Atlantic Canadian Tunicate Workshop Proceedings
Atlantic Veterinary College
Charlottetown, PEI

March 29, 2003

FINAL REPORT
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SECTION ONE - BACKGROUND

Background

During the late 90's two aquatic invasive species of tunicate were determined to be having a detrimental impact on numerous shellfish aquaculture sites in Nova Scotia *(Ciona intestinalis)* and Prince Edward Island *(Styela clava).* The tunicate populations have continued to increase in several areas and while research is on-going into the biology and possible mitigation measures it was felt that industry should meet with individuals with experience dealing with various types of tunicate and fouling mitigation measures.

On March 29, 2003 the Prince Edward Island Aquaculture Alliance and the Aquaculture Association of Nova Scotia co-sponsored the Atlantic Canada Tunicate Workshop in Theatre A of the Atlantic Veterinary College (AVC). The purpose of the workshop was to bring together mussel producers/processors, international tunicate experts (especially *Styela clava* and *Ciona intestinalis),* local researchers and interested government officials to discuss the current situation in Atlantic Canada and to develop potential management plans for those areas most heavily impacted and areas with minimal infestation.

The Atlantic Canada Tunicate Workshop was held between 9:00 am and 5:00 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. Speakers were brought in from the United States, New Zealand and Atlantic Canada, while growers from Nova Scotia and PEI gave a personal account of their experience at ground zero in the tunicate battle.

Participation at the workshop was encouraging with over 90 individuals from across Atlantic Canada, various aspects of the industry (growers, employees, manufacturers, 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 the registration fees collected at the venue. The in-kind donation of meeting venue and audio-visual services was provided by the Atlantic Veterinary College (AVC). The Aquaculture Association of Nova Scotia and the Prince Edward Island Aquaculture Alliance provided administrative services (i.e., mail-outs, telephone, organizational, etc.). Various members of the *Styela clava* Action Research Group (SCARG) assisted with the formation of the draft workshop agenda and initial contact of guest speakers.

Presentations

In March of 2003 the Atlantic Canada Tunicate Workshop posed the following questions to leading tunicate researchers and individuals with front line experience in an effort to better understand the animal that had invaded local estuaries:

- Why worry about tunicate invaders?
- What is the tunicate situation in Atlantic Canada?
- What are we doing about it? A world-wide view of tunicate mitigation efforts.
  - Are the efforts paying off in New Zealand and South Africa?
  - What has Nova Scotia been able to learn?
  - What are we learning about *Styela* on PEI?
  - Is there technology to treat processing plant effluent?
- What can we do about it?
  - How are they spreading now that they're here?
  - Can we limit the movement of tunicate?
  - What's the view from the boat? Industry's perspective from two Island mussel growers.
- What next? Strategies for 2003 and beyond.
  - Do we have a chance to eradicate or control them?
  - Are the resources available to do what needs to be done?

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

Guest Speakers

The Atlantic Canadian Tunicate Workshop organizing committee invited world renowned tunicate researchers Kevin Heasman of the Cawthron Institute, New Zealand and Gretchen and Charles Lambert of the University of Washington Friday Harbor Laboratories to bring their expertise and experience with tunicates to the workshop.

As is noted later in this document, local researchers from the Atlantic Veterinary College (AVC), the PEI department responsible for fisheries and aquaculture and Fisheries and Oceans, Moncton gave presentations on the current tunicate research being carried out in the region. Federal government representatives outlined regulatory requirements and funding options, and several mussel growers from Nova Scotia and PEI gave their view of the impact of the tunicate invasion on their sector.

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

SECTION TWO - WELCOME & OVERVIEW

Introduction and Welcome *Jim Jones, Regional Director General, Gulf Region Fisheries & Oceans*

Fisheries and Oceans Regional Director General for the Gulf Region, Jim Jones, welcomed the participants to the Atlantic Canadian Tunicate Workshop. Mr. Jones reviewed the past of the mussel aquaculture industry in the Atlantic region noting that one of the greatest strengths of the industry was overcoming uncertainty. He indicated that the answer to the tunicate challenge that the industry was facing was the same as in the past when there were uncertainties to overcome.

Murray River Islands - Courtesy Matt Smith

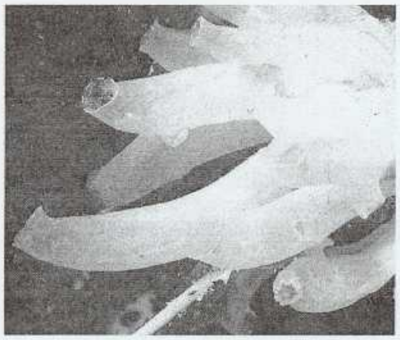
Mr. Jones noted that by working together and sensitizing different people in the industry and various levels of government to the issues, he felt confident that industry would once again work through its challenges.

Why worry about tunicate invaders? *Gretchen and Charles Lambert, University of Washington*

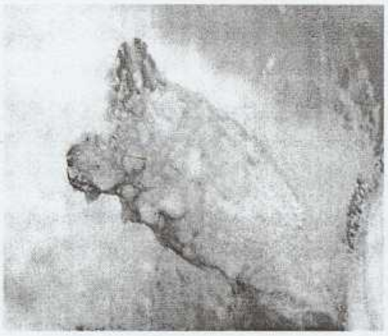
*Eminent tunicate researchers, **Gretchen and Charles Lambert** of the University of Washington Friday Harbor Laboratories have been working together on tunicate research since the mid 60's. Their input on the local tunicate situation was seen as valuable for understanding the biology, reproduction and population dynamics, settling preferences and basic life history of the two invasive tunicate fouling Atlantic Canadian aquaculture gear and marine habitat. **Gretchen Lambert** has been working on tunicate since 1965. She obtained a bachelor's degree from the University of Minnesota and a master's degree from the University of Washington on tunicate ecology. Gretchen Lambert is recognized world-wide as a leading tunicate researcher. **Charles Lambert's** background is in embryology and developmental biology. He received his bachelor's and master's degrees from San Diego State. He completed his PhD at the University of Washington in 1970 on reproductive biology of tunicates and has worked with Gretchen as an integral part of this "tunicate tag team" since their meeting in 1964 at the Friday Harbor Labs at the University of Washington. The Lamberts collectively write and circulate world-wide the Ascidian News, a newsletter dedicated to the advancement of knowledge and understanding on tunicate. The Lamberts chose to give separate presentations on this subject and to focus on their given areas of expertise.*

Gretchen Lambert began the presentation with a general overview of the morphology, physiology and life history of the two tunicates at issue in the Atlantic region, *Styela clava* and *Ciona intestinalis*, as well as tunicates in general. She indicated that tunicate and mussels prefer many of the same things but that there were likely areas of sensitivity (i.e. most tunicate cannot tolerate salinities below 25%) and that work could be done on in an effort to reduce the fouling of aquaculture gear.

Ciona intestinalis, currently found in NS, according to Lambert is generally solitary with a thin tunic. The *Ciona* is a short-lived creature and can be easily killed by drying out. The *Ciona* tunic tears easily, is sensitive to low salinity and spawns every day (day after day). She indicated that spawning is triggered by light, usually early morning.



Ciona intestinalis



Styela clava

On the other hand, *Styela clava* (also known as the clubbed tunicate), which is currently found in PEI, lives two to three years and has a thick tunic protecting its internal organs. The tunicates prefer very tiny food particles down to as small as one micron. According to Gretchen Lambert sediment is a major food source for tunicate because of the bacteria load. She also indicated that processing plant effluent would provide ample amounts of food for tunicate.

Gretchen Lambert indicated that *Ascidiella* (another invader) is extremely abundant in New England and that while many of the current species may not still be around in a few years, we should expect new invasive species. She noted the following examples of tunicate species coming our way in the next few years:

- *Didemnum* colonies that can be found as far north as the southern half of Maine. She indicated that this new invader to the Eastern United States will likely reach PEI.
- *Corella eumyota* is a southern hemisphere tunicate that recently invaded Brittany, France, but it is currently not posing a problem to mussel or oyster growers. It has not yet appeared in America but she believes there is a probability that it might. She noted that invaders can react very unpredictably in their non-native range.

According to **Dr. Charles Lambert** *Styela* is the most invasive and fastest spreading tunicate in the world today. He indicated, that because the tadpole swims for one to five days and transcontinental travel occurs at an increasingly short interval, it was not unthinkable for attachment, metamorphosis and transcontinental travel across the Atlantic to occur in this time frame.

Dr. Lambert indicated that, at spawning, light is important to the tunicate and that with 12 hours dark and 12 hours of light the conditions for *Styela* to spawn are favourable. He also indicated that metamorphosis of the tunicate requires hard substrate and shade.

After metamorphosis, Dr. Lambert told the workshop participants that the tunicate is ready to reproduce within one or two months, therefore it is an important farm practice to clean (either manually or with a high pressure hose) the mussel lines and equipment regularly. He indicated that metamorphosis is the vulnerable part of the tunicate's life cycle.

What is the tunicate situation in Atlantic Canada? ***Crystal McDonald, PEI Aquaculture Alliance***

> ***Crystal McDonald,*** *executive director with the PEI Aquaculture Alliance presented the history of the Styela and Ciona invasions in Atlantic Canada, including an overview of the current situation, the impact that the invasions were having on the local industry and industry concerns regarding future invasions.*

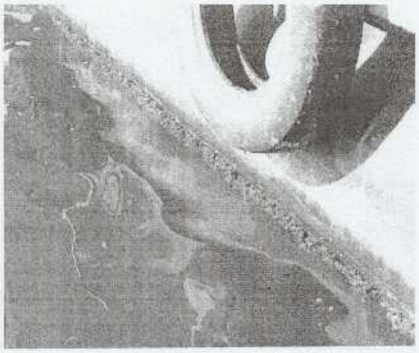
Invasive species have become a running battle for the region's aquaculture industry. *Styela clava* and *Ciona intestinalis* are two invasive species that have the potential to not only stymie the industry's further development in the Atlantic region but to put at risk the existing investments. The Atlantic region is an important contributor to Canada's aquaculture production with New Brunswick, Nova Scotia and Prince Edward Island responsible for in excess of $110 million in 2000. While finfish comprises 90 per cent of the Canadian industry's landings, shellfish aquaculture (especially mussels) plays an important role in the rural, coastal communities of Atlantic Canada. In fact, PEI is the leading mussel producer in North America with approximately 4,500 hectares in mussel production producing approximately 80 per cent of the Canadian mussel production (17,500 metric ton for a value of $24 million in 2000).

Clean Mussel Lines in Murray River
Courtesy of Matt Smith

It is thought that *Styela clava* was likely introduced to PEI on the hull or in the ballast or bilge water of a vessel docking at the Georgetown Wharf on the South Eastern end of the Island. In January of 1998, a mussel grower, with a background in biology, reported finding a new type of tunicate on his mussel lease in Brudenell River (not far from the wharf) and expressed some concern about the fouling potential of this new species. A PEI Department of Fisheries, Aquaculture and Environment diving survey of the lease and surrounding area early in 1998 reported no trace of the tunicate. It was hoped that the cold Island winter had eradicated the animal.

However, by the Fall of 1998 *Styela* was being found on mussels in Brudenell River and there were unconfirmed reports that it was also in Montague River. In 1999 and 2000 the spread of the tunicate to both the Montague and Murray River systems was confirmed. By 2001, *Styela* was found in the Montague, Brudenell, Murray and Orwell Rivers as well as St. Mary's Bay.

While Orwell River and St. Mary's Bay only experienced light fouling of mussel lines, Murray River and the Montague/Brudenell Rivers were heavily fouled. Because the tunicate competes with the



Styela on Brudenell Wharf in 1999
Courtesy of Matt Smith

mussels for space and food this population explosion created serious issues for the industry and the growers involved. While mussels in Brudenell and Montague River have had fouling problems with *Styela* longer than has been reported in Murray River the conditions in the Murray River system appear to have encouraged a population explosion similar to that reported in Holland.

In 2002 *Styela clava* was confirmed to have spread to Marchwater (Malpeque Bay) on the North Shore of PEI. All of this occurred despite industry requested restrictions on the movement of seed and harvested product from the infested areas to non-infested areas.

The cost to the mussel growers and processors with product in *Styela* infested waters has included:

- increased labour and Workers Compensation costs,
- the treatment (and sometimes replacement) of gear,
- the treatment of the mussel crop at various stages in its life cycle,
- the development of technology to treat the processing effluent water,
- as well as Introduction and Transfer restrictions on the movement of seed and harvested product from infested areas have implications.

Industry on PEI has taken a very pro-active approach to the *Styela* invasion from its early request to restrict the movement of shellfish out of and within infested areas to its involvement in collaborative research efforts such as the *Styela clava Action Research Group*. There are also two groups that have been formed to look at developing farm practices that might assist in managing the tunicate populations. The Eastern group is dealing with a full blown infestation and the Western group is looking at ensuring that the minimal number of tunicates found in a small area of one of our northern bays does not spread to other areas, or if it does, that it is delayed and that broodstock is kept to a minimum. The province, AVC and Fisheries and Oceans have been very involved in on-going efforts to monitor the presence/absence of the tunicate and to educate the boating public about the potential vectors for moving this species into new areas.

While PEI growers are contending with the *Styela clava*, Nova Scotian aquaculturists are struggling with a fast growing sea squirt known as *Ciona intestinalis*. Fouling by *Ciona* is occurring on mussel rope culture and oyster farms in Nova Scotia similar to other areas of North America, the Mediterranean, South Africa, Korea and Chile.

In 1997 *Ciona* invaded a Nova Scotia mussel farm at Corkum's Island, Lunenburg Bay. When farmers pulled up the socks all they saw were hundreds of tunicates. In fact, the entire crop ended up being written off with the weight of the *Ciona* pulling the mussels off the socks as they were raised out of the water. Efforts to leave the area lying fallow were not successful in eradicating this filter feeder because of the abundance of other hard substrate in the eco-system for it to colonize. The end result was that the involved grower removed all of his mussel structures from the water after nearly 20 years in the business. The removal of this production impacted not only the grower but the processor of his mussels and the two local communities involved.

Subsequent to the Corkum's Island invasion, Mahone Bay mussel leases were invaded by *Ciona*. The impacted grower has five of his seven leases "very infested" and has publicly expressed concern about the viability of the industry if a solution is not found. Currently *Ciona* has spread from the Pubnicos to Halifax in Nova Scotia and significant numbers can be found in Ile Madame in Cape Breton.

Nova Scotia growers, like their Island counterparts, have decided to work collaboratively on finding out more about the tunicate that is putting their livelihoods at risk. Several Nova Scotia growers are also taking part in PEI's research meetings to see if there are any commonalities that both areas can learn from. In fact, currently the PEI Aquaculture Alliance and the Aquaculture Association of Nova Scotia are involved in discussions with the New Zealand Mussel Industry Council to take a prototype technology that New Zealand has developed and bring it to the region to see if it will work on the *Ciona* and *Styela*. The goal is to develop a technology that can be commercialized and made readily and viably available to the growers in the area.

The future of the Nova Scotia and Prince Edward Island aquaculture industry is likely to include *Styela* and *Ciona* given that most experts indicate that eradication is unlikely once these pests have been introduced into a system. However, given time Mother Nature often plays a role in limiting an invasive species' impact on an eco-system. Industry is hopeful that with time things will balance out and predators, pests or parasites will bring the populations back into balance.

According to McDonald in the meantime we have a dynamic sector that is at risk if answers to the tunicate fouling are not found in a timely fashion. Industry will need to continue on its collaborative efforts to keep the populations in check and to understand what management practices and other options might be available to reduce the negative impact these tunicates are having on the economic sustainability of the industry and the environmental sustainability of the eco-system.

