanc

She explained that the production of eggs and sperm, or gametogenesis, from adults follows an annual cycle. Growth and ripening of eggs and sperm happens usually in the fall & winter months. The growth rate of gametes increases with the spring phytoplankton bloom. Spawning usually starts in May and lasts until June. In some areas, there is a second spawning in August-September. As a result, winter is a very important time for the storage of nutrients by mussels.LeBlanc mentioned that numerous factors affect the production of gametes. There are outside factors such as temperature, food and salinity. Optimum temperature for gametogenesis is between 2-15^{o} C. Food concentration is probably the most important factor for the production of eggs & sperm. Some researchers have found that mussels with low food ration delay gametogenesis. Therefore they produce less gametes or spawning will happen later

in the season and survival rate of larvae may be reduced. There are also endogenous factors that control gametogenesis, hormones and genotype.

She stated that the condition of adult bivalves is very important in the survival of larvae. Larvae depend on egg reserves for the first 30 hours of its life, before developing feeding structures. Studies show that the survival from egg to feeding larvae is highly correlated to the initial egg lipid content. The lipid content of eggs depends on the food ration to female mussels during the development of eggs, during winter. The more food the mussel ingests, the more lipids the eggs will contain and the chances of survival of larvae are higher.

According to LeBlanc, stressed mussels will put most of their energy into reproduction rather than maintenance. However, larvae produced by these mussels have lower growth rates. And even if they put a larger percentage of energy into the production of eggs and sperm, they might produce less of them. As a result, the biomass of gametes could still be lower than for well fed mussels. Reabsorption of gonads in starved bivalves is not uncommon. This means that when they are starved, they will use the energy invested in gametes for maintenance, to stay alive. Even though high survival of larvae is accompanied by high lipid content in eggs, this does not guarantee high survival of larvae once they start feeding. Larvae only depend on egg reserves until they start feeding. After that, they are on their own and survival becomes correlated to the ability to find food. However, Leblanc stated the more larvae that survive to the feeding stage, the more potential there is for a high survival of larvae overall.

The Role of Competitors - how can competitors affect mussel reproduction? According to LeBlanc, the critical period for storing nutrients and producing gametes is fall and winter. A previous study she conducted on foulers in Tracadie Bay, PEI showed that the biomass of foulers was reduced by October, and, thus stayed low during winter. Mussels could easily out compete the foulers left on the socks. However, this phenomenon has not been observed for tunicates. She stated tunicates seem to survive relatively well through the winter. As a result, LeBlanc mentioned they remain as potentially significant competitors throughout this critical period for mussel reproduction.

Mussel Condition Indices - In surveys she and her colleagues conducted in various bays on PEI they noticed the lowest condition indices of mussel were found in Murray River, which is heavily infested by tunicates and were poor collection of larvae has been reported. Other areas such as Brudenell River, St.. Mary's Bay and Cardigan River, where tunicates are present but in much lower biomass than Murray River, condition indices were average. Also in these areas, LeBlanc and her colleagues noticed that the collection of larvae did not seem affected.

Characteristics of feeding mussels – LeBlanc noted that mussels are selective feeders. They can select different size particles as well as different particles of similar size and prefer certain species of phytoplankton. This selectivity, however, is not as effective in highly turbid environments. Filtration rates typically increase with food concentration but reaches a certain level. At this point it remains relatively constant. Filtration rate seems to be adjusted so that ingestion rate remains constant. The difference between the two, is that filtration rate is the rate at which particles are cleared from the water while ingestion rate is the rate are actually ingested meaning that they go through the digestive system and not into pseudofaeces (food cleared from suspension but not ingested). Ingestion rate is therefore determined by the size of the digestive system. LeBlanc stated that mussels could only eat so much no matter how much food is available. Because of their selectivity mussels are well adapted to low food concentrations.As for the effect of temperature on feeding, LeBlanc stated that this is still debated. Some studies have shown that filtration rates are independent of temperature. Some have shown that filtration is relatively constant throughout the year due to long-term adaptation of mussels to temperature. In nature, temperature changes are gradual so mussels have time to adapt so filtration varies a little but overall is pretty constant. One

study in particular showed that at similar temperatures, filtration was higher in September-October than in February-March. The authors correlated this to food levels. Studies showing that filtration depends on temperature are usually short term and look at how mussels react sudden changes. These studies do not really reflect reality. However, LeBlanc mentioned that high water temperatures are not good for mussels and that at temperatures over 20^{o}C, growth decreases. Further more at 25^{o} C there is no filtration at all.*Characteristics of feeding tunicates* – LeBlanc touched on tunicate feeding stating that tunicates are non-selective. However, she mentioned that they retain certain sized particles better than others probably due to their anatomy. Filtration rates of tunicates decrease with increasing food concentration while squirting increases. High food concentration probably clogs their feeding structures. This indicates that tunicates may not be well adapted to turbidity. Also, their filtration rates are not constant and are temperature dependant. Filtration rates increase as temperature increases, but at high food concentrations, filtration becomes independent of temperature. LeBlanc stated that she does not know how tunicates react to low temperatures.

