

# An Economic Analysis of the Mussel Industry in Prince Edward Island

## Gulf Region



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## Executive Summary

The Blue mussel (*Mytilus edulis*) is the most important aquaculture specie on Prince Edward Island (PEI). This industry has grown during the last 13 years from 9.2 million pounds in 1992 to approximately 40 million pounds in 2004. The value at the harvesting level is presently close to \$24 million and almost \$49 million at the processing level. The Island mussel culture industry supplies 80% of the blue mussels in the North American market. Traditionally, mussels have been sold fresh in the shell, although in the last few years, some attention has been directed towards value-added products such as mussels in a prepared sauce, smoked mussels, and blast frozen cooked mussels.

Mussel culture occurs in many rivers and estuaries in PEI. However, the majority of the culture areas are concentrated along the Northern and Eastern coasts. Mussel leases account for a total of 10,831 acres. With 123 growers operating 291 leases and 8 processing companies (most of them holding leases), the industry has become a vital sector of the Island economy creating directly and indirectly the equivalent of 622 full-time jobs and generating sales of \$107 million in 2004. In terms of the contribution to the province's Gross Domestic Product (GDP), the mussel industry accounted for \$36.3 million in 2004.

One of the biggest challenges of the mussel industry in the last five years has been the population explosion of certain species of aquatic invaders. Presently, four species of tunicates have been identified in PEI waters: Clubbed tunicate appeared in 1998 followed by the Golden Star in 2001, and then the Violet and the Vase tunicates in 2004. These species are causing higher maintenance and labour costs for growers and processors. Research projects are presently being conducted to determine the impacts of these various types of tunicates on the mussel growth period and meat yields.

# Description of the Mussel Industry

## ***Site Selection***

The selection of a grow-out site that will produce quality market-sized mussels within an acceptable time frame is crucial for the profitability of a mussel culture operation. The ability to select the best site will depend on the understanding of specific local environmental factors that influence production levels, such as site exposure, temperature, current velocity, sediment loading, and food availability, as well as on the understanding of specific regional environmental factors, such as tidal amplitude, ice coverage, seasonal weather patterns, and climate.

## ***DFO's Role***

DFO is the lead federal agency for aquaculture and acts as both a regulator and enabler of the aquaculture sector, consistent with its role as a department of sustainable development.

As a regulator DFO is responsible for administering, monitoring and enforcing compliance with its regulations relating to conservation and protection, environment and habitat protection (Fisheries Act- sections 35 (1) (2); 36) and aquatic animal health (Fish Health Protection Regulations) in a clearly defined, reasonable and consistent manner.

As an enabler of aquaculture development, DFO is responsible for helping to improve the business climate for aquaculture by:

- ensuring that DFO's laws and regulations relating to aquaculture are clear, efficient, effective, consistently applied and relevant to the sector;
- investing in aquaculture science and research development;
- working in partnership with the provinces and territories to develop a proactive process for site approvals; and
- considering support for industry development programs consistent with DFO's mandate and objectives.

In addition to actions relating to its departmental mandate, as lead federal agency for aquaculture, DFO's role also includes:

- co-ordinating and bringing increased coherence to federal aquaculture policy and program development; and
- helping to brand Canada as a world leader in sustainable aquaculture development.

In Prince Edward Island, DFO is responsible for the administration of aquaculture leases since 1928. Most mussel lease applications will require a formal assessment under the *Navigable Waters Protection Act (NWPA)* and under the *Canadian Environmental Assessment Act (CEAA)*. The federal government must also assess the impact of proposed aquaculture sites with respect to a number of other matters including, native rights and land claims, migratory birds, utilization by other

stakeholder groups, shellfish food safety, protection of fish habitat and pollution prevention

## **Mussel Culture Methods**

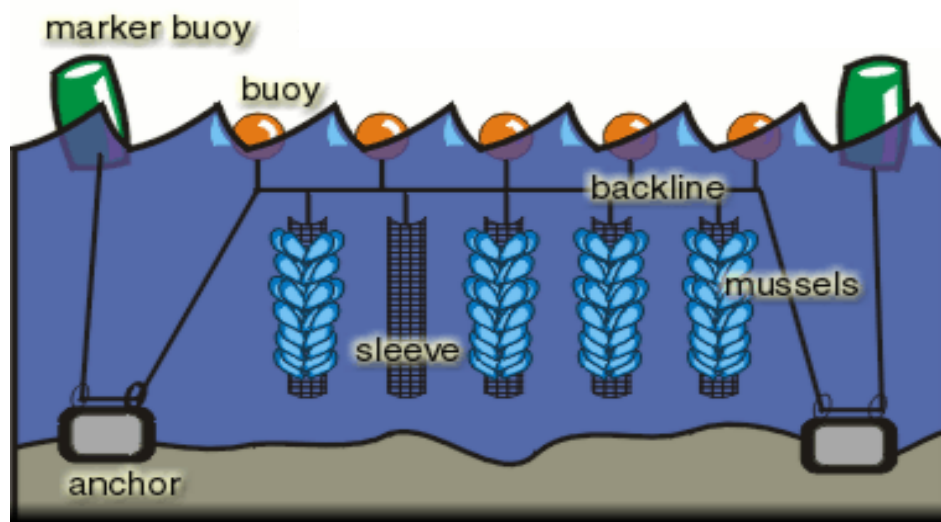
Around the world, some mussels are grown in bottom culture systems, but in many places they are grown in off-bottom systems (suspension) because suspended culture from rafts or longlines have proven to yield the greatest production per unit area. In PEI, all mussels are grown in suspension and the longline system is generally used.