McDonald presented an overview of what is required to enable the region's coastal communities and the aquaculture industry to battle tunicates, including the need for:

- tougher legislation on commercial shipping practices (i.e., ballast water treatment, hull cleaning, etc.);
- equity among the industries that utilize the aquatic resource including the inclusion of the commercial fishery (i.e., lobster, herring, tuna, etc.) in Introduction and Transfer guidelines so that wild fishery activities that offer the same or greater levels of risk are required to abide by the same rules as aquaculture;
- education of the aquaculture industry, recreational boaters, commercial fishery and the general public about the potential threat movement of invasive species from one area to another can pose;
- dedicated resources for not only the research of species like *Ciona* and *Slyela* but for the development of the management tools that industry may need to combat these challenges;
- DFO, as the federal department responsible for aquaculture and the aquatic resource, to take a leadership role on invasive species management and to ensure that federal resources are available to address these and other new invaders; and
- resources to monitor the movement of new invaders, sample and analyze new species, assist growers with the technical/financial aspects of dealing with invasive species as well as to test materials and develop treatment methodologies and equipment.

SECTION THREE - WHAT ARE WE DOING ABOUT IT?
Moderated by Richard Gallant, PEI Department of Fisheries, Aquaculture & Environment

Worldwide view of tunicate mitigation efforts. ***Gretchen Lambert, University of Washington***

Gretchen Lambert gave an overview of the types of mitigation efforts that other regions are trying with varied levels of success. One method of treatment is scraping the fouling off of the gear/equipment. Lambert indicated that if you scrape a solitary tunicate (both *Ciona* and *Styela)* off of a substrate it will not regenerate. But if you scrape a colonial tunicate and leave a bit of it behind it/they will regenerate.

A global look at growing areas, type of tunicate fouling and mitigation methods currently in use or tried:

- Chesapeake *Bay (Ciona)*
  - Manual scraping of cages (since *Ciona is* a solitary animal, the remains will not bud).

- New Zealand *(Ciona)*
  - Tunicate disappeared after 18 months, reason unknown.

- Washington State *(Botrylloides violaceus, Botryllus schlosseri)*
  - Desiccation and freshwater (leave oysters in the rain for 1-2 days when the tunicate is still at a young age).
  - In Puget Sound no treatment is necessary; fouling is minimal on the mussels even though it is a huge problem for the marinas in the same area.
  - At Penn Cove Shellfish (http://www.penneoveshellfish.com) minimal fouling therefore no treatment is necessary. At harvest the fouling is merely scrubbed off.

- Alaska *(Botrylloides violaceus)*
  - Can be a big problem for oyster farming
  - Hosing and scraping to remove the animal completely, buds included.
  - Salt dips are not effective.
  - Some leave oysters in the rain for 2 days and then hose off.
  - Also has a permit to grow sea squirts but has not raised any yet.

- New Zealand *(Didemnum)*

  Scraping hull or use of 'supersucker', but there is rapid regrowth due to the buds remaining.

- New Hampshire *(Didemnum)*
  - Rapid overgrowth of sub-tidal walls, float and boat bottoms.
  - No treatment, only monitoring the situation.

- Gulf of Mexico *(Didemnum perlucidum)*
  - Found on submerged decommissioned oil rigs in the Gulf that are used as artificial reefs.
  - No treatment, only monitoring the situation.

- Hawaii *(Gracilaria Salicornia)*

  - Control by early detection and involving the community to clean up the areas and compost the algae.

- PEI *(Styela clava)*
  - Recommended manual removal by community/volunteers since the tunicate impact more than aquaculture.
  - Requires early detection of new infestations and rapid removal the timing of which is important. Tunicate must be removed prior to release of larvae/gametes.
  - Avoid fragmentation of colonial tunicate fouling the gear.
  - Dispose of waste in landfill.
  - Dessication.
  - Control of processing plant effluent will reduce nutrients and gametes in the water.
  - Fresh or low salinity water immersions (less than 20%) or vinegar (acetic acid) dip which will kill the sperm but not the eggs.
  - Periodic high pressure seawater hosing. Coat the gear with nontoxic epoxy or silicone so that hosing removes fouling more easily.
  - Introduction of grazers (snails, flatworms, starfish) on lines? Nudibranchs?
  - Introduction of additional non-mussel lines for tadpoles to settle on. Do not clean these lines.
  - Exploration/development of new markets:
    - Market them to Asian restaurants and groceries. Related species farmed in France, Chile and other countries.
    - Potential antibiotic (antimicrobial and anti-cancer natural products also) for pharmaceutical companies.
    - Currently sold at 3$ per *Styela* for classroom education.

- Nova Scotia *(Ciona Intestinalis)*

  Ciona is an early settler; the numbers go down on substrates where there is earlier settlement of other species. Do like a light bacterial film covering though.

  Ciona is not eaten but could prove valuable for classroom demonstrations of development.

Are the efforts paying off in New Zealand and South Africa? *Kevin Heasman, Cawthron Institute, New Zealand*

Kevin Heasman, a research scientist with the Aquaculture Group at Cawthron Institute in New Zealand, was able to lend his expertise/experience on Ascidian bio fouling (particularly Ciona intestinalis) and aquaculture engineering. Mr. Heasman's research in both South Africa and New Zealand allowed him to discuss the biology and life cycle of the particular tunicate although due to confidentiality requirements he was unable to present on the newly developed lunicate mitigation technology that he had developed for the New Zealand Mussel Industry Council. Post-workshop meetings and tours of PEI and NS mussel sites experiencing heavy tunicate fouling were carried out with the PEIAquaculture Alliance, PEI Department of Fisheries, Aquaculture and Environment and the Aquaculture Association of Nova Scotia.

Kevin Heasman indicated, that in his opinion, although *Ciona* was resident when mussel farming started in South Africa and New Zealand, industry was unaware of *Ciona* fouling. He theorized that when the industry reached some undetermined critical mass of structures in the water, associated with the right environmental conditions, the fouling occurred.

Heasman indicated that *Ciona* cannot take high energy (i.e. wave action) although it could survive in high current. Peak fouling periods were from late spring to late summer. *Ciona* larvae seek shaded, calm areas for settlement and therefore the gaps between mussels are desirable as *Ciona* settlement sites. However, established ropes (i.e., ropes that have well attached and settled mussels, as against newly seeded ropes) are usually less well settled by *Ciona* because all of the mussels are facing out outwards making it difficult for Ascidian larvae to pass the mussels without being filtered out of the water column when trying to enter the gaps between the mussels. New Zealand growers have a continuous rope method of growing mussels, therefore, lines of seed and market ready crop are side by side. Heasman indicted that when *Ciona* came through it was the newly seeded lines that experienced fouling. Well established product lines were generally unaffected.

New Zealand research also indicates that if a mussel has good condition when the ropes are fouled they will slowly lose condition. Heasman indicated that fouling ascidians have a desired habitat and if you can change the habitat, os some characteristics of the habitat, you can manage the settlement. *Ciona* larval stage has a limited life and single settlement events are generally localized. New Zealand is currently monitoring to determine when/where the settlement events, or favourable conditions for an event, occur. This is proving hard to do. There have been complete die offs of *Ciona* in Chile, New Zealand and South Africa for no apparent reason. This year it appeared that the conditions were right for the New Zealand industry to be inundated with *Ciona* and yet only had 15 lines fouled.

South Africa has seen a 40% devastation of the crop in 8 weeks with the appearance of *Ciona*. However, the *Ciona* settlement events have not occurred every year. When an event occurs slower growth is accepted (i.e., eight months to market instead of the traditional five to seven months). There is no monitoring per se. Monitoring would be beneficial, however, since there were pulses of larvae found in the water column and not a continuous trickle.

South Africa use the Spanish raft system for growing their mussels. Heasman indicated that 98 per cent of the food entering the raft is extracted by mussels on the ropes. The centre of the raft is calm and shaded making it a very desirable settlement site for *Ciona*. With densities of 1:1 Ciona/mussels the *Ciona* pose a competition for space and you see soft mussel attachment. Densities of 3: 1 result in food competition and mussel losses as the mussels detach from the rope and move out toward the "open" water attaching onto the *Ciona*. Upon harvest the mussels fall off of the rope.

According to Heasman New Zealand growers experienced basically the same infestations of *Ciona* as South Africa. Washing and de-clumping of seed occurs before the seed is transferred to other sites. This is normally sufficient to kill *Ciona* if they are not in very high numbers (<800/m).

In 2000/2001 Ciona colonised farms in the Marlborough Sound which resulted in a loss of - NZ $15 million. The *Ciona* are found in low energy areas. To quote Heasman, "We don't think it *[Ciona]* moved into the Sounds, we think that the conditions moved into the Sounds to induce them to settle." He indicated that researchers should consider the entire system, not just where the *Ciona* are because the conditions which induce the fouling event may have started 100's of kilometres from the site.

During the discussion Heasman indicated that while restocking was one method that had been used, one had to be accurate with your timing or the *Ciona will* be able to re-colonize. At 40 to 60 cents per metre to reseed, the industry was trying to avoid the need to repeat the process. He indicated that the ropes with low densities of seed or gaps of exposed rope would experience fouling problems. Also, Heasman indicated that the uniformity of the mussel sizes was important since 10 to 40 millimetre seed would provide gaps and holes where the tunicate can get inside and are shaded. He indicated that if the growers used all graded mussels and have them established before the conditions induce *Ciona* larval release out there is a reduced inoculation density.

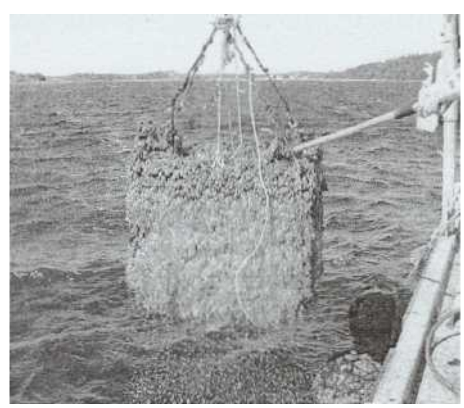
The Cawthron Institute and New Zealand Mussel Industry Council are working together to develop methods of control and currently have a mitigation tool at the trial stage. However, due to confidentiality agreements he was unable to elaborate on the method.

What has Nova Scotia been able to learn? *Claire Carver, Lunenburg Shellfish Inc.* & *Peter Darnell, Indian Point Marine Farms Ltd.*

> ***Claire Carver,*** *researcher with Lunenburg Shellfish Inc. partnered with* ***Peter Darnell*** *of Indian Point Marine Farms Ltd to give an overview of the Ciona fouling situation in Nova Scotia and earlier research that had been carried out on treating oyster and mussel gear fouled with this particular tunicate.*

Claire Carver indicated that *Ciona* has been observed in the Lunenburg area of Nova Scotia at very low levels since 1983 but that the populations suddenly exploded in 1996. She indicated that by 1997 the infestations started to have serious impacts on the local mussel culture industry (i.e. reduced growth rates, flow interference, competition for food, increased production costs, eventually the abandonment of suspension culture). By *1999* the infestation had spread to the adjacent oyster/scallop culture operation and continues to cause problems as of 2002.

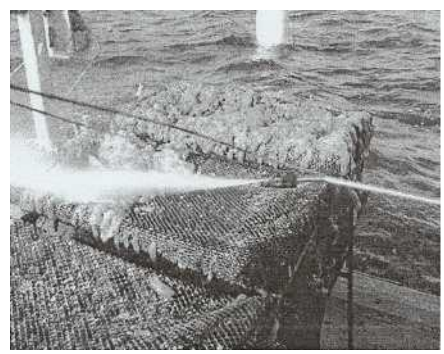
A project funded by Lunenburg Shellfish Inc. and the National Research Council's Industry Research Assistance Program in 2001 indicated one settlement peak from mid-May to late June, followed by a second peak in August. The juveniles which settled in May became reproductively active by early August at a length of 50 millimetres. It was estimated that a single *Ciona* individual may produce 15,000 eggs over its 12 - 18 month life cycle.



Ciona Covered Oyster Bags
Courtesy Claire Carver

Possible methods of control, included:

- Mechanical options: Pressure washing is effective but labor intensive and does not remove tunicates attached to the shellfish on the inside of the oyster bags.
- Biological options: *Ciona* never observed on the bottom substrate, just on off-bottom tables or floating structures. Also rarely seen on the upper surface of bags on tables. Possible benthic predators include starfish, crabs and snails. The Rock crab *(Cancer irroratus) (50-80* mm) was found to be a voracious tunicate predator. They slice a hole in the tunic with their pincers and drag out the body tissues. Depending on the size of the tunicates they can eat six to twenty individuals per day. They do not appear to like eating the tunic but have no problem eating the body. Green crabs *(Cancer maenas)* prefer mussels over tunicates but will eat them. It is possible that the grazing activity of snails placed in the oyster bags may dislodge recently settled tunicates.
- Chemical options: Acetic acid (4%) is the most effective chemical option with 90-100% efficacy with a one minute dip. Spray application of acetic acid was also very effective. Other chemicals not as effective included Javex/bleach (no mortality after 20 minutes), brine, lime (4%), freshwater, hot freshwater (killed small mussels).
- The "Tunicator", which incorporates various treatment options, was designed and built by Atkinson and Bower Manufacturers (Shelburne, NS). It is a combination whippersnipper, brush, pressure washer and chemical sprayer for Acetic acid (with a re-circulation system). The whippersnipper alone is 80 per cent effective in killing the tunicates, but not in removing them from the bag surface. It is likely that the whippersnipper, in combination with the acetic acid, would achieve 100 per cent mortality rates.



Pressure washing *Ciona* Off Bags
Courtesy Claire Carver

Possible management strategies included:

- Re-schedule the timing of field activities so that equipment is changed/cleaned post settlement (August - September) but prior to fall bloom (October - November).
- Continue monitoring of recruitment patterns to document interannual variability.
- Evaluate the use of available control methods under field conditions (crabs, acetic acid and the "Tunicator").
- Encourage natural predation (i.e., promote rock crab activity/survival).
- Identify/evaluate natural cleaners for the inside of the bag (e.g. snails).
- Identify other possible mechanical and chemical treatment options.

Discussion on the natural predators followed the presentation. Heasman indicated that in South Africa the rock crab was inside the bags and very territorial and while they would clean the bags they did not touch the shellfish.

Peter Darnell, Nova Scotian mussel farmer, began his presentation with a warning to his fellow growers in the audience that they should be leery of the "this will never happen to us" attitude. Perhaps his opening remarks, noted below, about the seriousness of the issue in Nova Scotia best sum up the level of concern the mussel industry in that province has with tunicate fouling.

" We're having fun growing mussels but at the end of the year you have to make a profit and we can't do that anymore because of Ciona. "

Cion,(Fouling NS Mussel Socks & Gear
Courtesy Dale Small

The following highlight what Darnell presented as key messages and items that need to be done:

- Growers need to be educated to recognize the tunicates. If we cannot identify the various types of tunicate how can we keep them from moving around?
- Emphasis should be on farm management and settlement avoidance versus treatment.
- Farmers are not manufacturers and need assistance to develop the tools to deal with these pests.
- Environmental concerns must be in the forefront. The solution cannot put other species and the environment at risk.
- Tunicate free areas must be kept tunicate free (i.e., need for strict Introduction & Transfer rules and on-going inventories on where the tunicates are to be found).
- Mussel seed must be treated before it is moved.
- Need to involve agricultural expertise (pest management control for many years).
- Other stakeholders (finfish farms, processing plants, floating docks, recreational boaters etc.) should be made aware of the implications of the tunicate issue and should be encouraged to do something about it.
- Need a definitive answer that there are no food safety issues posed by tunicate fouling so that consumers' concerns can be addressed. (Gretchen Lambert noted that Madel on Mottet of Sitka Sea Farm in Alaska said that consumers are put off aesthetically by remnants of the colonial tunicate *Botrylloides violaceus* on oyster shells so they need to be very thoroughly scrubbed to be marketable.)
- We have a tremendous resource in our people and expertise and NS is in the process of forming an advisory group similar to the *Styela Clava* Action Research Group that is working in PEI.
- International cooperation is required.
- Need to increase price per pound of mussels to minimize economic impact on the growers.

Darnell indicated that he is seeing a lot of dead tunicates this spring, but that the juvenile tunicates are still alive. He indicated that the following mitigation efforts have been used at Indian Point Marine Farms Ltd.:

- Previously mussels were socked at higher densities which was successful in keeping the *Ciona* off the first year, but in the second year the higher socking density resulted in slower mussel growth and heavy fouling.
- This year he will be trying to lightly sock the mussels and get them to market before the second set of tunicates can occur.