Styela on mussel sock, buoy and line - Courtesy PEIDAFAF

LeBlanc and her colleagues conducted studies on competition between mussel and tunicates in July 2002. She found that mussels have a higher filtration rate per unit of weight than tunicates. In another study they looked at different densities of mussels and tunicates in September 2003. They did not find any significant differences among densities. She mentioned that the different result might be related to food levels and level of gonad development.

LeBlanc summarized her presentation by stating the following:

- At low food concentrations, mussels may have higher filtration rates than tunicates
- Filtration rates of mussels may be higher than that of tunicates in winter
- However, in Murray River, PEI where tunicates are abundant, tunicate filtration exceeds mussel filtration by 2-5 times
- Tunicates have the potential to reduce food available to mussels
- Reduction in food negatively impacts gametogenesis
- Lipid content in eggs is lower and as a result, there is a lower survival rate of eggs to feeding larvae
- Once larvae start feeding, tunicates may be a significant competitor

LeBlanc concluded by mentioning what she does not know about competition between mussel and tunicates:

- How tunicates react to low temperatures and low food concentrations
- Fall and winter is when energy storage is important for mussels
- How will decaying tunicates change water quality (chemically) and consequently, mussel productivity

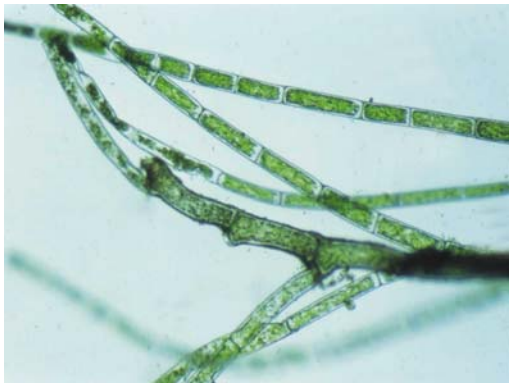
The Green Curse: Biology, ecology and impact of green algae in estuaries, *Bob Semple, Bedford Institute of Oceanography, DFO, Dartmouth, NS.*

Bob Semple, a Phycologist from the Bedford Institute of Oceanography, gave presentation of the impact the green algae can have on the aquaculture industry especially mussel seed collection in the Maritimes. He stated in his introduction that there are hundreds of species green seaweeds but there are three groups of greens that cause problems in coastal areas around the world. They are quite different in appearance:

- *Ulva* sp. – flat leaf-like blades
- *Enteromorpha* sp. – tube or hollow blades
- *Cladophora* sp. – branching single cell filaments

Semple mentioned that *Ulva* is perhaps the most common green seaweed around the coast of PEI. It is typically found on the outer coast but in the estuaries, bays and basins it is frequently dominant to all other vegetation. *Enteromorpha* is closely related to *Ulva* but is more likely to be attached than drifting free. However, it can tangle with other seaweeds and produce mats. Semple stated that if you wiggle it between you fingers you will be able to tell it has a tube structure. When attached to substrates *Enteromorpha* tend to be short and broad.

Green mats – are a mixture of green and blue green algae. They are unattached and float on surfaces, lying on bottom. They can restrict water movement and oxygenation and can entangle on any fixed gear. Mats can cause problems with any benthic animal or bottom shellfish culture. They change the circulation of water near the bottom and when they breakdown use up the oxygen. Mats can also float when gas builds up in them.



Cladophora – Courtesy Bob Semple

Cladophora - This is a very fine stranded seaweed but it can proliferate to form mats or fuzzy covering on any surface that develops into long interwoven strands. It is a filament of single cells but branched. *Cladophora* can form mats with no single attachment point. Semple stated that it grows 3 to 30 cm long. In terms of its life history, *Cladophora* is both sexual and asexual. It has a 2N sporophyte and 1N gametophyte stage with no difference in appearance. Any cell on the plant can become fertile. The two generations of adult plants are indistinguishable. The zoospores and gametes swim to a limited extent with whip like structures called flagella.
Enteromorpha and Ulva - Similar to *Cladophora* but the entire thallus can become reproductive. Both macroscopic phases are identical and the planktonic spores and gametes have a wide dispersal (> 35 km).

Enteromorpha
Courtesy Bob Semple

Semple stated that regardless of the species, All cells have the potential to become reproductive. This potential will at times create a green soup of spores or gametes. Spores of *Enteromorpha* and *Ulva* are found in the water column from March to October. Peak densities of over one million per square meter per hour have been observed. The spores can over winter at densities of 300 per square cm. These numbers of spores provide many opportunities for the plant to become established on any surface. The ability to over winter means that late reproduction in the fall will succeed in the spring.
Reproduction by fragmentation – Semple explained that if all else fails the small pieces breaking off the plant for any reason can survive and grow. They can drift for months still actively growing, but they cannot reattach but can become entangled and reproductive.
Green algae ecology – Green algae are widely distributed from the intertidal to shallow subtidal (<10m). They occur in a wide range of habitats from extremely wave sheltered basins and salt marshes to high current ocean channels. They are tolerant of a wide range of salinities, from fresh to very saline and tolerant of a wide range of temperatures, from –1 to +25^{o}C. In general, Semple stated, greens are not sensitive to many things and very tolerant to a wide range of environmental conditions.