### **Longline system**

Mussel growers in PEI choose the fully suspended method because their experience has shown that mussels that do not touch the bottom do not pick up grit or form pearls (although this is true for the first two years of growth, growers have experienced mussels that grow pearls if kept in suspension longer than 24 months). Another reason for choosing the suspended method of culture is that mussels are distributed evenly in a control setting where they have equal access to nutrition and therefore, are more likely to have an even growth rate with high meat to shell ratio. In fact, growers in PEI have shown that their cultured mussels produce twice the amount of mussels, as well as meat yields that are usually 3 to 4 times higher than wild mussels.

The longline system consists of a backline (headrope), sleeves (or socks), buoys, anchors, and anchor rods (Figure 1). The seed collectors or socks are attached to the backline and most longline operations use long polypropylene ropes (80-150 m) that are anchored securely at both ends and supported by floats tied at intervals along their length.

**Figure 1 - Longline system**



Floatation devices represent a major cost of the mussel operation. More expensive buoys such as pressurized plastic floats are gaining popularity because of their longer life expectancy and greater buoyancy which may translate into a better investment over time. However, the most common floatation device is still the standard styrofoam lobster buoy coated with paint.

Throughout the years, the mussel industry in PEI has used many different types of anchors such as sea anchors, scrap metal pieces, railroad rails, and concrete blocks. The anchoring system chosen will depend on cost, bottom type, current, ice and other local factors. Presently, the most common anchoring system is the anchor screws and/or the steel barrel cut in half and filled with concrete installed at the end of each line.

### **Seed (spat) collection**

To be able to grow mussels you first need to obtain seeds, and growers require huge quantities of seeds to ensure a good crop. That is one reason growers will have mussel seeds and larger mussels growing at the same time. Unpredictable and insufficient seed supply due to poor recruitment can become a constraint to the expansion of the mussel operation. The selection of a site for the collection of seeds is therefore as important to the identification of a grow-out site. The recruitment success at a particular site is dependent on various factors, such as duration and timing of the settlement period, the number of viable larvae produced, retention of larvae within the system, and predation. In PEI, seeds are usually collected in the upper reaches of inlets or rivers where shallow water depths limit grow-out operations.

Acquiring a mussel lease allows you to collect your own seeds on your lease. There is only a small proportion of growers (i.e. around 5%) that will also buy seeds from licenced fishers who are allowed to collect seeds in the spring or in the fall within certain areas. Growers depend on this important source of seeds. The seed collectors can be made from all sorts of materials such as old rope, Italian socking material, nylon bags, and vexar mesh, the most common being 12-18 mm polypropylene rope around two metres in lengths. Whatever the material being used, the collectors are usually attached to the longline (backline) 30-50 mm apart and weighted to keep them suspended vertically in the water column, usually giving a relatively uniform size distribution of seeds. Providing adequate floatation of longlines (so they do not touch the bottom) is important, especially to avoid mortality of seed by predators or fall-offs during storm events.

The seed collectors are usually hung to the backline just before the spat are expected to settle in the summer and because of the availability of spat occurring between late May and late June, the window of opportunity to put the lines in place is relatively short. Once the lines are in the water, it takes 2 to 3 weeks to determine if a good set has been received.

### **Socking**

Mussel larvae settle on the collectors and grow rapidly, reaching a seed-size of 10 to 25 mm, usually by fall. At this time, the harvesting of the seeds begins and mussel seeds are manually stripped off the collectors and are transported to shore where specialized grading equipment (declumper) cleans and sorts the seeds into two or three sizes depending on the grower's preference (Figure 2). Seeds too small (usually less than 4 mm) are removed.