Darnell also indicated that the continuous socking and re-socking, similar to New Zealand's experience is expensive and may need to be improved.

Regarding the cost of combating the tunicate situation, Darnell indicated that it is expensive and that the Nova Scotian industry has already lost some of its players.

What are we learning about *Styela* on PEI? *Neil McNair, PEI-DFAE*

> *Neil MacNair, a biologist with the PEI Department of Fisheries, Aquaculture & Environment, presented an overview of some of the results the Department has attained to date on research they have carried out as part of a large, industry-led, collaborative research project that looking to develop mitigation tools for the industry including farm management techniques and treatment options at the farm and processing level. The research studied the spawning cycle of Styela, the effects of varying mussel socking densities on tunicate settlement, the efficacy of brine, lime and acetic acid on tunicates set on rope collectors and the efficacy of various treatment agents on tunicates set on mussel socks.*

Neil MacNair presented the results of the Department's on-going tunicate mitigation work in several Island bays. He indicated that in the 2002 season, the *Styela clava* spawning window in Murray River was from June 24, when the water temperature was just barely at 15 degrees Celsius, to Oct 18t' when the water temperature was just below 15°C.

Lime Dip Trials
Courtesy of Neil MacNair

Several control methods were explored by staff of the Department over the past two years, including:

- Adjustments to socking densities. Results indicate that the mussel density in socks (i.e., 100, 140-160 and 200 mussels per foot) did not have an effect on *Styela* recruitment (i.e., 765, 644 and 707 - *average numbers of Styela* individuals per foot of sock respectively). The tunicates were attached mainly to the socking material and to the mussel byssal threads.
- Studies to determine the best time to treat. (The study was based on the premise that it would be realistic to treat crop and gear only once per season.) Results show that the optimal ti me to treat would be in late September or later after the majority of tunicates have set.
- Experiments with immersion in lime, brine and acetic acid as treatment agents; Brine was ineffective and appeared to actually enhance tunicate settlement and growth; Lime (4 %) treatment proved to be most effective using a 15 or 30 second immersion, however lime results were inconsistent; Acetic acid (5 %) treatment (in/out quick dip, 15 or 30 seconds) proved to be the most effective treatment overall. Most of the tunicates were killed with the quick dip.
- Other treatments were also experimented with utilizing spray and immersion applications. Results showed that the most effective treatment agents overall were acetic acid, ammonia and sodium hydroxide (5%). (Sodium hydroxide breaks down in salt water to salt and water.)
- Experimental results also showed that spring socked mussels were more heavily fouled than mussels socked in the fall, with the tunicate settlement occurring on exposed socking material.

MacNair indicated that spray application would probably be the most efficient/economical way to go about applying chemical treatments, however spray application, using current application techniques, is not as effective as immersion application. There are complications with using immersion applications such as dilution of the treatment agent and determination of the concentration of the treatment agent. The research also showed no difference in mortality, growth and meat yields between the untreated control mussels and those that underwent the treatments.

The research to date has been on what chemicals might be available/effective on controlling *Styela* fouling. If any of the chemicals tried are to become a control method, MacNair indicated there would be issues that need to be resolved including efficient application methods, ensuring the safety of the individuals carrying out the application, acceptance for use in the environment and cost/efficacy factors.

Gretchen Lambert, in the discussion following the presentation, indicated that because the *Styela* are a large part water and are going to hang down and pour out when the gear is pulled from the water for treatment, there will be a great deal of dilution occurring the further down the sock you go. Growers also indicated that there would likely be problems doing treatments in September because the mussels are not tightly attached at that time.

Potential impact of recruitment on mussel productivity. *Daniel Bourque, DFO*

> ***Daniel Bourque,*** *a biologist with Fisheries and Oceans Moncton Branch, presented an overview of some of the results he has attained to date on research he has carried out as part of a large, industry-led, collaborative research project that is looking to develop mitigation tools for the industry including farm management techniques and treatment options at the farm and processing level.*

Daniel Bourque (Fisheries and Oceans) reviewed his research on settlement of *Styela* and the impact of the recruitment on the productivity of infested mussel lines and areas. He indicated that his research for 2002 showed that they first showed up on the July 17`h sample which would be settlement from the previous week (i.e., July 9`h). The last sample to show settlement was October I 't. He indicated that this confirmed that recruitment occurs on a 12 week period even though the larvae are in the water for 16.5 weeks (i.e., June 24th to October 18")

Regarding potential tunicate densities Bourque indicated that he saw hardly anything on the collector plates the first week and that this was likely due to the need for a bio-film to build up prior to recruitment. Peak recruitment was seen on the August 27`h samples. He indicated that he felt it would be possible to monitor for peak recruitment since in his studies it has coincided with the highest water temperature.

Tunicates Compete for Space & Food
Courtesy Daniel Bourque

At the end of the experiment period Bourque indicated that the adult tunicate were four inches long. Research indicates that the maximum growth rate coincides with the peak recruitment and therefore one can assume that conditions are good for all levels of *Styela* development.

As to the competition between *Styela* and mussels, Bourque noted the following:

- *Styela* produced significantly more ammonia than mussels or the experiments with *Styela* and mussels combined.
- On Chlorophyll A, Nitrate, Nitrite and Phosphate there were no significant differences between the species.
- It is very probable that the two are competing for food and that the feeding behavior is influenced by temperature, food available and turbidity (i.e., particles in suspension).

In the discussion, a concern was raised that because there are two animals in one tank (i.e., *Styela* and mussels) instead of one animal that would be in the other tanks (i.e., *Styela* or mussels), the filtering rate would be suppressed.

Is there technology to treat processing plant effluent? *Chris Mills,* PEI-DFAE

> *Chris Mills, an aquaculture specialist with the PEI Department of Fisheries, Aquaculture & Environment, presented an overview of some of the results he has attained to date on research he has carried out as part of a large, industry-led, collaborative research project that is looking to develop mitigation tools for the industry including farm management techniques and treatment options at the, farm and processing level.*

Because of concerns that mussel plants are a potential vector for the transfer of tunicates, Chris Mills has been working extensively with the PEI mussel processing sector to determine an efficient method to treat processing plant effluent.

To achieve effective effluent treatment, not only does the adult tunicate life stage have to be removed, the eggs (150 micron) and the larvae (60 microns X 1000 microns long) must be removed or killed as well. Mills indicated, that in plants where mussels are being harvested from tunicate infested areas, it is possible to find up to 25 per cent of the holding capacity of the plant taken up by tunicates.

Monitoring done by the province is revealing a variable number of eggs in the effluent water depending on the activities happening in the plant. If the tunicates are falling onto the stripping floor in the plant there is a good chance that they are being stepped on by employees, potentially mixing and fertilizing the eggs. Mills noted that monitoring the effluent is made difficult by the sediments present (i.e., total suspended solids concentrations of 3500 ppm while stripping with the average particle size of 30 microns and 85 percent of the particles smaller than 90 microns). These characteristics also make treating with mechanical filtration very difficult. This poor water quality is caused by silt, mussel feces and pseudo feces.

Tunicates Attach To Byssal Threads Courtesy Garth Arsenault

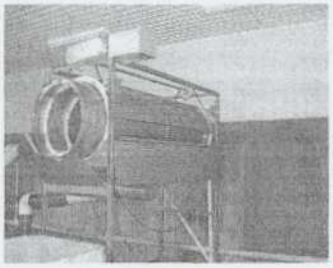
In an effort to slow down the spread of tunicates terms and conditions were established for the effluent release of plants processing mussels from tunicate infested areas. Federal guidelines administered by Fisheries and Oceans under the National Code of Introductions and Transfer of Aquatic Organisms require these plants to:

- remove the whole adult tunicate where the water temperature is less than 10°C; and
- remove the adult, eggs and larvae (i.e. screen size less than 80 microns)where the water temperature is warmer than 10°C.

There are several options for effluent treatment currently on the market, including:

- Mechanical Filtration: Physical removal of the solids from the effluent in two stages (primary treatment: remove particles greater than 750 microns; secondary treatment: remove particles less than 750 microns). Primary treatment, perforated plate/wire mesh (convex stationary screen, rotating drum); Secondary treatment, micro-screen (rotary drum, continuous belt). The advantages of mechanical filtration include equipment availability and low maintenance requirements. The disadvantages include the need to work with a high suspended solid load, the backwash water and equipment specifications/performance.
- Solid Separators: Settling pond and or swirl separator; Centrifuge separation (primary/secondary), no moving parts, very little maintenance, removes 95 per cent of 45 micron particles with a specific gravity of 1.2 or greater.
- Ultraviolet radiation: UV rays scramble the DNA structure of the cells of the tunicate rendering it incapable of reproduction, essentially killing the animal. Relatively low cost and systems readily available but efficiency is reduced with high suspended solids and there are maintenance costs (i.e. bulb replacement).
- Ultrasonic Technology (Cavitation): uses sound waves to damage the tissues of the *Styela*. Development occurring within Canadian/US navies in an attempt to address ballast water issues. Likely cost prohibitive.
- Ozone: Ozone is a very powerful oxidizer that ruptures the cell wall. It can be used to clarify/disinfect water. While there is very low maintenance the cost of a full scale unit will probably be in the \$100,000 to \$500,000 range.
- Chemical Treatment: While chlorination has been an effective effluent treatment for other applications, it is being discouraged due to its toxicity to shellfish larvae.

In summarizing his efforts Mills indicated that treating shellfish processing plant effluent for the removal of tunicate eggs and larvae is a new application for these technologies which equates to delays and resources to perfect the systems. He indicated that there may be some value in combining several of the systems since all of the technologies explored to date dealt with reduction not elimination of the larvae from the effluent.



Treatment Trials
Courtesy of Chris Mills

Since management of the tunicate in the plant will reduce the potential for discharge, Mills advocated the following:

- Accessing mussels from tunicate free areas during peak tunicate spawning times.
- Keeping the tunicates off the floor to minimize the potential for eggs/sperm to get in the effluent.
- Decreasing the effluent flow rate so that treatments could be more effective.
- Removing silt and small particles from the sock before they reach the plant.

SECTION FOUR - WHAT CAN WE DO ABOUT IT? *Moderator Thomas Landry, Fisheries & Oceans*

How are they spreading now that they're here? *Dr. Jeff Davidson, AVC*

Dr. Jeff Davidson and Garth Arsenault, *with the Atlantic Veterinary College (A VC), presented an overview of some of the results they have attained to date on research carried out as part of a large, industry-led, collaborative research project that is looking to develop mitigation tools for the industry including farm management techniques and treatment options at the farm and processing level.*

The Atlantic Veterinary College is currently involved in a collaborative project with the PEI Department of Fisheries, Aquaculture & Environment, DFO Science in Moncton and the PEI Aquaculture Alliance funded by AVC, the industry, the Aquaculture Collaborative Research & Development Program, the Aquaculture & Fisheries Research Initiative, and the National Research Council's Industry Research Assistance Program.

AVC Lab Explores Recruitment
Courtesy Garth Arsenault

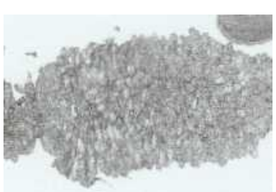
The objectives of the tunicate recruitment portion of the project, that are being carried out by AVC, is to:

- quantify the settlement and growth of tunicate in different locations in three infested areas (Brudenell River, Murray River and Vernon/Orwell Rivers); and to
- look for any associations between temperature, salinity and productivity.

Three buoys were deployed at each of three locations in each of the three river systems in early July 2002. Temperature recorders were also deployed at each site and a monthly visit to the sites occurred to examine and photograph the buoys and perform secchi disc readings. The buoys were then collected in November of 2002 for analysis at the AVC lab.

In Brudenell River and Murray River:

Bio-fouling was present on the buoys after three weeks in the water (July 25), however, no tunicates were recognizable yet. By week five (August 8) a small number of tunicates were observed on the buoys. After eight weeks in the water (August 20) tunicate settlement was most obvious on the bottom of the buoy and on the dark lettering (AVC acronym) on the buoy. By the 12"' week in the water the buoys had a high density of tunicate settlement on the bottom end of most buoys.

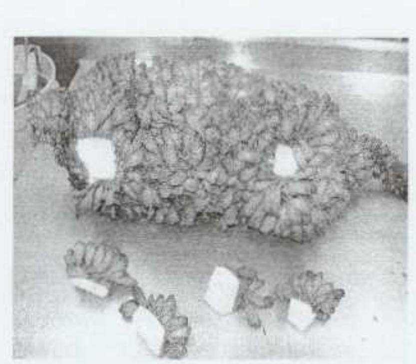


Settlement After 20 Weeks
Courtesy Garth Arsenault

After 20 weeks there was a high density settlement of tunicates on most of the surface area of the buoys and they were removed from the water and taken to the AVC lab for analysis.

In Vemon/Orwell: Only one tunicate was found on the buoys placed in Vernon River.

Back at AVC: Back at the lab there were four sub-samples (5 cm x 5 cm) taken from each of the buoys. All of the tunicate were taken from each of these sub-samples, counted and measured. Length data was combined for each river and a significant difference in body length was noted between the Brudenell River and Murray River tunicates.


Sub-samples Back At the AVC Lab
Courtesy Garth Arsenault

Surveillance On Suspect Sites: Early reports of tunicate sightings in Marchwater, on the North Shore of PEI, lead to an intense diving survey of the area in September of 2002. A limited number of tunicates were found and the area was subsequently added to the Introductions and Transfers restricted list.

In October of 2002, several areas of Tracadie Bay were also extensively searched for the presence of tunicates. Two of these areas had a historical record of movement of Murray River mussel seed and one was in close proximity to the processing plant on the Tracadie Wharf. No tunicates were found.

Can we control the movement of tunicates? *Colin MacIssac, DFO*

> ***Colin MacIssac**, with the Conservation and Protection Branch of DFO, discussed the current restrictions that are in place for the PEI mussel industry regarding the movement of mussels within, into and from areas that are known to have Styela clava.*

Colin MacIssac reviewed the PEI situation to date, including the industry's request in the fall of 2001 to restrict the movement of shellfish out of tunicate infested bays. A tunicate sub-committee comprised of federal/provincial government, academia and industry was established in October of 2001 to review and assist with the situation.

Current restrictions in place on PEI include the need for a licence to transfer molluscan bivalve shellfish out of, within, or between the following waters:

- all the waters in King's County, PEI, commencing at Burnt Point (near Georgetown) and following the various courses of the coastline in a southerly direction to Cape Bear including all estuaries, tributaries, rivers and bays in this area.
- all of the waters in Queen's County, PEI, in the Orwell Bay and tributaries upstream from a straight line drawn from Penn Point to Birch Point.
- all the waters in Price County, PEI, 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 Courtin Island from there southeasterly to a point on the shore at the end of the Beach Point Road in the community of Hamilton.

Anyone wanting to transfer molluscan shellfish between or within these areas or out of these areas to other waters, processing or socking facilities in PEI must apply to the Introduction and Transfer Committee for consideration.

MacIssac urged anyone finding *Styela clava* in other areas or attached to the hulls of their vessels to notify either DFO, provincial fisheries and aquaculture or someone in the industry so that a follow up could take place to ascertain if other areas are affected.

What is the view from the boat? *Carl Reynolds, Reynolds Island Mussels & Robert Fortune, United Mussel Farms*

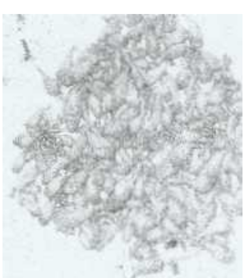
> ***Carl Reynolds,*** *of Reynolds Island Mussels, and* ***Robert Fortune,*** *of United Mussel Farms, presented their views as mussel growers on the seriousness of the tunicate fouling situation in Murray River, PEI, including increased costs of production, increased incidence of soft tissue injuries and processing challenges.*

Carl Reynolds, Reynolds Island Mussels

Carl Reynolds is a mid-size grower with a mussel lease in Murray River. In 2000 he and his crew observed no tunicate on their gear and mussel socks. In 2001 he indicated that they had a few tunicates on buoys and in July of 2002 the socks and gear on his lease looked like they had in 2001 (i.e., minimal fouling). However, by mid-August of 2002 tunicates were widespread on his lease and the density of the infestation (and area infested) increased throughout the summer and early fall.