Green shapshifters are morphologically adaptable – Semple mentioned that green seaweeds can adapt both their shape and means of attachment to assure success in a wide range of habitats. They can grow in size related to the hydrodynamics of an area. They are attached or unattached depending on substrate

available and water currents. They will also grow on any semi-stable bottom or substrate from rubber tires to pebbles.*What drives green seaweed growth* - It does not take much to drive the growth of green seaweed. They do not store nutrients so turn any nutrient increase into growth and tissue. As soon as these conditions change growth declines rapidly. Semple stated what drives green algae growth includes:

- High nutrients coming from land sources, agriculture, recreation and domestic sewage
- Rainfall bringing the above nutrients into the systemHigh temperatures within annual cycle
- High temperatures caused by poor water circulation
- Light both total hours of sunlight and amount of light reaching the plant and can be affected by turbidity and self shading

Enteromorpha on mussel line
Courtesy Bob Semple

Growth - The bladed green seaweeds can grow much faster than the filamentous types per unit of weight. However, the growth of filamentous types can be rapid as more and more growing tips are produced. He mentioned that:

- Whole plant grows, either at the edges or at the tips of branches
- The growth rate in optimal conditions of light, temperature and nutrients can result in a doubling of the biomass every 4 to 5 days *Ulva* and *Cladophora* about 5% per day
- In optimal conditions the only limit to growth can be self-shading or crowding.

Potential green algae impacts in estuaries – Eutrophication – Semple mentioned that this is a fancy word that describes the result of too many nutrients in the water from any source. It means you have reached a point which green seaweeds exponentially grow and reproduce with many negative consequences for other living things. Eutrophication is characterized by:

- Biomass accumulation
- Reduced water circulation
- Removal of oxygen due to tissue breakdown*Blooms* – Semple showed and example to an *Ulva* bloom in a tidal basin in the east end of the province. He mentioned that by July, this arm of the basin is totally dominated by green biomass that has accumulated at the rate of 10% to 40% per day until it floats on the surface, covers the bottom and drifts in the water column. By October, 95% of the biomass has been consumed, decayed, or drifted from the basin. However for a period of 3 -6 weeks parts of the basin have no oxygen due to decay of the seaweed.

Ulva bloom in PEI Estuary
Courtesy Bob Semple

Potential green algae impacts in estuaries: Fouling –Semple summarized the following indices of fouling by green algae:

- Attachment to floating structures and sessile invertebrates
- Additional weight and increased hydrodynamic pressure
- Coating of surfaces preventing further recruitment or settlementHe also mentioned that fouling was a big problem in the fall of 2003 in Cove Head PEI. Mussel spat either could not settle or settled spat were entangled in the filaments of *Cladophora* or *Enteromorpha*. *Enteromorpha*, however, appeared less of a problem and does not seem to reach the densities of *Cladophora.*

Green Algae control problems – Semple stated that we have an idea from the reproductive strategies and general ecology that green seaweeds are very difficult to either manage around or get rid of.
The problem in controlling with green algae is:

- They can reproduce using spores and gametes and the microscopic stages are carried in the water column great distances (> 30 km)
- They can reproduce by fragmentation of the thallus
- They can float as whole plants with water currents and establish new population
- They can over winter

What can we do? – Semple listed possible control/prevention methods as follows:

- Avoid over wintering of spores or filaments: keep gear out of the water during winter
- Place gear in the water as close to spat settling time as possibleAny chemical treatment or drying out must be done as soon as any filaments are noticed
- Change the environmental conditions of the collection area, less nutrients, less runoff, better water circulationHe mentioned that these alternatives might not be practical for the growout or spat collection strategy normally used. However, these are the least complicated. Semple stated that the last measure depends on a wide range of factors including politics, economics and environmental legislation.

Desperate measures I: Biological – Semple explained that controlling herbivore populations is not easy and ultimately green seaweeds can out grow the loss due to grazing and also create anoxic conditions killing grazers. He offered the following possible solutions:Enhance herbivore population, isopods, amphipods, snails

- Problem at the time that the grazing population is high the growth of green seaweeds is at a maximum and out grows the rate of their consumption
- High nitrogen levels correlated with low grazer density
- Introduced algal diseases: promotes other algal species*Desperate measures II: Chemicals* – Semple stated that the use of herbicides, or other chemicals to treat green seaweeds is fraught with problems from permitting to food quality. He listed the following as ideas for chemical treatment:

Enteromorpha and mussels
Courtesy Bob Semple

- Apply herbicides/ other chemical
- Problem obtaining permitting and incompatible with food production and marketing
- The outer layers of plant tissue absorb the chemical and the inner layers are protected

Desperate measures II: Mechanical – Semple mentioned that direct removal of green algae is “like bailing out the ocean” because a lot of water comes along with the seaweed and the seaweed is growing so fast. He mentioned that you may in fact enhance the growth of the remaining material by reducing shading and improving the nutrient supply.

Research needs – Semple explained that there are many sources of nutrients in the coastal zone. If we can identify the major source or sources, some measure could be made to reduce input. There is of course a need for nutrient for phytoplankton production. So the right balance is delicate. New techniques include Ultra sound. He also mentioned that we need to know when the green algae growth peaks to plan any management measures such timing for placement of collectors and control measures. Semple stated that the timing of spore and gamete production is critical to optimal spat collection techniques to avoid over whelming green fouling. There a wide range of potential control measures with many questions associated with the timing, intensity and type of application.