The seeds are then transferred to grow-out units where the "sleeving" or "socking" operation begins. The large majority of growers undertake socking operations from early October to mid or late November, which corresponds to the time of year when employment in the mussel industry peaks. Socking is the operation by which seed mussels are loaded into socks or mesh sleeves, usually at a density of 120 to 240 seed mussels per foot of sock. The sock, a long mesh tube often strengthened with a strand of polypropylene twine, is about 40 mm in diameter and average 2.5-3.0 meters in length depending on local water depths. After socking, the mussels are sometimes bathed in seawater for some twelve hours to allow the formation of byssal threads before suspending them from the longlines where they grow to market size which can take from 18 to 24 months (Figure 3).

**Figure 2 - Mussel seed grading equipment**



**Figure 3 - Mussel Socks**





Water quality has to be monitored during this time and as winter approaches, the grower's time requirement will increase, as it is critical that the lines be prepared for the winter. Freeze-over of mussel-producing bays and rivers in winter has resulted in development of adaptive technology to safeguard losses of gear to ice, particularly in spring. Any longlines left at the surface risk being destroyed by ice, therefore it is recommended that the grower have knowledge of the average ice depth in the area (normally between 30 and 90 cm), so that the lines may be lowered below that level. In November, weights such as concrete blocks are usually tied to the backline at 10-15 m intervals and the floatation buoys are adjusted accordingly in order to sink the longline at least 1.5 m beneath the water surface yet allowing the socks to float clear of the bottom.

## **Harvesting**

The average mussel sock will hold between 15 and 30 kilograms of mussels once they reached market size (between 55-60 mm) and a line will contain nearly two tonnes of mussels. At this stage, the harvesting is carried out on special vessels that have equipment such as a boom and a manual or hydraulic winch system that lifts the longlines from the water. In the warmer months, the socks can then be detached and transferred in the fishing boat or small barge. To minimize the losses of mussels during this transfer, the vessel may have a chute to guide the longline and socks aboard or sometimes a basket is placed below the sock to recover any fallen clumps. Other growers may also double sock over the mussels to prevent fall-offs.

Harvesting during the winter months is cold hard work and time consuming, but worthwhile because the market is strongest during the winter. The ice presence imposes a specific harvesting technique, which typically begins in December once the ice has set in. The first step is to be able to identify with precision the location of the mussel longline system, which is easily done with the Global Positioning System (GPS), but some growers locate lines using ice poles. Workers will get to the location using snowmobiles, all terrain vehicles, small trucks, or sleds, depending on ice conditions, and they will drill holes in the ice, generally with a chain saw equipped with a special ice cutting blade. The longline system is then hauled out of the water with a hydraulic system attached to an A-frame by a diver. As the lines emerge, the socks are cut from the backline and stacked in insulated plastic boxes to protect them from wind-chill.

## **Processing**

Part of the PEI mussel industry's success has been its capability to serve the market year-round. Because a processing plant usually processes tonnes of mussels each year, it needs to have predetermined delivery dates for harvested mussels, which consequently determine the harvesting schedule of the grower (who needs to respect his contract with the plant). However, if for specific reasons such as weather conditions, the grower can not harvest in the specified time, an alternative grower will be notified. The predetermined schedule also keeps the market from becoming saturated with mussels and regulates production levels so that product is not wasted.

Harvested mussels must be carefully looked after and must not be left in the direct sunlight. In mild weather they may be left stacked in tubs, providing that they are protected from any breeze, but once harvested, mussels must be transported to the

processing plants as quickly as possible so they remain fresh and do not sit in their own liquids or muddy water. Once transported to the processing plant, the mussels are stripped from the socks and mechanically declumped, washed and graded. Also, the byssus (beard) are usually removed by a debyssing machine before the final inspection that will remove any broken or substandard shells. Finally, the mussels are packed and ready for shipment.

### **Mussel Growing Operation Summary of Activities and Investment**

Tables 1 and 2 provide a brief summary of winter and summer activities of a typical mussel growing operation and table 3 shows some of the average investment costs associated with a growing operation. Each operation is different and the activities and costs are very site and operator specific. In other words, a lot depends on the size and method of operation, as well as other external factors such as experience, number of employees, weather conditions, etc.