Reynolds told the participants that by the fall of 2002 buoys were so heavy they had to be handled one buoy at a time onto the boat or wharf, even though in the past these buoys could be grouped together in bundles and moved by one individual. The addition of tunicates to mussel socks and gear in Murray River meant an increased labour requirement (both at the farm and plant level), as well as increased soft tissue injuries for crew members.

Treating Socks With Vinegar
Courtesy Garth Arsenault



Murray River Collector Sample
Courtesy Garth Arsenault

Reynolds noted a five inch piece of mussel seed collector rope taken out of Murray River during the past summer had 300 tunicates at various stages of growth and only five or six mussels.

Last year, Reynolds spent $40,000 to $50,000 in expenditures to clean tunicates from his lease and gear. His crew used a vinegar spray (5 % acetic acid) on the mussel lines and lime dip for the buoys.

Robert Fortune, United Mussel Farms

Robert Fortune, a large mussel grower and processor with leases in several tunicate infested areas (including Murray River) gave a brief overview of his experiences with the tunicate situation and the on-going tunicate research. He indicated that he felt that eradication of *Styela clava* was not possible but that there was a need to determine how to control the population.

Fortune indicated that in 2002 he treated all of his gear with the exception of one lease in the outer portion of Murray River that only had moderate tunicate settlement and that would be harvested in the fall. The comparison of the data from the 2001 and 2002 harvest (with a fixed number of lines) showed almost identical quality of size of the mussels and a minimal decrease in meat yield (one per cent) in 2002. However, while there was approximately 145,000 pounds of mussels harvested each of the years, in 2001 the harvest was accomplished with 13 loads (20 tanks per load) while the 2002 harvest took 17 loads. According to Fortune, this meant that in 2002 he and his crew harvested four loads, at 20 tanks per load, of tunicates. Between the extra harvesting costs and the clean-up of buoys fouled by the tunicates, Fortune indicated he had spent approximately another four cents per pound in 2002 to harvest his mussels from the area than he had the prior year. He also indicated that working in the tunicate infested areas was having an impact on the morale of the crews in the area.

Murray River Mussel Lines in 2002
Courtesy Matt Smith

As a part owner in a processing facility, Fortune indicated he had paid another $4,600 trucking tunicates to the plant, $1,900 for tippage fees to dispose of the waste, $7,100 for extra labour and $10,600 for processing. These costs, combined with the costs incurred by his grow out operation, meant that the mussels with tunicates on this lease cost an extra 11 cents per pound to market than those without tunicate fouling. Fortune indicated that these numbers could be considered conservative given the fact that the tunicates on the lease in question were small and the crop was only one year old.

Given the current numbers of pounds being harvested on PEI, if the tunicate situation is not addressed quickly, he felt the cost to the aquaculture industry alone could be in the $4.5 million range.

Fortune concluded that the industry needs extensive support from the scientific community to understand how to control and kill the tunicate.

SECTION FIVE - WHAT NEXT? STRATEGIES FOR 2003 AND BEYOND *Moderator Dr. Jeff Davidson, Atlantic Veterinary College*

Do we have a chance to eradicate or control them? Are the resources available to do what needs to be done?

PANEL DISCUSSION:

The following are the key points raised in the Panel Discussion at the end of the workshop:

- Eradication is not conceivable seemed to be the consensus. Management is the only alternative.
- *Styela* has no known predators in PEI, unlike *Ciona* in NS.
- Population control to reduce adult population is not conceivable because of the explosive capacity of this species.
- Control of tunicates add a cost (conservative) to growing mussels:
  -$0.045 per lb for the grower (cleaning socks and equipment)
  -$0.070 per lb for the processor (clogs equipment, dumping tunicate)
  -Total cost : $0.115 per lb
- Some mussel crews learned to spray socks using known agriculture techniques and equipment.
- Dr. Charles Lambert indicated that juvenile tunicates are attracted to tunicate adults. Perhaps researchers can explore the viability of growers making collectors to attract the tunicates and placing them along side the mussel lines, to reduce fouling on the crop.
- Gretchen and Charles Lambert have never seen such heavy infestations in the past 40 years they have been involved with tunicate as what they have seen in PEI.
- What the acetic acid (vinegar) does to kill the tunicate is unknown at this time.
- Tunicates will usually avoid light (260 nm) and they thrive under the mussel lines.
- Questions were raised about the validity of leaving an area fallow for a year (i.e. a rotation of crops). However, Kevin Heasman pointed out the impracticality of this approach given the tunicate larvae are moving over such large areas. A NS grower had tried this approach in the past to see if he could eliminate the *Ciona* fouling from his lease but he concluded there were too many other surfaces in the aquatic system for the tunicate to attach to.
- *Styela is* more abundant in higher current sites than *Ciona.*
- Best approach is a proactive one: early detection and immediate removal. Everyone is ill-equipped to deal with these tunicates.

\+ Heasman indicated that the technology New Zealand had developed to control *Ciona* on their mussel crops would, in all likelihood, work in Atlantic Canada and indicated that limiting the inoculation pressure was the key to managing the tunicate.

- While funding is often available for long term scientific projects (AFRI, IRAP, CCFI, etc.) they have lengthy approval processes and sometimes have prohibitive requirements for the industry (i.e. application timing, industry contribution requirements, etc.). The aquaculture industry requires an emergency fund in place to help farmers deal with invasive problems (similar to what is seen for terrestrial farmers/sectors) and to find suitable solutions in a timely fashion.
- There should be a short term (emergency) and a long term (developmental- mitigation efforts) fund in place.

APPENDICES

ATLANTIC CANADIAN TUNICATE WORKSHOP
Atlantic Veterinary College, Lecture Theatre `A'
Charlottetown, PEI
March 29, 2003

8:30 Welcome and Introductory Remarks - DFO

8:45 Why Worry About Tunicate Invaders? *Gretchen & Charles Lambert*
Basic Life History of *Ciona, Styela* and other aggressive invader tunicate species, Reproduction and Population Dynamics, Settling Preferences, New Invaders

9:15 What Is The Tunicate Situation In Atlantic Canada? *Crystal McDonald*
History of Ciona and Styela invasion, Current Situation, Impact, Future Concerns

Open Discussion

10:00 "What Are We Doing About It?" *(Moderator Richard Gallant)*
15 minute presentations + 5 minute Q&A

A **World-Wide View Of Tunicate Mitigation Efforts** *Gretchen & Charles Lambert*

10:20 BREAK

10:30 What Are We Doing About It? (Continued)

Are The Efforts Paying Off In New Zealand & **South Africa?** *TBA*

What Has Nova Scotia Been Able To Learn? *Claire Carver/Peter Darnell*

What Are We Learning About Styela On PEI? *Neil MacNair*

Potential Impact of Recruitment on Mussel Productivity. *Daniel Bourque*

Is there technology to treat processing plant effluent? *Chris Mills*

Open Discussion

12:15 LUNCH (AVC **Cafeteria)**

1:15 "What Can We Do About It?" -Policy & **Regulation** *(Moderator Thomas Landry)*

How Are They Spreading Now That They're Here? *Jeff Davidson*

Can We Control The Movement of Tunicates? *Colin McIssac*

BREAK

What's The View From the Boat? *Carl Reynolds*
Industry View Point

Open Discussion

3:15 **"What Next?" - Strategies For 2003** & **Beyond** *(Moderator JeffDavidson)*
Do We Have A Chance To Eradicate or Control Them?
Discussion Panel: Gretchen & Charles Lambert, Robert Fortune, Peter Darnell, Neil MacNair

Are the Resources Available To Do What Needs To Be Done?
Panel: Colin Maclsaac, Susan Vatcher, Carl Reynolds

Summary & **Closing Comments**

Atlantic Canadian Tunicate Workshop

March 29, 2003

List of Participants

PARTICIPANT	COMPANY
Andre Mallet	Mallet Research Services Ltd.
Andrea Locke	Fisheries & Oceans Canada
Andrew Bagnall	N.S. Agriculture & Fisheries
Andy Woyewoda	National Research Council/IRAP
Angeline LeBlanc	Fisheries & Oceans Canada
Barry Campbell	Stewart Mussel Farms Inc.
Benedikte Vercaemer	Fisheries & Oceans Canada
Blaine Thibeau	Blue Cove Aqua Farms
Bob Creed	Ocean View Mussel Farms Ltd.
Bob Johnston	Northern Aquaculture
Brian Gillis	P.E.I. Fisheries, Aquaculture & Environment
Carl Reynolds	Reynolds Island Mussels Company Ltd.
Charles Lambert	University of Washington Friday Harbor Laboratories
Chris Mills	P.E.I. Fisheries, Aquaculture & Environment
Chris Somers	Somers Island Blue Inc.
Christine Paetzoid	Atlantic Veterinary College
Claire Carver	Mallet Research Services Ltd.
Colin Adams	Stewart Mussel Farms Inc.
Colin Maclsaac	Fisheries & Oceans Canada
Colin Reynolds	Reynolds Island Mussels Company Ltd.
Crystal McDonald	P.E.I. Aquaculture Alliance

Dale Cooke	Corkums Island Mussel Farm
Daniel Bourque	Fisheries & Oceans Canada
Darlene Elie	Office of the Commissioner for Aquaculture Development
Darrell Harris	Bedford Institute of Oceanography
Darrell MacLeod	Cape North Mussels Ltd.
Dave Younker	P.E.I. Fisheries, Aquaculture & Environment
David Gavin	E & G Rogers Mussel Farm s Ltd.
Denise Methe	Aquaculture Collaborative Research & Development Program
Dianne Rogers	E & G Rogers Mussel Farms Ltd.
Don Deibel	Nfld. Memorial University
Frank Boothroyd	Atlantic Veterinary College
Fred Hillier	Hillier Mussel Farms
Garth Arsenault	Atlantic Veterinary College
Gary Rogers	E & G Rogers Mussel Farms Ltd.
Gary Smith	P.E.I. Fisheries, Aquaculture & Environment
Gordie MacLean	Mussel Bound Inc.
Gretchen Lambert	University of Washington Friday Harbor Laboratories
Irwin Judson	Sea Springs Industries Inc.
Jaques Mallet	N.B. Agriculture, Fisheries & Aquaculture
Jason Mullen	Aquaculture Association of Nova Scotia
Jeff Davidson	Atlantic Veterinary College
Jerry Bidgood	Prince Edward Aqua Farms Inc.
Jerry Coles	E & G Rogers Mussel Farms Ltd.
Jim Jones	Fisheries & Oceans Canada
Jim Martin	Fisheries & Oceans Canada
Job Halfyard	Sunrise Fish Farms

John Clark	n/a
John Sullivan	Atlantic Mussel Growers Corp.
Kenny Jackson	n/a
Kent Burry	E & G Rogers Mussel Farms Ltd.
Kent Ferguson	Go Deep International Inc.
Kevin Heasman	N.Z. Cawthron Institute
Lea Murphy	Fisheries & Oceans Canada
Leon Lanteigne	Senpaq Consultants
Lew Clancey	N.S. Agriculture & Fisheries
Lisa McKillop	P.E.I. Aquaculture Alliance
Marcel Poirier	M.P. Aquaculture Inc.
Marie-Josee Maillet	N.B. Agriculture, Fisheries & Aquaculture
Mario Noel	Noel Aquaculture Inc.
Matt Smith	P.E.I. Fisheries, Aquaculture & Environment
Maurice Levesque	Fisheries & Oceans Canada
Maurice Mallet	Fisheries & Oceans Canada
Nathalie Chaisson	Noel Aquaculture Inc.
Neil Blackett	N & L
Neil Ellsworth	Stewart Mussel Farms Inc.
Neil LeBlanc	Atlantic Veterinary College
Neil MacNair	P.E.I. Fisheries, Aquaculture & Environment
Patrick Stewart	Envirosphere Consultants Ltd.
Peter Darnell	Indian Point Marine Farms Ltd.
Ralph Bernard	Stewart Mussel Farms Inc.
Ralph MacPherson	Murray River Mussel Ltd.
Randy Patton	Ocean View Mussel Farms Inc.
Richard Farmer	Sea Springs Industries Inc.
Richard Gallant	P.E.I. Fisheries, Aquaculture & Environment

Robert Fortune	United Mussel Farms
Robert Murphy	Murphy Mussel Farms Ltd.
Robert Thompson	P.E.I. Fisheries, Aquaculture & Environment
Rodney Gamble	Stewart Mussel Farms Inc.
Roger Townshend	New Wave Shellfish Farm
Ron Arsenault	Stewart Mussel Farms Inc.
Russell Dockendorff	Atlantic Shellfish Inc.
Sam Bower	Atkinson & Bower Ltd.
Sean MacNeill	Nfld. Aquaculture Industry Alliance
Shane Bernard	Stewart Mussel Farms Inc.
Shawn Banks	P.E.I. Fisheries, Aquaculture & Environment
Shawn Robinson	Nfld. Fisheries & Aquaculture
Sirje Weldon	Aquaculture Association of Nova Scotia
Stephanie Howes	Dalhousie University
Stephen Lanteigne	Office of the Commissioner for Aquaculture Development
Stephen Stewart	Stewart Mussel Farms Inc.
Steve Yoston	n/a
Susan Vatcher	National Research Council/IRAP
Thomas Landry	Fisheries & Oceans Canada
Toby Balch	N.S. Agriculture & Fisheries
Tommy Joe MacDonald	P.E.I. Fisheries, Aquaculture & Environment
Trevor LeClair	E & G Rogers Mussel Farms Ltd.
Troy Perry	Stewart Mussel Farms Inc.
Vernon Yoston	n/a
Wayne Smith	Ocean Echo Shellfish Inc.
Wayne Turple	Turple's Blue Bay Mussel Farm

Ascidian workshop

Charlottetown, P.E.I. March 29, 2003
Gretchen and Charles Lambert
Univ. of Washington Friday Harbor Labs
glambert@fullerton.edu, clambert@fullerton.edu

What is a tunicate?

Phylum Chordata

Sub-phylum Urochordata (= Tunicata) [the invertebrate chordates]
all marine; related to echinoderms
Class Ascidiacea (= ascidians, tunicates or sea squirts) - **sessile filter feeding adults, swimming short lived non-feeding tadpole larvae**

- Order Phlebobranchia - SOLITARY OR SOCIAL; THIN TUNIC.
  Examples: *Ascidiella, Ciona, Corella*
- Order Stolidobranchia - MOST ARE SOLITARY with THICK LEATHERY TUNIC *(Styela, Molgula);* a few are *colonial (Botrylloides, Botryllus)*
- Order Aplousobranchia -- ALL COLONIAL. Examples: *Didemnum, Diplosoma*

Life History Strategies

- **Solitary species:**

No budding.
1000s of eggs. Most species spawn gametes into the sea.
Develop in sea one or 2 days.
Tadpole swims 1-5 days -> Metamorphosis. **Tadpole prefers shade:** Becomes photonegative when ready to settle.

- **Colonial species:**

Extensive budding -* New zooids.
1-20 eggs per zooid, develop in colony several weeks. Tadpole released ready for metamorphosis, swims only a few minutes.

Reproduction and Life Cycle

- **Spawning**

Light Important. *Ciona:* dark 1 hour minimum, then 30 minutes light -* Spawn; *Styela:* 12 hours dark then 12 hours light -* Spawn.

- **Fertilization**

All ascidians are both male and female (= hermaphrodites) but fertilization is usually from another individual. Eggs attract sperm.

- **Development**

Solitary: Mostly free in sea, generally one day until hatching of tadpole larva which swims one (usually) to several (rarely) days until metamorphosis.

Colonial: Eggs develop in colony up to several weeks then release tadpole larvae ready to metamorphose.

- **Metamorphosis:** Requires hard substrate and shade.
- **Growth And Reproduction:** After metamorphosis, only one or two months until reproductive. Important to clean (manually, high pressure hose) mussel lines at intervals shorter than time from metamorphosis to spawning. Colonial species can regrow asexually from colony fragments left behind during cleaning.

Tadpole larva

- **Structure**

Solitary: Simple Structure 1 mm long.