He concluded by summarizing the research needs for green algae control as follows:

- Determine the main sources of nutrients in the areas of spat collection
- Determine the relationship between growth and fouling rates
- Determine the timing of spore/gamete production
- Test possible control measures

Treatment Trials on *Styela, Dr. Jeff Davidson, Atlantic Veterinary College, Charlottetown, PEI*

Dr. Jeff Davidson, Shellfish Pathologist and Veterinarian with the Atlantic Veterinary College, gave a brief summary of a project he and his colleagues are conducting on mitigation treatments on *Styela clava.* One of the main questions Davidson is attempting to answer is how to tell when *Styela* is actually dead. Davidson and his colleagues have conducted laboratory trials on *Styela* using 5% vinegar (acetic acid) and sodium hydroxide. They have found that a two-minute exposure time with vinegar will kill it. Trials are on going and results will available in the fall 2004. Other areas/research questions that Davidson and his colleagues are examining include:

- What are the affects of treatment on mussel health and fitness?
- What are the affects of treatment on the mussel sock itself?

Davidson has assessed the effects of treatments on one of the snails commonly found on mussel socks, Mytrella sp. and also on a commonly found skeleton shrimp. In field treatment trials to date Davidson noted that the snails were not negatively affected by vinegar but the skeleton shrimp were killed by the same treatment four days post treatment. However, they noticed that the skeleton shrimp population rebounded 5 weeks post treatment with vinegar. Further research is being conducted in this area.

Note – a Discussion Panel dealing with Optimizing Mussel Collection was originally planed in the agenda but, in the interest time, was incorporated into the discussion of issues and setting of R&D priorities at the end of the workshop.

SECTION FIVE – POLICY & MANAGEMENT OF MUSSEL SEED PRODUCTION – *Moderator Richard Gallant (PEIDAFAF)*DFO Spat Collection Policy: Access to wild resources as it applies to aquaculture*, Maurice Mallet, DFO Gulf-Region, Moncton, NB*

Maurice Mallet, Aquaculture Coordinator, DFO Gulf-Region, gave an overview on the newly developed Fisheries and Oceans Canada spat collection policy dealing with access to wild resources as it applies to aquaculture. He stated in his introduction that the main objective of the policy is to provide a framework and criteria in order to facilitate access by aquaculturalists to wild aquatic fish and plants. He outlined the scope of the policy as follows:

- Deals exclusively with *direct* access to wild fish and aquatic plant resources for aquaculture.
- *Does not apply* to fish legally harvested as part of wild fishery or to fish purchased from licensed fishers or other aquaculturists.*Does not apply to* mammalsMallet mentioned that there are three categories of management of access to wild resources. He described each in sequence.

Category 1: no authorization is generally required as these deal with activities on lease, for the species that are being cultured. Aquaculture activity is managed by the leasing authority through leases and licenses. This applies to spat collection of "lease species" on the lease and deals with growout species for sale. An exception to this general policy could related to leases that are specifically issued only for the purpose of a fishing activity – i.e. the situation in Quebec where aquaculturalists have a lease only for spat collection. Since the primary purpose of the lease is a wild fishing activity, these operations should also require a fishing authorization from DFO.

Category 2: ·Where harvest levels are particularly insignificant to the wild stocks, i.e., less than 1% of TAC or landed volume, fishing licenses or collection permits will be issued on a routine basis, with appropriate conditions. This category applies to:

- Spat off-lease
- Very low volumes (for example, when requested levels do not exceed .1% of TAC, or harvest volume where no TAC exists), either on individual request or collective basis:
    - for broodstock development
    - wild aquatic plants for feed

- Specified “nuisance species” on-lease with or without intent to sell
- Collection of shellfish for relaying
- Incidental collection of specific finfish resident in cages during harvest with or without intent to sell

Category 3**:** This category is where Mallet believes the most DFO effort should be expended. The cases are more complex requests that will require some review in region or where there may be issues that need to be referred to National Committee. This category is used for requests where access requested is higher than 1% of TAC, either on an individual request basis or cumulative if several similar applications made, or where fisheries are under moratorium or there are Species At Risk Act (SARA) implications. Mallet summarized this category as follows:


Mussel sock
Courtesy Garth Arsenault

- Low volumes but where access may be contentious or does not otherwise fall under Category 2:*
  - for broodstock development
  - wild aquatic plants for feed
- Collection of resources where the fishery is under moratorium, or where there are SARA implications
- Special collection of wild finfish for on-growing (not through normal fisher allocations)
- Collection of nuisance species and “by-catch” of finfish species not covered in categories 1 and 2

* *Note*: the level of access under this policy will always involve small numbers at a level that will not affect existing allocations; if requests exceed this threshold they would be managed through other fish management processes.

Mallet then touched on regional issues or perceptions dealing with this policy. He outlined some of these perceptions as follows:

- Authorization to collect seeds without a licence on leases could result in thousand of bottom leaseholders to begin collecting seeds in suspension.
- In the Gulf, "purging" of a site prior to the issuance of an aquaculture lease is not authorized.
- Licensing of spat collection in PEI is considered as an effective measure in trying to minimize the risk of transferring invasive species i.e. tunicates, from one estuary to another.
- Spat collection lines look much like mussel lines and it will be difficult to enforce the NWPA requirements.
- Collection of nuisance non-mammalian species on lease should not be "for sale" unless a commercial fishing license has been issued.
- Relaying of shellfish is generally considered a limited fishery in the Gulf Region.Mallet concluded by summarizing the next steps involved with the policy. He stated that industry and Provincial comments are sought by March 17, 2004, prior to finalizing the interim policy approval set for March 31, 2004. He mentioned that the National Policy will form the basis for the development of a Gulf Region more operational Spat Collection Policy. He stated that ideally, it would be good to get approval at this workshop and that some wording changes can be accommodated.

Introductions and transfers of mussel seed in the Maritimes, *Colin MacIsaac, DFO Charlottetown, PEI*

Colin MacIsaac, Chief Regional Manager, DFO, Charlottetown, gave the final presentation of the workshop on introductions and transfers of mussel seed on PEI. MacIsaac introduced the national Code on Introductions and Transfers stating that the codes main objectives is to establish a mechanism fro assessing proposals to intentionally introduce or transfer aquatic organisms, so that all jurisdictions have a consistent process to evaluate and minimize the potential for three types of risks.

These risks are:

- Risks of harmful alterations of natural aquatic ecosystems (e.g. tunicates).
- Risks of deleterious genetic changes in indigenous fish population.
- Risks to fish health from the potential introduction and spread of pathogens and parasites.MacIsaac then outlined the policy and guidelines dealing with the transfer or release of live fish into fish habitats and transfer of live fish to a fish rearing facility. He explained that a license is required to release and transfer live fish according to the following stipulations:
  - the release or transfer of the fish would be in keeping with the proper management and control of fisheries;
  - the fish do not have any disease or disease agent that may be harmful to the protection and conservation of fish; and
  - the release or transfer of the fish will not have an adverse effect on the stock size of fish or the genetic characteristics of fish or fish stocks.

MacIsaac then explained how PEI is zoned for introductions and transfers. He stated that while PEI may be considered to be a single zone for the purposes of transferring shellfish, it is recognized by Federal and Provincial agencies that zone may be required to be established within PEI for the purposes of controlling the transfer of shellfish (e.g. tunicates). Based on the current problem with the clubbed tunicate, *Styela clava*, the Regional Director General for Fisheries and Ocean Canada, Gulf-Region has given official notice that a license will be required to transfer bivalve shellfish out of, within and between the following PEI waters:

Mussel socks eastern PEI
Courtesy PEIDAFAF

- All the waters in King's County, Prince Edward Island, commencing at Burnt Point (near Georgetown) and following the various courses of the coastline in a southerly direction to Cape Bear. This includes all estuaries, tributaries, rivers and bays in this area.
- All the waters in Queen's County, Prince Edward Island, in the Orwell Bay and tributaries upstream from a straight line drawn from Penn Point to Birch Point.
- All the waters in Prince County, Prince Edward Island, inland of a point commencing at Royalty Point (near Cabot Park, Malpeque Bay) southwesterly to a point at or near the northwest corner of Big Curtain Island from there south-easterly to a point on the shore at the end of the Beach Point Road in the community of Hamilton.

MacIsaac then mentioned that any ppersons wishing to transfer molluscan bivalve shellfish out of these areas to other waters, processing or socking facilities in P.E.I. or between or within these same areas must apply to the Introduction and Transfers Committee for consideration of their request. The application form is available from DFOs' Licensing Centre in Charlottetown.

He stated that investigations are underway to ascertain if other areas are affected. If any person finds the clubbed tunicate in other waters or attached to the hulls of their vessels, they are asked to please notify either DFO, the Provincial Department of Fisheries, Aquaculture and Environment, or someone in the industry.

MacIsaac stated that there are three members, including himself who chair the Atlantic Introduction and Transfers Meetings held twice a year. The objective of this committee is to promote best industry practices and minimize risks associated with introductions and transfers.
He outlined the suggested licensing procedures as follows:

- Need approval in principle from Shellfish Health Unit (SHU report or recent correspondence)

- All shellfish be declumped, washed & cleaned of all mud, extraneous material and any other biofouling attached to the shell or stocking prior to leaving the harvest site.
- From PEI – That the shellfish are cleaned using fresh water at a maximum of 10^{o} C.
- That all shellfish are segregated for lot storage & processing.
- That the facility & equipment be cleaned of all debris before and after the processing of each lot.
- That access to the facility/research site for inspection purposes (site & records) be provided on an as required basis.
- That product loss above the normal industry mortality in NB, NS & PEI be reported to the SHU-Moncton, NB at 1-506-851-6983.
- That the DFO be notified 24 hrs in advance of any transfer. The contact and notification information will be contained as a condition of license when required.MacIsaac then outlined the proposed text for commercial mussel license conditions as follows:

- Must be valid for inland & tidal waters of PEI
- No recreational fishing of any kind is allowed
- Fishers NOT authorized to transfer mussels out of the restricted waters identified below to other waters, processing or socking facilities or between or within these restricted waters unless authorized to do so under the authority of an Introduction & Transfer License issued by DFO.