Colonial: More than 1 mm long, very complex, sometimes with several buds.

- **Properties**

Does not feed.

Short Lived: *Styela clava* tadpole swims 1-5 days. Colonial tadpole swims minutes.

Metamorphosis

- Requires hard substrate such as rock, rope or mussel. Shade preferred.

Vulnerable Point in Life Cycle.

Strategy: Provide nearby lines to encourage metamorphosis on non-mussel substrate. These do not need to be as strong as mussel lines. Do not clean; metamorphosis is induced by adult *Styela* on non-mussel lines. Outcome -> reduces metamorphosis on mussels.

Recommendations for control of *Styela clava*

- **Early detection and rapid response**

Manual removal. Timing important: prior to release of larvae/gametes. Avoid fragmentation of colonials. Disposal in landfill. Involve the community.

*Dessication

*Fresh or low salinity water immersion (< 20 ‰) or vinegar dip

Periodic high pressure seawater hosing

Introduction of grazers on lines? Nudibranchs?

Introduction of additional non-mussel lines for tadpoles to settle on

Development of new markets

Food, pharmaceuticals, research and classroom education

Styela clava as a food source

- Highly prized by Asian cultures, farmed in Korea and Japan. Related species farmed in France, Chile and other countries.
- **Korea:** Dr. Jae-Yoon Jo: Head of Department of Aquaculture, Pukyong Natl. University. e-mail: jyjo@dolphin.pknu.ac.kr
- **Japan:** Dr. Haruhisa Shionoya, Hands and Mind Ltd., Sapporo, Japan hm@izasio.co.jp

What is the tunicate situation
in Atlantic Canada?

Atlantic Canadian Tunicate Workshop
Atlantic Veterinary College
Charlottetown, PEI
March 29, 2003

Presentation Overview

- Canadian & Mussel Aquaculture At A Glance
- Two Tunicates Seriously Impacting Atlantic Shellfish Aquaculture
  - *styela daua*
  - *Bona intestinalis*
- History and Current Situation of the Styela Invasion of
- History and Current Situation of the Ciona Invasion of NS
- PEI & NS Mussel Industry Impact/Efforts To Date
- Future Concerns

Canadian Aquaculture At A Glance

- 2000 Value of $665 M
  - Finfish 90%, shellfish 10%
  - NB & BC major production provinces
  - NB - $50M
  - NS -- $43.5M
  - PEI - $28M in shellfish (80% Canadian Mussel Production)
- Economically/environmentally sustainable
- Poised for continued growth/development

Mussel Aquaculture At A Glance

What is *Styela clava?*

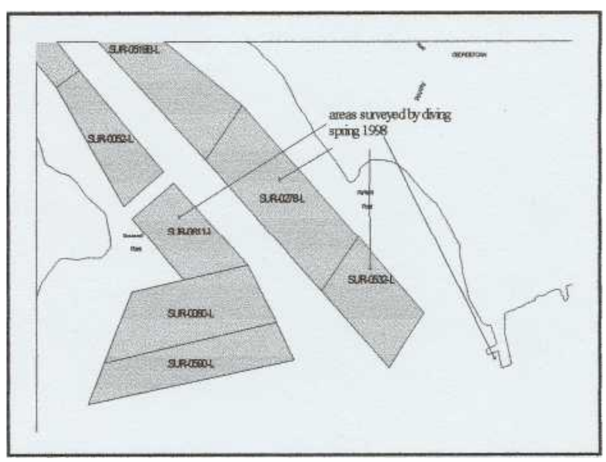
- Fouling organism that will grow on most substrates
- Invertebrate species - filter feeder that competes directly with shellfish for space and food
- Animal named from protective covering (sac) known as the tunic

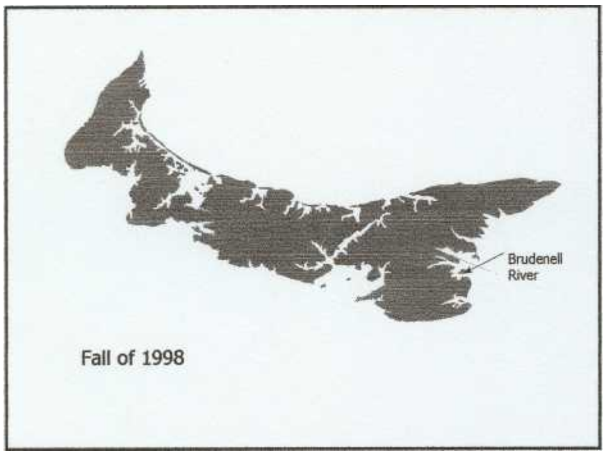
Styela clava Origin

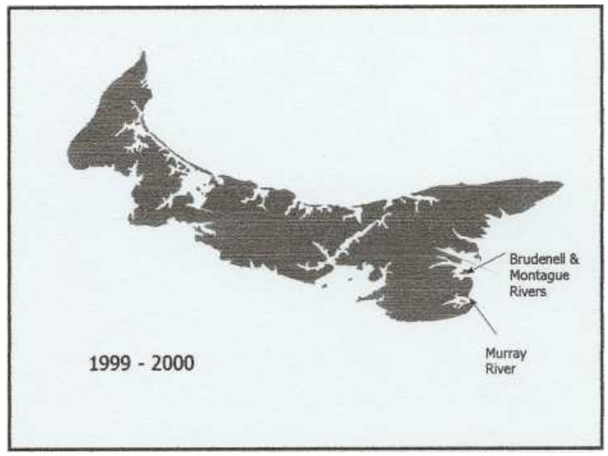
- Likely originated in Asia (It's spread first implicated with Korean War military ship traffic)
- Reported in Australia, South Africa, Europe (France, Holland, Denmark, S. Ireland) and US (E/W Coast)
- Very successful in newly established areas - very hardy, resistant to salinity and temperature fluctuations
- Holland - reported population spread as "explosive" once established

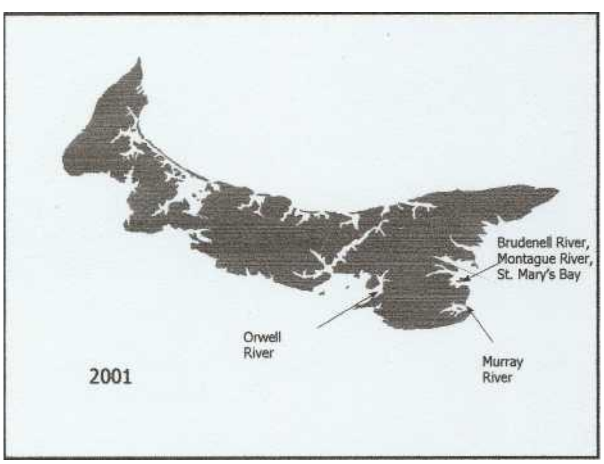
Styela History In Atlantic Canada

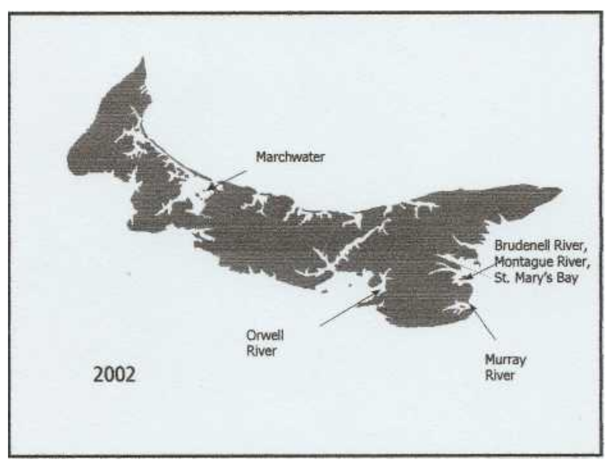
- Spread likely due to adult animals being moved on bottoms of boats, on/with affected shellfish, or in ballast/bilge water
- First/only report in Canada - PEI in Spring 1998




Brudenell
River
Fall of 1998


Brudenell &
Montague
Rivers
Murray
River
1999 - 2000


Brudenell River,
Montague River,
St. Mary's Bay
Orwell
River
Murray
River
2001


Marchwater
Brudenell River,
Montague River,
St. Mary's Bay
Orwell
River
Murray
River
2002

Current Status of *Styela* In Atlantic Canada

- Mussel farms heavily fouled in Murray River, Brudenell River & Montague River
- Light fouling of spat collection lines in Vernon & Orwell Rivers
- Light fouling of gear in Marchwater

What's being done?

- Ongoing efforts to develop treatments
- Research into the basic biology
- Farm practices being discussed/developed
- I & T restrictions on movement of shellfish
- Extensive monitoring
- Education efforts

What is *Ciona Intestinalis*?

- Large tubular sea squirt
- Grows up to 15 cm in length
- Body is soft
- Pale translucent greenish yellow (with or without orange bars)
- Filter feeder with two large siphons at the top (inhalant/exhalant)

What is *Ciona Intestinalis*?
(continued)

- Commonly found attached to hard substrates (i.e. docks)
- Prefers habitat with low wave exposure and some water flow

Ciona Intestinalis Origin

- Believed to have originated as a North Atlantic species
- Has spread widely through shipping to all temperate regions
- Significant nuisance fouling species in aquaculture, reported in mussel rope culture, oyster farms from NS, the Mediterranean, S. Africa, Korea, Chile and North America

Ciona History In Atlantic Canada

- Mid-90's an invasion of a NS mussel farm at Corkum's Island in Lunenburg Bay
- Subsequent invasion of Mahone Bay mussel leases
- Corkum's Island leaseholder removed all structures after nearly 20 yrs in the business
- Mahone Bay processor impacted by Corkum's Island loss

Current Status of *Ciona* In Atlantic Canada

- Mahone Bay grower concerned with viability (5 of 7 leases "very infested")
- Currently spread from the Pubnicos to Halifax
- Ciona in Ille Madame in Cape Breton in significant numbers

What is being done?

- Industry/government research into treatment methods
- Individual growers trying techniques
- Discussions with others (e.g. PEI, New Zealand) regarding potential mitigation measures

Future Prospects

- Styela and Ciona will likely survive and continue to spread
- Eradication not likely an option
- Control via treatment will not be as straight forward as with native pests
- Collectively we need to develop methods and techniques to manage
- New invasive tunicates on the radar screen?

What Are We Missing?

- Tougher legislation on commercial shipping practices (ballast water treatment, hull cleaning)
- Inclusion of commercial fishery (i.e. lobster) in the National Introduction and Transfers Guidelines
- Education and policies for recreational boaters and local fishers
- Dedicated research and development resources

What Do We Need?

- DFO leadership on invasive species management and response to new invaders
- Resources to:
  - monitor the movement of new invaders,
  - sample and analyze new species,
  - assist grower with the technical and financial aspects
  - trial materials, develop treatment methodologies and equipment
- Recognition that growers' and fishers' pockets are only so deep

AQUACULTURE ASSOCIATION
OF NOVA SCOTIA

Tunicates Effecting the Nova Scotia Shellfish Industry

The Shellfish industry is currently facing serious problems from invasive fouling species, particularly Tunicates. Tunicates are from the phylum Urochordata in which they are formally known as Ascidians or commonly as sea squirts. The name sea squirt derives from the fact that they are filter feeding organisms that continually feed on microscopic zoo and phytoplankton from the water column and are contractile when disturbed expelling the water from their bodies. Tunicates are seen in three varieties solitary, colonial and pelagic. Solitary tunicates such as *Ciona intestinalis* are often seen to have two `siphons' that are used as an incurrent and excurrent flow for food containing seawater. These structures join the torso of the animal called the tunic, as it often resembles, hence the name Tunicate **(Fig. 1).**

Figure 1 Solitary Tunicate, *Ciona intestinalis*

Tunicates have been a growing concern to shellfish farmers around the world, and have become a top priority for applied research. The impact of these animals on hanging culture (i.e. mussels, oysters, scallops) is significant as they can become heavily concentrated on this substrate, competing for food with the mussels as well as adding an immense amount of weight to the lines that often cause cultured mussels to be pulled off their lines and fall to the bottom where they are preyed upon by crabs and starfish. Organisms such as tunicates settle more easily and grow better on the shells of the mussels and on nets which are exposed to water from all sides. In competing for food and space the tunicates affect the commercial yield of shellfish on rope culture. They can easily overgrow mussels and nets to the point where mussels can no longer open their bivalve shells to feed (Fig. 2).

Figure 2. *Styela clava & Ciona intestinalis* on Mussel lines in Denmark

The dispersal of these animals is usually limited since fertilized eggs and developing larvae are maintained in mucus strings. However, short-distance dispersal does occur by drifting eggs, egg-strings and swimming larvae. Introduction in other sites may also be caused by adult specimens attached to boats, rafts or some drifting materials.

In Atlantic Canada, the shellfish culture industry is currently facing a threat from three species of tunicates, *Ciona intestinalis, Styela clava* and *Botryllus scleroseri.* The species *Ciona intestinalis, is* a solitary tunicate, has been found on several mussel farms in Nova Scotia, particularly on the south shore region. However, this tunicate has been rapidly increasing in abundance and prevalence on these farms at an alarming rate **(Fig 3).** As a result of the severity of *Ciona intestinalis* fouling, some mussel farmers have gone out of business, while others still in the business are still struggling to maintain the viability of their operations.

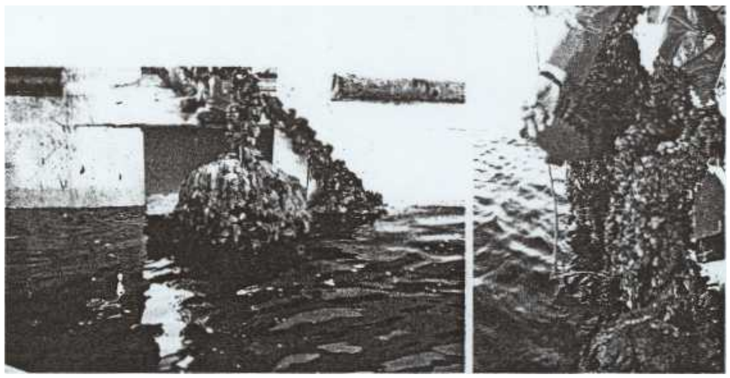


Figure 3. *Ciona intestinalis* on a Nova Scotian Mussel Farm

The tunicate *Botryllus scleroseri,* colonial tunicate, has been recently found on oyster farms in Nova Scotia, particularly affecting juvenile oysters on seed collectors. This colonial tunicate which is seen as an assemblage of many single tunicates, completely covers the young oysters and subsequently kills them by restricting their access to flowing water which they rely on for respiration and feeding **(Fig. 4).** This tunicate has recently also been seen in increasing intensities on mussel farms in throughout Maritime Provinces.

Figure 4. Colonial Tunicate, *Botryllus scleroseri*

The third species which has been causing considerable damage to the PEI mussel industry is *Styela clava.* Styela clava is solitary tunicate that has a thick, hardy epithelium and has proven to be a tough competitor for settlement space and food. Since its introduction it has been spreading rapidly throughout farms in the province significantly reducing the ability of farmers to grow their mussels because of the overwhelming abundance of these animals on their sites **(Fig. 5)**

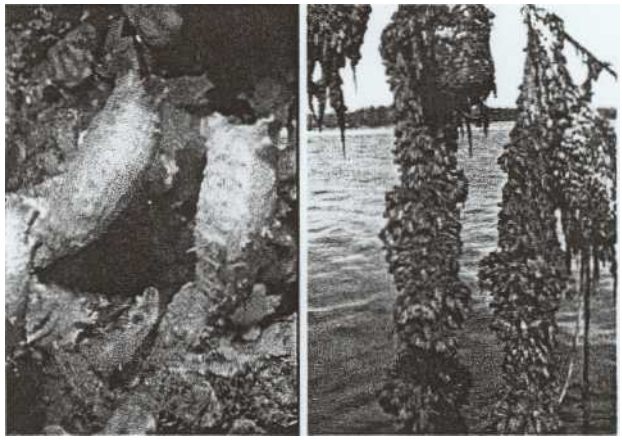


Figure 5 - Styela clava & Heavy infestation of *Styela clava* on a PEI mussel farm.