MacIsaac then discussed a flow chart (see appendices for slide) outlining the PEI introduction and transfers process. A grower interests in transferring fish/shellfish must first file an I&T application. The Regional Manager for DFO will then review it. If the applicant has a license to transfer the application is entered into the DFO Aquaculture database. If no license the applicant must apply for one. Once entered in the database a file number is assigned to the application. The PEI Introduction and Transfers Committee then reviews each application in file/application in the database. Three different results for the application may be possible:

1) Routine transfer – approved with condition
2) Non Routine – approved with condition or denied
3) Non Routine – deferred pending a formal regional application

SECTION SIX – DISCUSSION OF ISSUES, SETTING RESEARCH & DEVELOPEMNT PRIORITIES – ***Facilitator Crystal McDonald***

To facilitate maximum discussion in this section, the participants divided up into three groups, one from NB, NS and PEI. Federal Government representatives attempted spread themselves evenly among the three groups. A facilitator was assigned to each group to give a brief summary after the discussion period. Three questions were given to each group to discuss as follows:

1. What are the major concerns over seed supply in the Maritimes (quantity, quality, fellow travelers/fouling agents, others)?
2. What are the main mechanisms that can address these concerns (I&T, record keeping, others)?
3. What are the top five research and development priorities dealing with mussel seed quality?

New Brunswick

Question 1: Concerns

The New Brunswick group divided their concerns into Eastern NB and the Bay of Fundy:

Eastern NB:

- We produce seed
- No disease
- No/few fellow travellers
- Mortality issue

Bay of Fundy:

- Experimental mussel operation
- Could have a supply issue due to algae, *Mytilus trossulus*, *Styela clava*
- Issue with seed movement within bays in the Bay of Fundy
- Are mussels a vector for salmon disease?
- Polyculture concerns

Question 2: Mechanisms

1. Certification (Industry driven)
   - health/disease/fellow travellers – under I & T Committee
   - species – identify indicators
     - establish traceability (information reported to an independent body or research body
2. Research Projects
3. Introduction and Transfer Policy for handling requirements such as a Quality Management Program.
   - Standardized procedures across (i.e. France: all products go to depuration)

Question 3: R & D priorities

Not ranked:

- establish whether the mussel becomes a vector for fellow travellers (green crab, tunicate). Establish windows of opportunities for seed transfer. Could be addressed by Bay Management
- seed performance/fitness project (temperature, salinity, heterozygosity, current, circulation, *M. edulis*, *M. trossulus*) within specific geographical entities
- monitoring program: historic and on-going movement of seeds. Building traceability records and seed performance
- identify measurements/characteristics standards for quality standards. Basic monitoring at first and move up to more complex research when problems occur

Nova Scotia

The Nova Scotia group combined all three discussion questions and listed action items that needed addressing. They identified three main issues as priorities for Nova Scotia's Mussel Industry regarding Mussel seed quality, supply and transfer.

1) Need for local seed source in Nova Scotia.

   Nova Scotia has been dependant on seed supply from out of province sources for the last several years. While this seed source has been reliable, recent concerns over seed mortality and fouling organisms have led Nova Scotia mussel growers to develop viable seed sources closer to their operations.

   Action Items: This has been proposed to NSDAF to begin a survey of available leases in Nova Scotia that may exhibit the mussel seed qualities of high M. edulis content, free of fouling organisms and disease(tunicates, green algae, castrator parasite), and high fitness.

2) Need for research to ensure effective treatment of mussel seed for transfer inter and intra provincially**.**

The introduction of 'fellow travelers' with the transfer of mussel seed into Nova Scotia as well within the province has become a serious concern to Nova Scotia mussel growers. Of particular concern is the introduction of the tunicate *Styela clava* that has caused a serious impact to the PEI mussel industry. Currently, treatment of seed has included 24 hr fresh water immersion and declumping. These treatments must be tested to prove their effectiveness in killing fouling organisms as well as the effect of these treatments on the shelf life of the mussel seed.

Action Items: The current AquaNet project headed by Jeff Davidson and Thomas Landry looking at the physiological aspects of tunicate mortality will be expanded to address the efficacy of the current treatment protocols for mitigating tunicate transfer. This information will provide mussel growers with a scientific evaluation of current practices that will either show that these practices are sufficient or lacking.

The results of these experiments will be made available to seed growers to ensure the effective treatment of seed and to assure buyers of the viability and cleanliness of the product. It is intended that these measures would become part of the Industry Best Practices document.

3) Need for awareness of invasive species concerns with other coastal resources users to deter the spreading invasive species to seed producing bays.

In particular invasive species such as tunicates and green algae that have been know to impact the mussel industry need to be brought to the awareness of coastal resource user groups such as fishermen and recreational boaters associations. While the aquaculture industry has become heavily regulated through such programs as the DFO regional Introduction and Transfer committees, many other coastal resource user groups have no such regulation and may likely be involved in the transmission of these unwanted organisms within and between the Maritime Provinces.

Action Items: NSDAF along with industry to produce pictographic literature identifying current invasive species in Nova Scotia as well as potential invasive species threatening to invade Nova Scotia. This information will be delivered to fisheries and recreational groups as another step toward mitigating the spread of invasive species onto Nova Scotia mussel farms.