Efforts are underway now in PEI to control the effects and spread of the tunicate *Styela clava.* This tunicate has spread throughout much of PEI's mussels industry and put the vitality of many of their operations in jeopardy. The mussel industry in Nova Scotia is very concerned about the introduction of this species through mussel seed transfers and boat traffic that regularly occur between the provinces as it does not have this tunicate at this time.

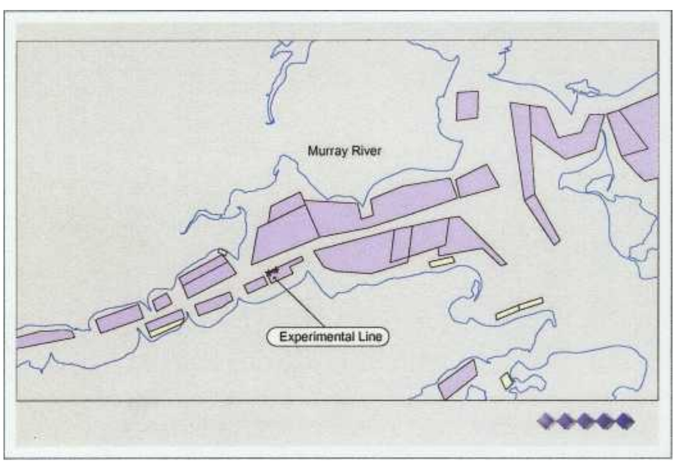
Previously the Aquaculture Association of Nova Scotia has conducted a world wide search on the effect of this organism on shellfish aquaculture production around the world and has data based regional and international researchers and industry partners that have been addressing this tunicate problem. We are now at the point where it is necessary to conduct experimental control measures on the species of tunicates that are affecting shellfish culture in Nova Scotia. We are seeking support from government regulatory bodies, researchers and research funding agencies to work in conjunction with the PEI mussel industry to solve this problem facing our industry. Tunicates are now appearing at other previously uninfected sites in Nova Scotia and Prince Edward Island and could prove to be a major constraint to the survival and expansion of the shellfish industry. Efforts must be made to control the population of this invader on affected farms and contain its spread to other farms throughout the region.

Results of S. *clava* Field Studies - 2002

PEI Department of Fisheries, Aquaculture and Environment

Presentation Overview

- **Survey for tunicate larvae.**
- **Tunicate #'s on spring socked mussels @ 3 seed densities.**
- **Brine, lime and vinegar treatments on tunicates on collectors.**
- **Treatments on tunicates on spring socked mussels using various substances.**

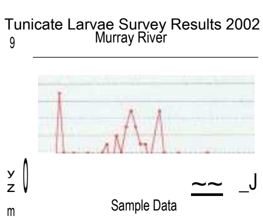


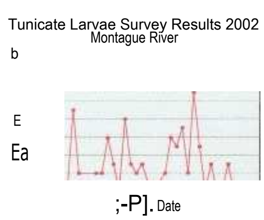
Tunicate Larvae Survey

- Survey for tunicate larvae presence at three locations -Murray River, Montague/Brudenell River, and Orwell River.
- Late June to November - samples collected twice weekly.

Tunicate Larvae Survey

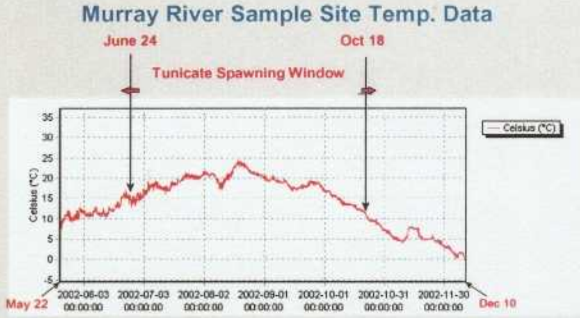
- Pump samples collected by 3 minute pump @ 50 L/min. through a 60 micron screen (procedure used for mussel larvae).
- Samples were collected in the top 3 meters of the water column.
- Sample were generally collected at midday.





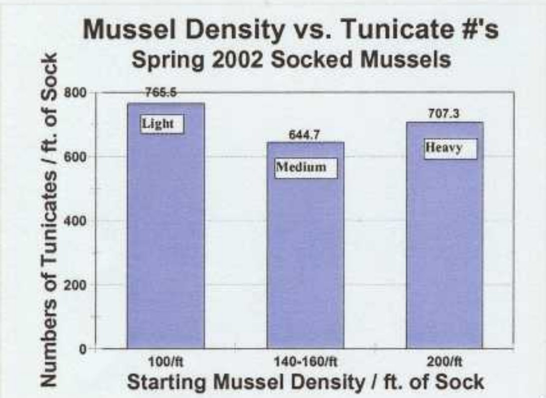
In comparison to mussel larvae sampling - these numbers would be reported as low to medium concentration (avg. of 1 per 4L).

Murray River Sample Site Temp. Data



Mussel Density vs Tunicate #'s

- **Three densities of spring socked mussels light, medium and heavy - in triplicate.**
  - Light @ approx. -100 mussels/ft.
  - Medium @ approx. - 140-160 mussels/ft.
  - Heavy @ approx. - 200 mussels/ft.
- **Put out on June 21/02 .**
- **One ft. removed November 04/02- mussels counted, measured and tunicates counted.**



Tunicate Treatments

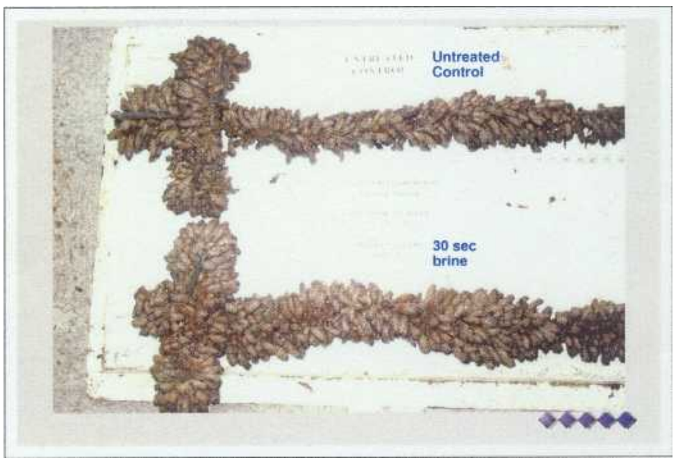
- Placed 150 collectors out in June.

Tunicate Treatments

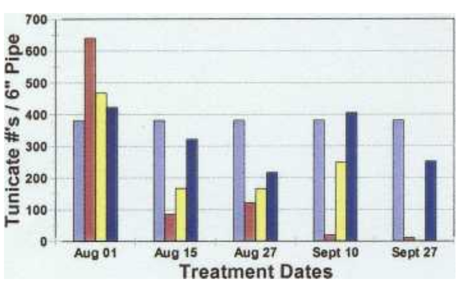
- Wanted to determine:
  - best time of year to treat (based on the premise that realistic to treat one time only (time and expense) - 5 treatment trials in Aug and Sept - 30 collectors/trial.
  - best treatment agent - sat. brine, 4% lime or 5% acetic acid (vinegar) - 9 collectors /treatment + 3 untreated.
  - treatment immersion time required - 30", 15", quick dip (in/out) - three collectors/treatment time.
- Collectors treated one time only.

Tunicate Collector Treatments

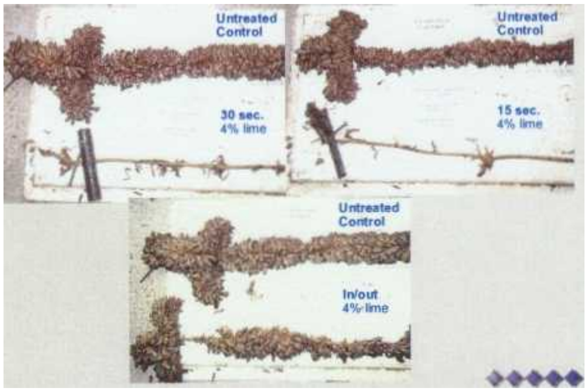
- **November - collectors harvested**
  - Weight and numbers of tunicates determined on 1 foot of rope and on 6 inches of pipe.



Tunicate Collector Treatment Trials
4% Lime

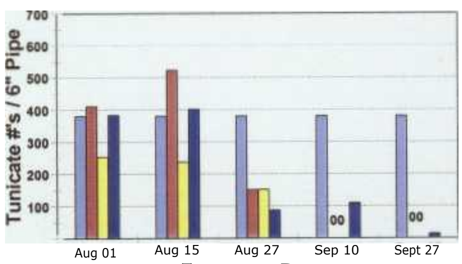


Control ,, **30 sec.** **15 sec.** — **in/out**



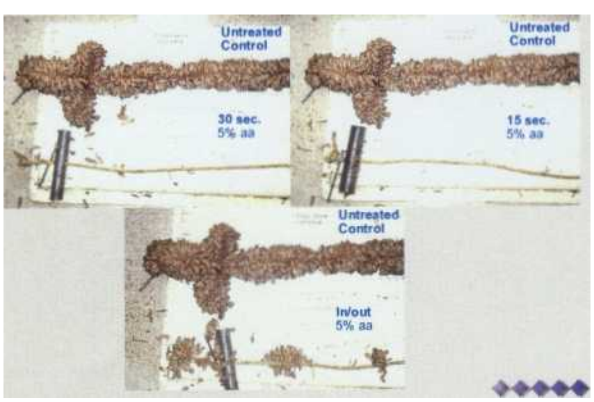
Tunicate Collector Treatment Trials

5% Acetic Acid



Treatment Dates

Control ® 30 sec. 15 sec. — in/out



Tunicate Collector Treatments

Conclusions

- Brine was ineffective - even on the smaller tunicates. Seemed to improve tunicate growth and settlement.
- Lime was most effective at the 30 and 15 second immersion times - but unpredictable.
- Acetic acid (vinegar) was the best treatment overall.

Tunicate Collector Treatments

Conclusions

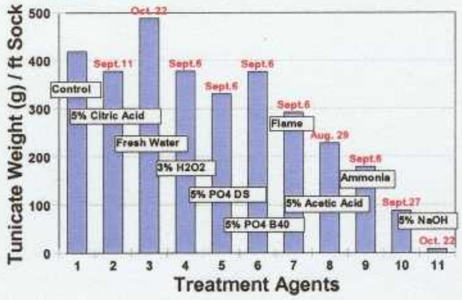
~ The best time of year to treat is after the tunicate set - late September and after.

Spring Socked Mussel Treatments

- From Sept. to Oct. a variety of treatments were applied to tunicate fouled spring socked mussels.
- Treatments included:
  Citric acid, fresh water, hydrogen peroxide, phosphoric acid with two detergents, propane flame, acetic acid ammonia, sodium hydroxide and electricity.

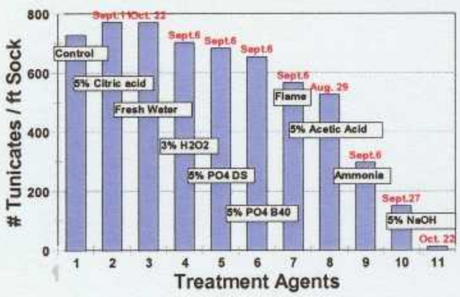
Tunicate / Mussel Treatment Trials

Spray Application - Tunicate Mortality



Tunicate / Mussel Treatment Trials

Spray Application - Tunicate Mortality

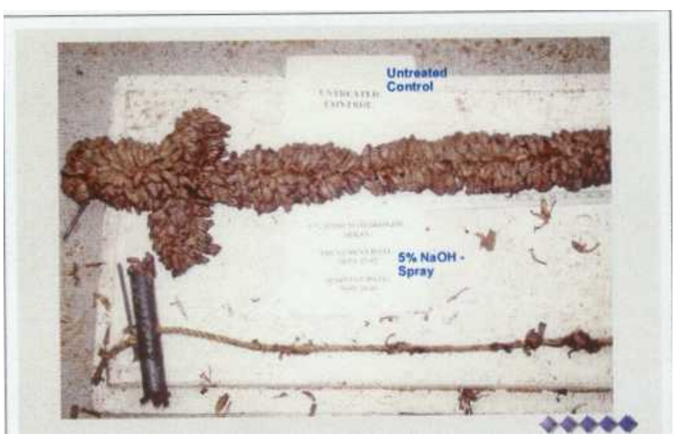


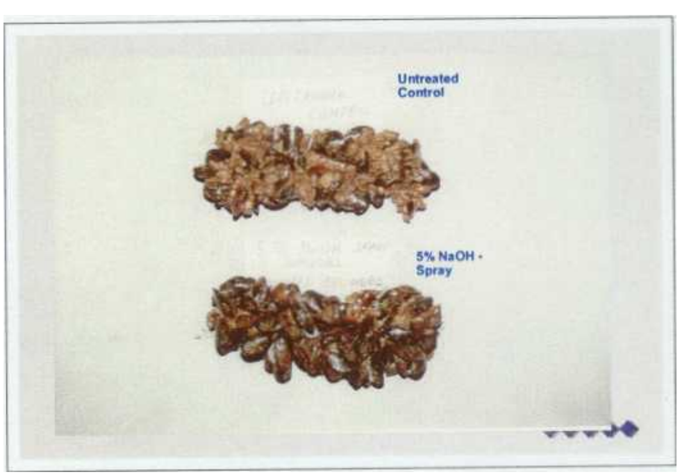
Conclusions

Spray Application

- Ineffective treatments included: citric acid, freshwater, phosphoric acid, flame, electricity (15" and 60 amps @ 4000 and 1000 volts).
- Treatments that showed promise include: acetic acid, ammonia and sodium hydroxide.


Untreated Control
25% Ammonia Solution Treated Sept. 10, Harvested Dec 05

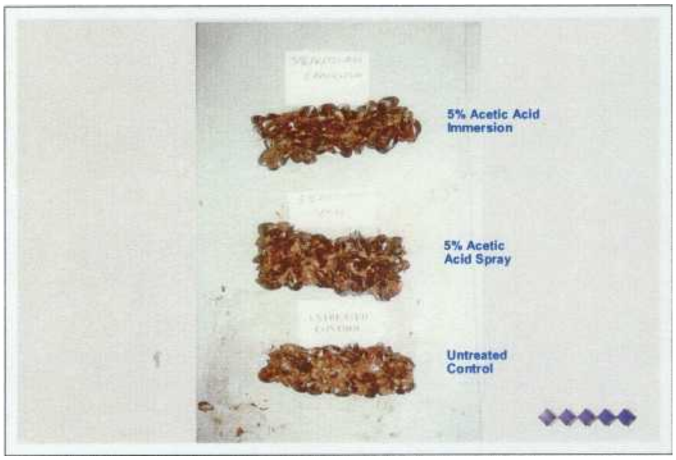

Untreated Control
5% NaOH - Spray

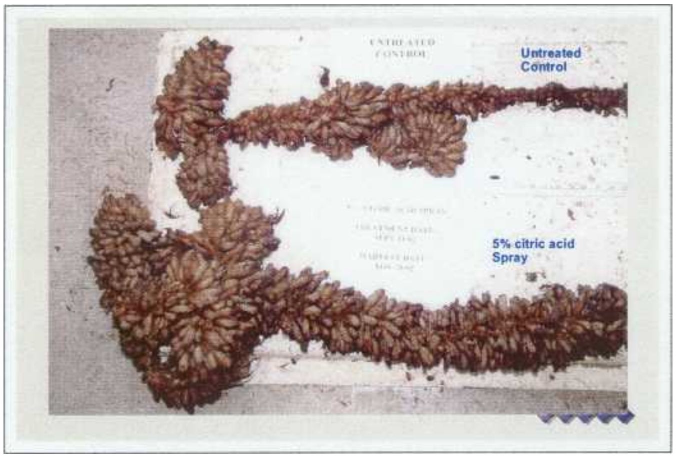

Untreated Control
5% NaOH - Spray

Conclusions

Immersion Application

- Application methods - immersion vs. spray needs field testing.
- Immersion appears to be more effective but the application logistics are complicated - (le. dilution and determination of concentration).