Prince Edward Island

The Prince Edward Island group kept a similar format to the New Brunswick group and reported the following:

Question 1: Concerns

The PEI group identified the following as current major concerns:

- Shortage and quality of Island and off Island seed
- There has been a borderline supply on PEI for the last 5 years
- Damage from Hurricane Juan compounded the problem
- Fouling organisms (tunicates, green algae) are having huge negative impact on seed collection and growout
- Winter agriculture soil erosion covering ice then smothering shellfish during spring ice out.

Question 2: Mechanisms

- Need to assess Island seed requirements
- More research projects to address fouling organisms (green algae, tunicates, hydoids, others)
- Seed Certification and traceability is required to ensure quality, disease and traveler free seed
- Seed certification could also be a marketing tool
- Seed certification on PEI is dependent on the area where seed originated.
- Need to address seed shortage and capacity because the perception of a seed shortage depends on whether you are a buyer or seller
- Need for regulations governing wild seed collections and to communicate the requirements to the industry

Question 3: R&D Priorities

Not Ranked:

- Fouling organisms (green algae especially)
  - Determine mechanisms to clean/remove algae from collectors
  - Determine why the algae does not appear to survive during the mussel growout phase
  - Examine the basic biology of green algae, life cycle and spore release to help predict outbreaks and determine mitigative treatments.
  - Support research initiative (ACRDP or AFRI) by DFO Halifax and PEIDAFAF to conduct green algae project
- Improve Island seed quality
  - Need to grade seed better to ensure high quality
  - Improve the declumping process to increase seed quality
- Seed Requirements & Husbandry Techniques
  - Survey to determine Island seed requirements
  - Husbandry and collection techniques need reviewing
  - Action Item – plan a visit to NB farms to see first hand their seed collection technology
- Continue to support the PEI Mussel Monitoring Program
- Review spat collection policy and the new I&T list
  - Fresh water rinsing does not make sense in terms of killing tunicate larvae

APPENDICES

Agenda

Mussel Seed Quality Workshop
March 10, 2004
8:30 am – 5:00 pm
Holiday Inn Express, Charlottetown, PEI
Avonlea Room

INTRODUCTION – Overview of Issues Facing Maritime Mussel Seed Industry: 8:30 am to 9:30 am

Moderator: Crystal McDonald (PEIAA)
Speakers: **Maritime Mussel Seed Panel:** Representatives from NB, NS & PEI
Florence Albert (PSGANB)
Peter Darnell (AANS)
Greg MacCallum (PEIAA)

MUSSEL SEED QUALITY: 9:30 am – 12:30 pm

Fitness and genetics of mussels in Atlantic Canada
Moderator: Thomas Landry (DFO, Gulf Region
Speakers:
Anne Veniot (DFO, Gulf Region) Disease issues in the blue mussel *Mytilis edulis*
Bruno Myrand (MAPAQ, Iles-de-la-Madeleine): Summer mortality of blue mussels in the Magdalen Islands

HEALTH BREAK: 10:00 am – 10:15 am

MUSSEL SEED QUALITY continued: 10:15 am – 12:00pm

Thomas Landry (DFO, Gulf Region): Reproductive variation between wild and cultured stocks of mussels
Rejean Tremblay (UQAR Rimouski, PQ): Mussel seed genetics and genetics
Neil Leblanc (AVC): Growth, survival and heterozygosity in blue mussels
Thomas Landry (DFO, Gulf Region): Development of a comprehensive program on bivalve mortality in France

Mussel Seed Quality Industry Panel: representatives from NB, NS & PEI – industry perspective on cost and benefit of improving mussel seed quality

LUNCH – Provided on site: 12: 00 – 1:00 pm

OPTIMIZING MUSSEL COLLECTION: 1:00 – 2:30 pm

Moderator: Neil MacNair (PEIDAFAF)
Speakers:
Neil MacNair (PEIDAFAF): Treatment of fouling pests in mussel seed
Daniel Bourque (DFO. Gulf Region): *Styela clava*: potential impact on mussel larvae
Angeline LeBlanc (DFO, Gulf Region): Impact of competitors on mussel productivity
Bob Semple (DFO, Halifax): The Green Curse: Biology, ecology and impact of green seaweeds in estuaries
Optimizing Mussel Collection Panel: Crystal McDonald (PEIAA); Jeff Davidson (AVC); Neil MacNair (PEIDAFAF): Cost and benefits of improving mussel seed production

POLICY and MANAGEMENT OF MUSSEL SEED PRODUCTION: 2:30 – 3:00 pm

Moderator: Richard Gallant (PEIDAFAF)

Spat Collection Policy
Speaker:
Maurice Mallet, Aquaculture Coordinator (DFO, Gulf Region)
Leasing Policy on seed collection

Introduction and Transfer of Mussel Seed in the Maritimes
Speaker:
Colin MacIsaac (DFO, PEI)

HEALTH BREAK: 3:00 – 3:15 pm

DISCUSSION OF ISSUES, SETTING R&D PRIORITIES: 3:30 – 5:00 pm

Discussion break out groups (same room)

Facilitator: Crystal McDonald (PEIAA)

Industry Perspective on the Current Mussel Seed Issues:

1. What are the major concerns over seed supply in the Maritimes (quantity, quality, fellow travelers/fouling agents, others)?
2. What are the main mechanisms that can address these concerns (I&T, record keeping, others)?
3. What are the top five research and development priorities dealing with mussel seed quality?