UNTREATED
CONTROL
Untreated
Control
5% citric acid
Spray

Conclusions

- The issues of: application method, safety, acceptance for use in the environment and cost all require discussion.

IS THERE TECHNOLOGY FOR PROCESSING PLANT EFFLUENT TREATMENT?

Atlantic Canadian Tunicate Workshop
AVC, Charlottetown, PEI
March 29, 2003
Presented by Chris Mills, PEI DFAE

THE ISSUE

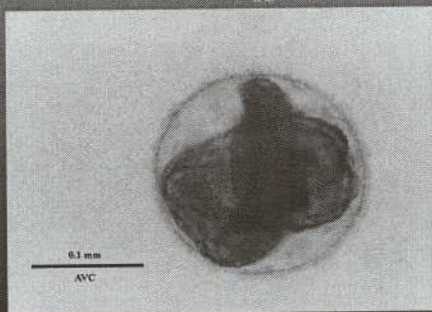
- Live whole tunicates that exit a processing plant in the effluent.
- Tunicate larvae
- Fertilized tunicate eggs

THE ISSUE

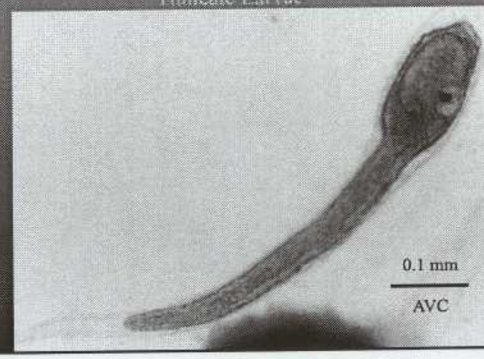
THE ISSUE

THE ISSUE

THE ISSUE
Tunicate Eggs



THE ISSUE
Tunicate Larvae



WHAT ARE WE SEEING?

- Eggs in the effluent (non-fertilized?)
- Some larvae exiting the holding tanks
- Monitoring the effluent is made very difficult due to the high suspended solids in the effluent
- No larvae found in effluent stream in river adjacent to plant.

THE ISSUE
Water Quality

- Total Suspended Solids (TSS) concentrations of 3500 ppm while stripping.
- Average particle size of 30☞
- 85% of the particles are < 90☞
- What causes this poor water quality - silt, mussel feces and pseudofeces

INTRODUCTIONS AND TRANSFER LISCENSE CONDITIONS

- Terms and conditions of effluent release developed in response to the effort to slow down the spread of tunicates.
- Pertain to processing mussels from tunicate infested areas
- Federal regulations administered by DFO under the National Code of Introductions and Transfer of Aquatic Organisms

INTRODUCTIONS AND TRANSFER LISCENSE ORIGINAL CONDITIONS

- Water temperature < 10°C - remove the whole tunicates
- Water temperature >10°C - remove the eggs and larvae   ie. Screen size < 80☞

INTRODUCTION AND TRANSFERE CURRENT CONDITIONS

- Screen effluent to 750 microns.
  - Not temperature dependant
- Continue efforts to remove larvae and eggs from effluent

OPTIONS FOR EFFLUENT TREATMENT

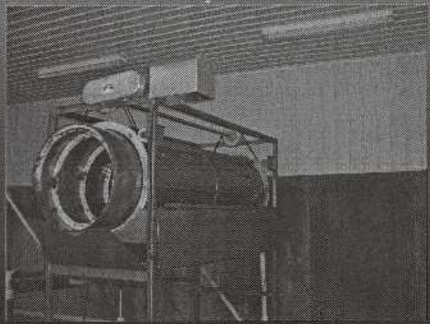
- MECHANICAL FILTRATION
- SOLID SEPARATORS
- ULTRAVIOLET RADIATION
- ULTRASONIC TECHNOLOGY (Cavitation)
- OZONE
- CHEMICAL TREATMENT (Chlorination)
- MARINE BIO-FOULING CONTROL (Copper anode)

MECHANICAL FILTRATION

- Physical removal of solids from the effluent
- Two Stages:
  - Primary treatment that removes particles >750 ☞
  - Secondary treatment that removes particles <750 ☞
- Primary treatment
  - Perforated Plate/Wire Mesh
    - Convex stationary screen
    - Rotating drum

MECHANICAL FILTRATION

Primary Treatment



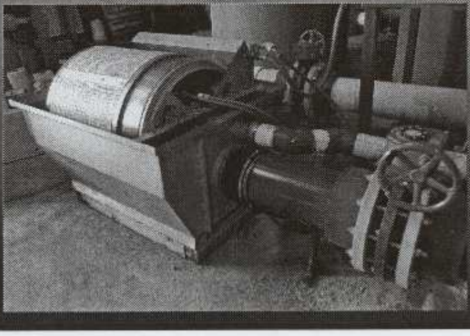
MECHANICAL FILTRATION

Secondary Treatment

- Microscreen
  - Rotary drum
  - Continuos belt

MECHANICAL FILTRATION

Secondary Treatment



MECHANICAL FILTRATION

- Advantages
- Used for many applications so the systems are readily available
- Low maintenance
- Disadvantages
- High suspended solid load
- Backwash water
- Equipment specifications / performance

SEPARATORS

Primary/Secondary Filtration

- Settling Pond / Swirl Separator
- Centrifuge Separator
- Remove 95% of 45 [illegible] particles with a specific gravity of 1.2 or greater
- No moving parts means little maintenance

ULTRAVIOLET RADIATION

- UV rays scrambles the DNA structure rendering the organism sterile.
- Advantages
- Relative low cost
- Systems readily available
- Disadvantages
- Efficiency is reduced with high suspended solids
- Maintenance costs in bulb replacement

ULTRASOUND (Cavitation)

- Uses sound waves to damage tissues
- Technology is being developed by American and Canadian navies to treat ballast water.
- Very little maintenance
- Preliminary contact with several companies indicate that this technology may be cost prohibitive.
- Mixed results depending on application

CHLORINATION

- Being discouraged due to possible impacts of chlorine on environment (toxic to shellfish larvae).
- Difficult logistics of providing enough contact time for treatment and de-chlorination.

OZONE

- Very powerful oxidizer. Ruptures the cell wall, releasing the contents of the cell for further oxidization
- Can be used to clarify and disinfect water
- Very little maintenance
- Preliminary contact with companies indicate that the cost of a full scale unit will be $100,000 to $500,000 for 1000 GPM flow

MARINE BIO-FOULING CONTROL

- Copper anode used to emit Copper ions into water.
- Copper stops the metamorphosis of larvae to adult forms.
- Literature that suggests that the develoment of eggs is also effected.
- Will solve problem of mussel fouling in effluent lines as well.

MARINE BIO-FOULING CONTROL

- Initial indications suggest system to treat 50 and 1000 GPM would cost $2,000 and $13,000 respectively.
- Unknown maintaince costs.

SUMMARY

- Mussel processing plants are a potential vector for the transfer of tunicates.
- Primary treatment with low cost mechanical filters ae proven to eiminate discharge of live whole tunicates.
- Development of systems to screen to < 80☞ is more challenging.

SUMMARY

- New application for these technologies which means time and money for development.
- All technologies talk in terms of reduction NOT elimination.
- Consideration should be given to combining systems and/or technologies.

SUMMARY

- Management of tunicates in the plant will reduce the potential for discharge
- Access mussels from tunicate free areas during the peak tunicate spawning period.
- Keep the tunicates off the floor. Minimize the possibility of eggs and sperm getting into the effluent.
- Decrease the flow rate of the effluent.
- Remove silt before it reaches the plant.

Tunicate Recruitment in Three Mussel Growing Areas of PEI

Jeff Davidson & Garth Arsenault
Atlantic Veterinary College
March 29, 2002

Collaborative Project between:

- Atlantic Veterinary College
- DFO Science Branch-Moncton
- PEI Dept. of Fisheries, Aquaculture and Environment
- PEI Aquaculture Alliance

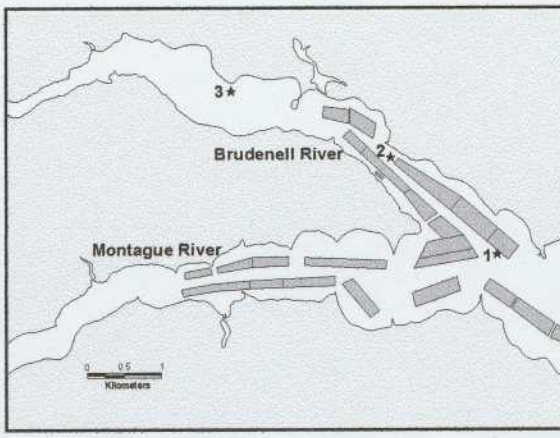
Funded by:

PEI Aquaculture Alliance

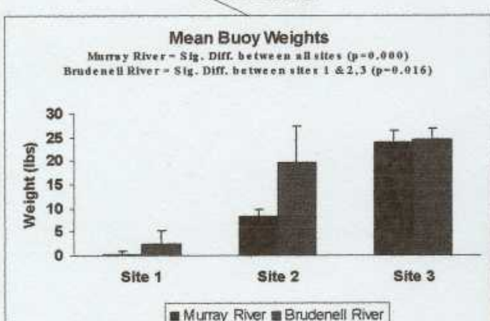
PEI Aquaculture and Fisheries Research Initiative (AFRI)

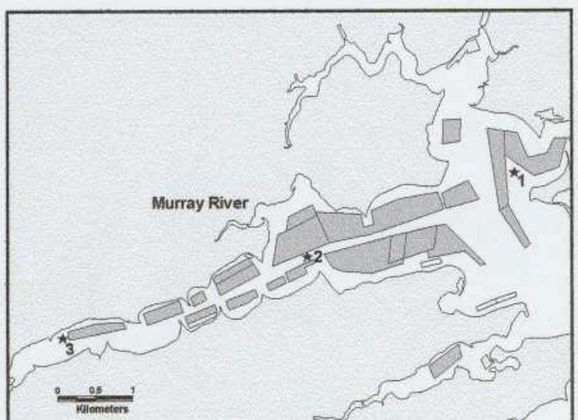
NRC – IRAP programme

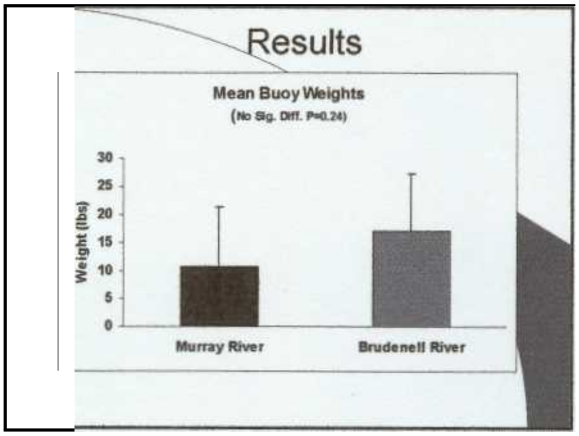
- Objectives:
  - quantify the settlement and growth of tunicates in different locations in three infested areas
  - Associations with temperature, salinity and productivity
- Brudenell, Murray and Vernon/Orwell Rivers
  - History of tunicate infestation
- Deployed three buoys at each of three locations in each river system - early July, 2002
- Deployed continuous Vemco temperature recorders at each site
- Returned monthly to examine and photograph buoys and perform secchi disc reading
- Collected buoys in November for analysis at AVC lab



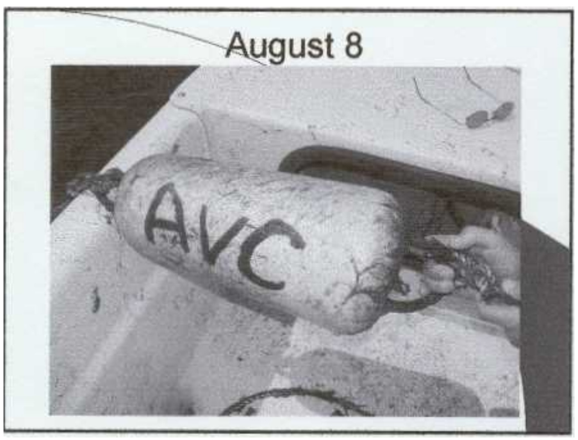
Results

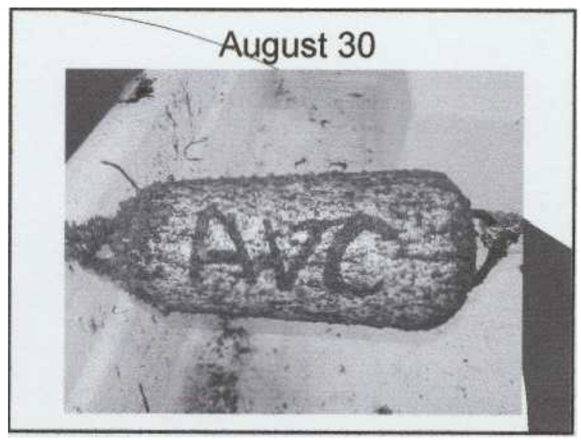


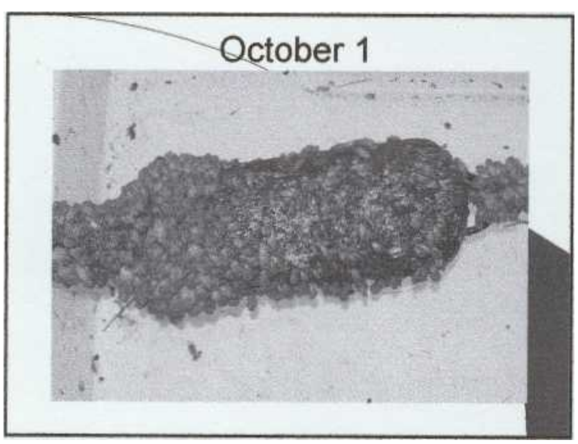


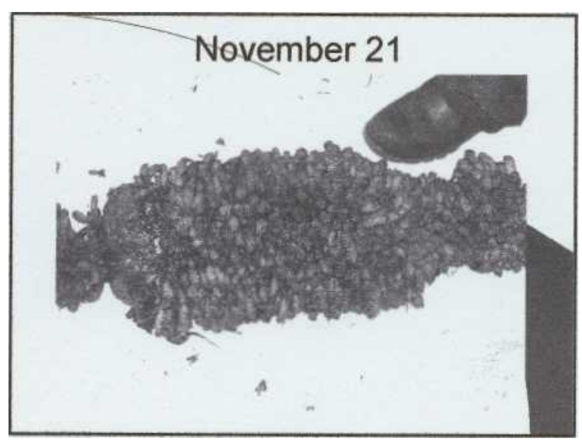

Results
Mean Buoy Weights
(No Sig. Diff. P=0.24)
Weight (lbs)
30
25
20
15
10
5
0
Murray River
Brudenell River