Closing Remarks & Plan of Action: 5:00 – 5:10 pm

Crystal McDonald (PEIAA)

Note: If time allows, one or two questions can be asked after each speaker. If not they can be held until the discussion session at 3:30pm

Mussel Seed Quality Workshop
March 10, 2004

List of Participants

PARTICIPANT	COMPANY
Albert, Florence	Professional Shellfish Growers Assoc. of NB
Bagnall, Andrew	NS Dept. Agriculture & Fisheries
Berry, Harold	Jomac Canada
Bidgood, Jerry	Prince Edward Aqua Farms Inc.
Bourque, Daniel	Fisheries & Oceans Canada
Campbell, Mac	Fish Farming
Chiasson, Adam	Chiasson's Aquaculture
Clancey, Lewis	NS Dept. Agriculture & Fisheries
Cusack, Bill	True North Salmon Ltd.
Darnell, Peter	Indian Point Marine Farms Ltd.
Davidson, Jeff	Atlantic Veterinary College
Dennis, Scott	n/a
Drake, Nathan	n/a
Drake, Peter	n/a
Drake, Roy	n/a
Drake, Vaughn	n/a
Fortune, Stephen	Blue Bucks Inc.
Gallant, Richard	PEI Agriculture, Fisheries, Aquaculture & Forestry
Gidney, Randy	n/a
Gillis, Brian	PEI Agriculture, Fisheries, Aquaculture & Forestry
Gionet, Chantal	Coastal Zones Research Institute
Hancock, Bruce	Aquaculture Assoc. of N.S.
Hardy, Matthew	Fisheries & Oceans Canada
Hillier, Fred	Hillier Mussel Farms
Jenkins, Jim	Fisheries & Oceans Canada
Johnston, Bob	Northern Aquaculture
Kenny, Thomas	n/a
Landry, Thomas	Fisheries & Oceans Canada
LeBlanc, Angeline	Fisheries & Oceans Canada
LeBlanc, Kevin	Fisheries & Oceans Canada
LeBlanc, Neil	Atlantic Veterinary College
Leger, Marcel	NB Agriculture, Fisheries & Aquaculture
MacAskill, John	5M Aqua Farms Ltd.
MacCallum, Greg	PEI Aquaculture Alliance
MacDonald, Tom Jr.	T.J.'s Shellfish
MacDonald, Tom Sr.	T.J.'s Shellfish
MacDougall, Lloyd	n/a
MacDougall, Rick	n/a
MacIntyre, Daniel	5M Aqua Farms Ltd.
MacIsaac, Colin	Fisheries & Oceans Canada
MacKay, Eldon	n/a
MacKay, Glen	M.R.S. Mussel Ltd.

PARTICIPANT	COMPANY
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Mallet, Maurice	Fisheries & Oceans Canada
Martin, Jim	Fisheries & Oceans Canada
McDonald, Crystal	PEI Aquaculture Alliance
McGrath, Vince	McGrath Shellfish
McKillop, Lisa	PEI Aquaculture Alliance
Methe, Denise	ACRDP-DFO
Mills, Chris	PEI Agriculture, Fisheries, Aquaculture & Forestry
Muise, Brian	Aquaculture Assoc. of NS
Mullen, Jason	Aquaculture Assoc. of NS
Murphy, Dawn	PEI Agriculture, Fisheries, Aquaculture & Forestry
Myrand, Bruno	MAPAQ - Ministere de l'Agriculture, des Pecheries et de l'Alimentation du Québec
Ouellette, Marc	Fisheries & Oceans Canada
Peters, James	n/a
Piercey, Jeff	University of New Brunswick
Reynolds, Carl	Reynolds Island Mussel Co. Ltd.
Reynolds, Colin	Reynolds Island Mussel Co. Ltd.
Robinson, Shawn	Fisheries & Oceans Canada
Rose, Martin	n/a
Semple, Bob	Fisheries & Oceans Canada
Simpson, Jason	n/a
Small, Dale	Fisheries & Oceans Canada
Smith, Gary	PEI Agriculture, Fisheries, Aquaculture & Forestry
Smith, Matt	PEI Agriculture, Fisheries, Aquaculture & Forestry
Smith, Wayne	Ocean Echo Shellfish
Stairs, John	Aquaprime Mussel Ranch
Stewart, Ian	n/a
Stewart, Stephen	Stewart Mussel Farms Inc.
Stuart, Robin	Ocean Stuarts Consulting Services
Sutton, Cheryl	n/a
Thompson, Robert	PEI Agriculture, Fisheries, Aquaculture & Forestry
Townshend, Isaac	New Wave Shellfish Farm
Townshend, Roger	New Wave Shellfish Farm
Tremblay, Rejean	UQAR - Université du Québec a Rimouski
Vatcher, Susan	IRAP/NRC
Veniot, Anne	Fisheries & Oceans Canada
Yoston, Andre	n/a
Yoston, Steve	n/a
Yoston, Vernon	n/a

PRESENTATIONS

For additional copies or information on the workshop, please contact:

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