July 25
AVC

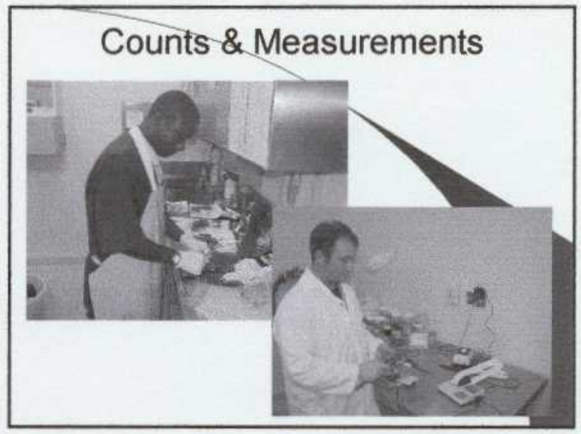

August 8
AVC

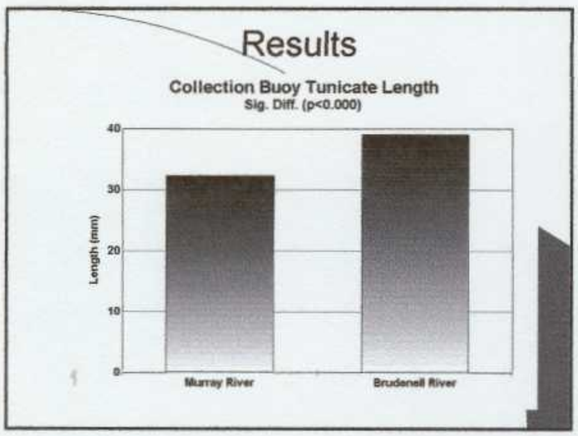

August 30
AVC

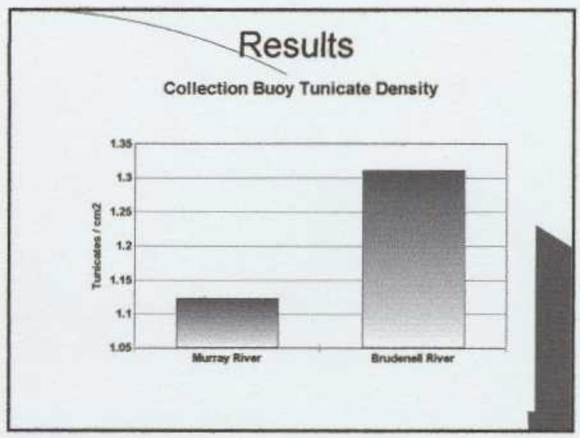

October 1

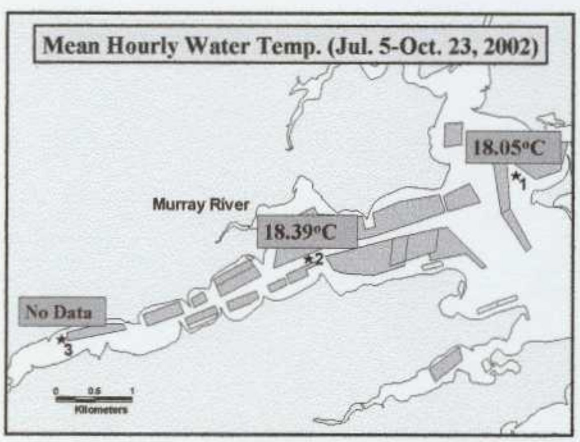

November 21

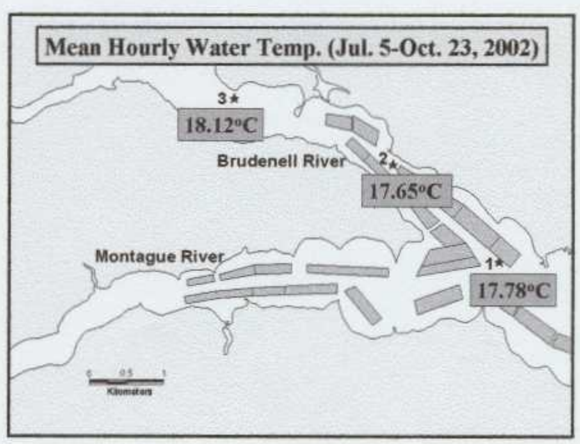

Back at the Lab!

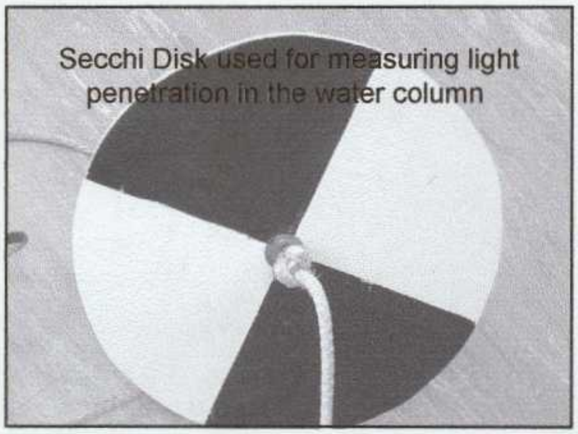

Counts & Measurements

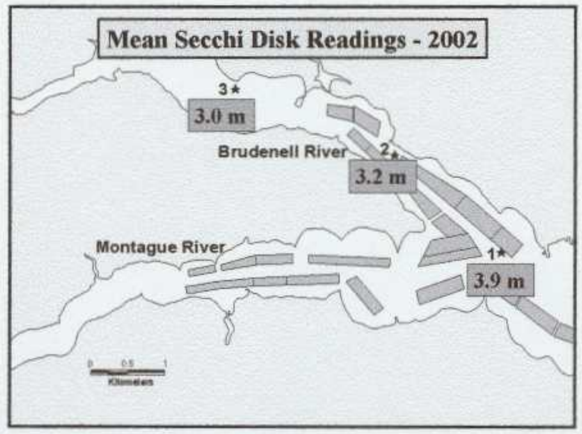

Results
Collection Buoy Tunicate Length
Sig. Diff. (p<0.000)
Length (mm)
40
30
20
10
0
Murray River
Brudenell River

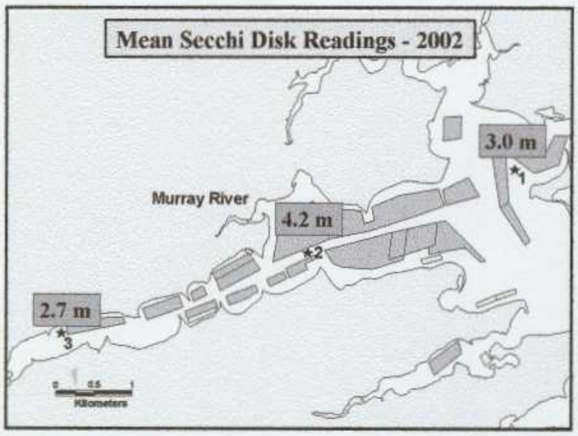

Results
Collection Buoy Tunicate Density
Tunicates / cm2
1.35
1.3
1.25
1.2
1.15
1.1
1.05
Murray River
Brudenell River

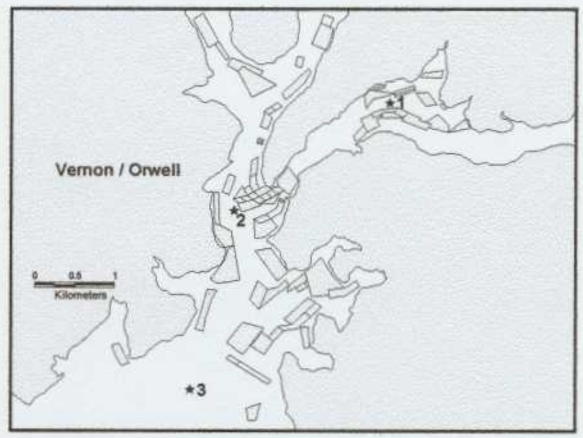

Mean Hourly Water Temp. (Jul. 5-Oct. 23, 2002)
18.05°C
1
Murray River
18.39°C
2
No Data
3
0 0.5 1
Kilometers


Mean Hourly Water Temp. (Jul. 5-Oct. 23, 2002)
3
18.12°C
Brudenell River
2
17.65°C
Montague River
1
17.78°C
0 0.5 1
Kilometers



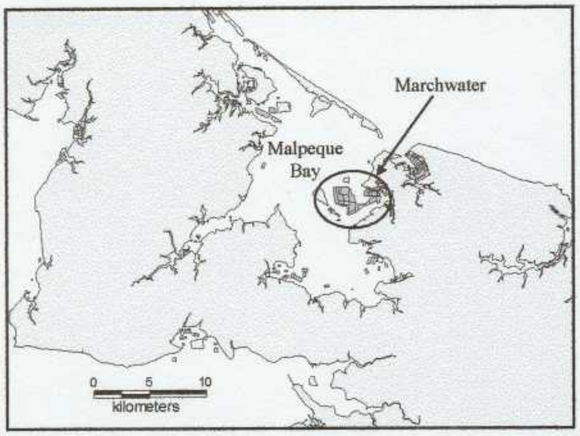


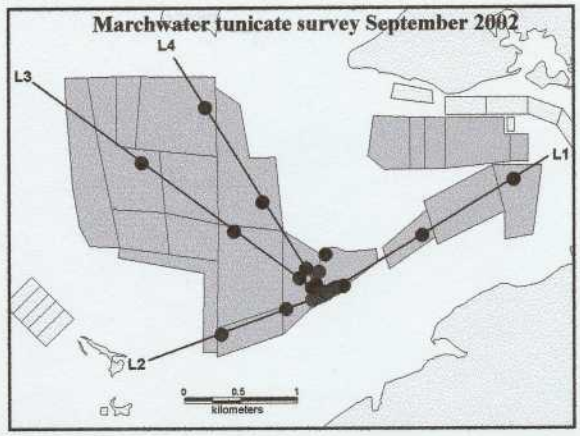


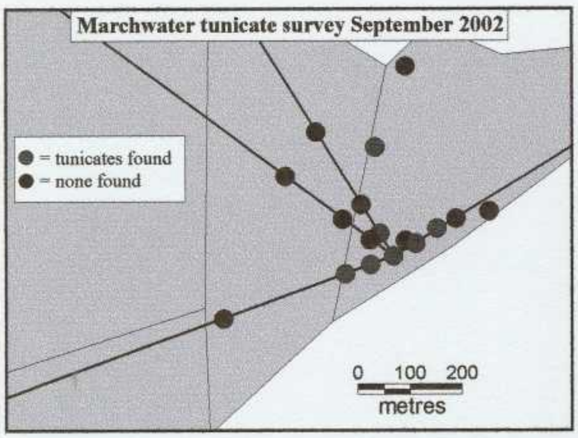


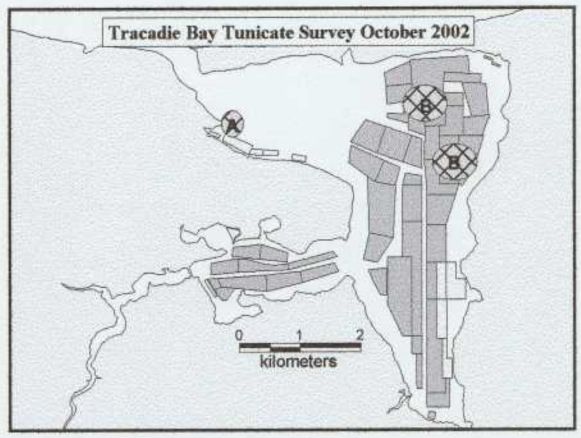
Vernon River (1 Tunicate) Found

Surveillance in Suspected Areas


Marchwater
Malpeque
Bay
0 5 10
kilometers

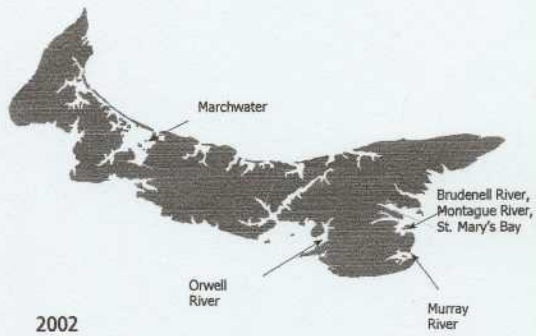

Marchwater tunicate survey September 2002
L4
L3
L1
L2
0 0.5 1
kilometers


Marchwater tunicate survey September 2002
= tunicates found
= none found
0 100 200
metres


Tracadie Bay Tunicate Survey October 2002
A
B
B
0 1 2
kilometers

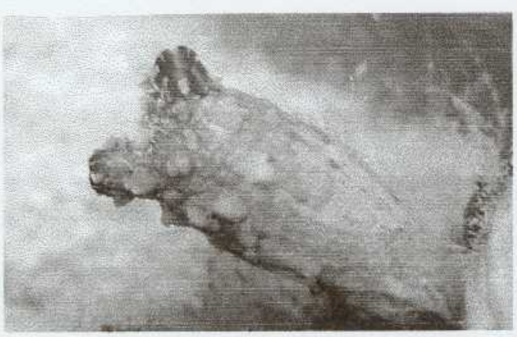
What's The View From The Boat?

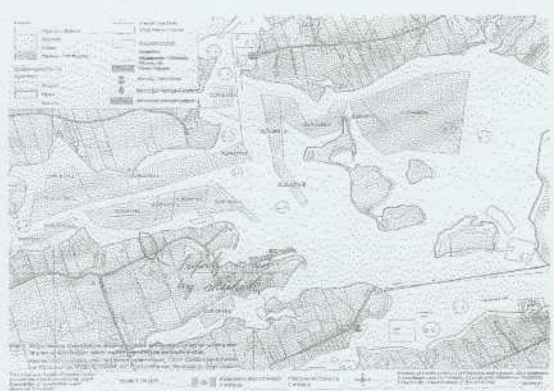
Atlantic Canadian Tunicate Workshop
Atlantic Veterinary College
Charlottetown, Prince Edward Island
March 29, 2003

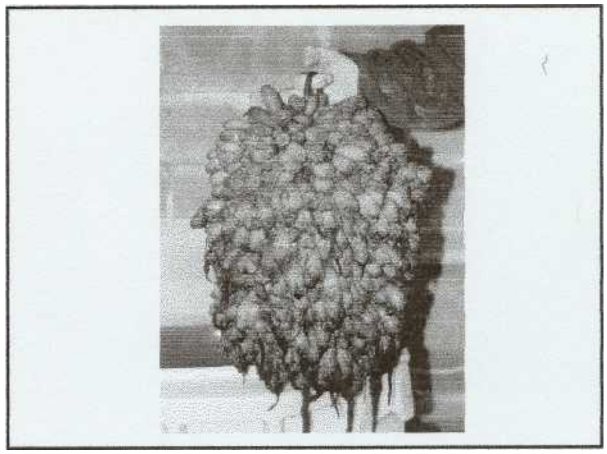


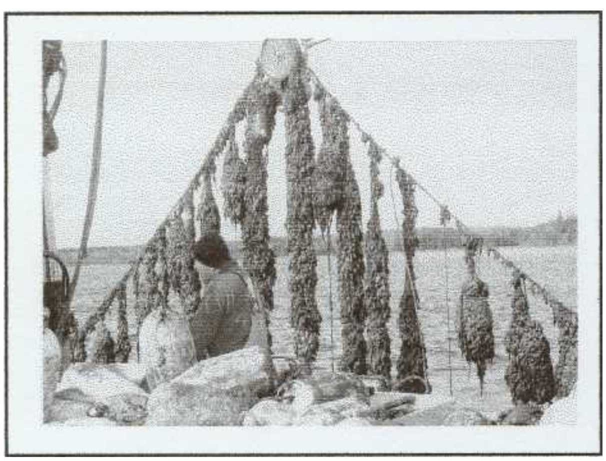
2002

What is styela clava?

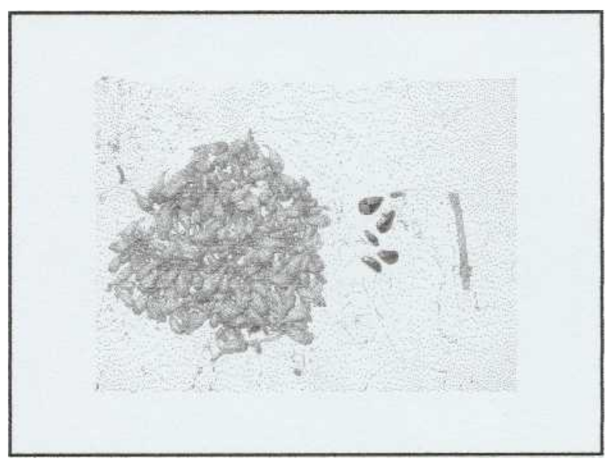










What Do We Need?

- DFO leadership on invasive species management and response to new invaders
- Resources to:
  - monitor the movement of new invaders,
  - sample and analyze new species,
  - assist grower with the technical and financial aspects
  - trial materials, develop treatment methodologies and equipment
- Recognition that growers' and fishers' pockets are only so deep

What Are We Missing?

- Tougher legislation on commercial shipping practices (ballast water treatment, hull cleaning)
- Inclusion of commercial fishery (i.e. lobster) in the National Introduction and Transfers Guidelines
- Education and policies for recreational boaters and local fishers
- Dedicated research and <u>development</u> resources

And For Mother Nature To Give Us A Break

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

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