**Table 1 - Winter Activities of a Mussel Growing Operation**

<b>Months</b>	<b>Activities</b>
November-December	<ul style="list-style-type: none"> <li>• Setting the lines for the winter</li> </ul>
December – March	<ul style="list-style-type: none"> <li>• Winter harvest</li> <li>• Maintaining equipment and preparing for the summer season</li> </ul>
November – May	<ul style="list-style-type: none"> <li>• Maintenance and monitoring and possibly harvesting</li> </ul>

**Table 2 - Summer Activities of a Mussel Growing Operation**

<b>Months</b>	<b>Activities</b>
May – June	<ul style="list-style-type: none"> <li>• Setting spat collectors and monitoring older lines</li> </ul>
June – October	<ul style="list-style-type: none"> <li>• Summer harvest</li> </ul>
September – October – November	<ul style="list-style-type: none"> <li>• Harvesting spat for socking, and returning the socks to the line</li> </ul>
May – November	<ul style="list-style-type: none"> <li>• Monitoring the lines and preparing the lines and equipment for the winter</li> </ul>

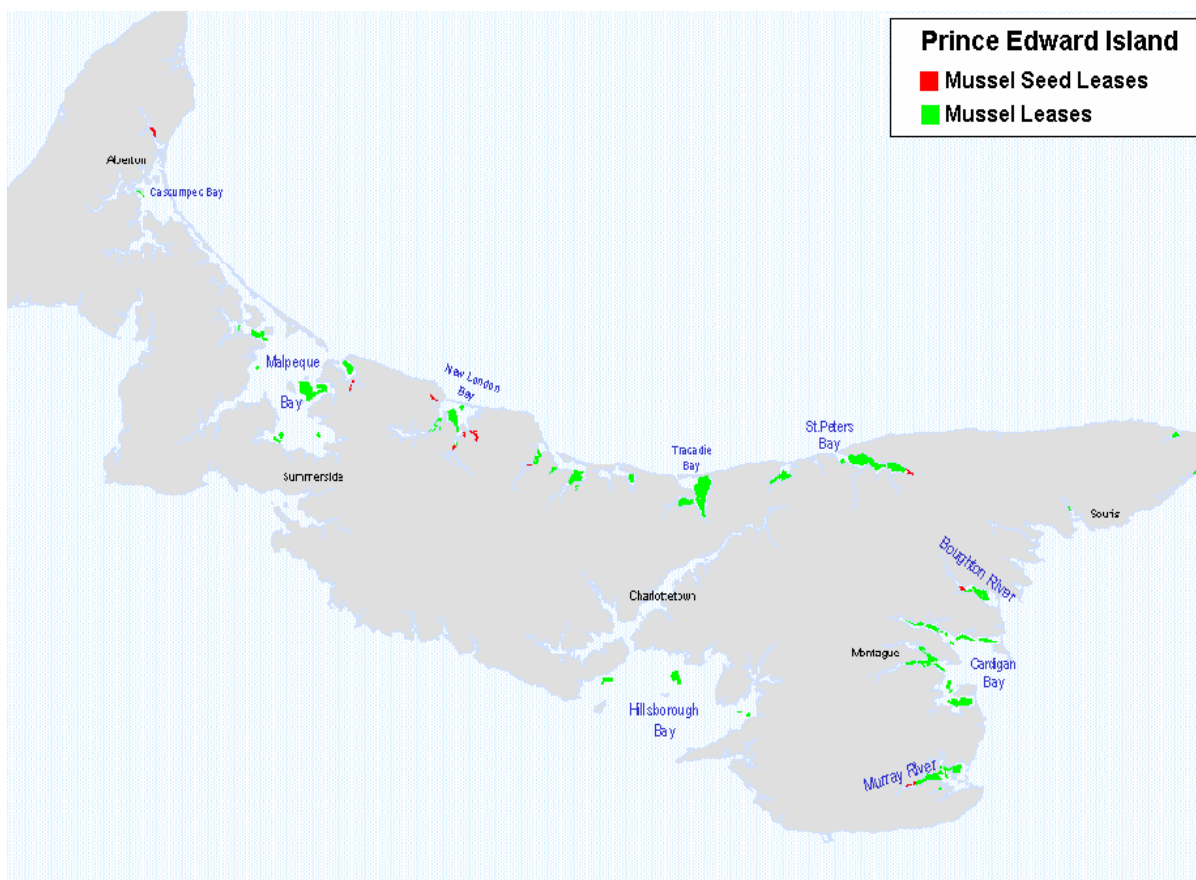
**Table 3 - Investment of a Mussel Growing Operation**

Hydraulics	\$5,000.00 - \$10,000.00
Floation Devices	\$2.75 - \$3.00 each
Anchors	\$20.00 - \$25.00 each
Insulated Boxes (with covers)	\$500.00 - \$600.00 each
Declumper	\$10,000.00 - \$15,000.00
Sock Mesh	.07 - .12 cents per meter
Mussel Boat	\$25,000.00 - \$40,000.00
24' aluminum boat	\$70,000.00 - \$100,000.00
40' mussel boat	\$200,000.00 - \$300,000.00
Lease (annual fee)	\$10.00 per acre
Aluminum socking table	\$3,000.00 - \$5,000.00

***Culture Areas and Production***

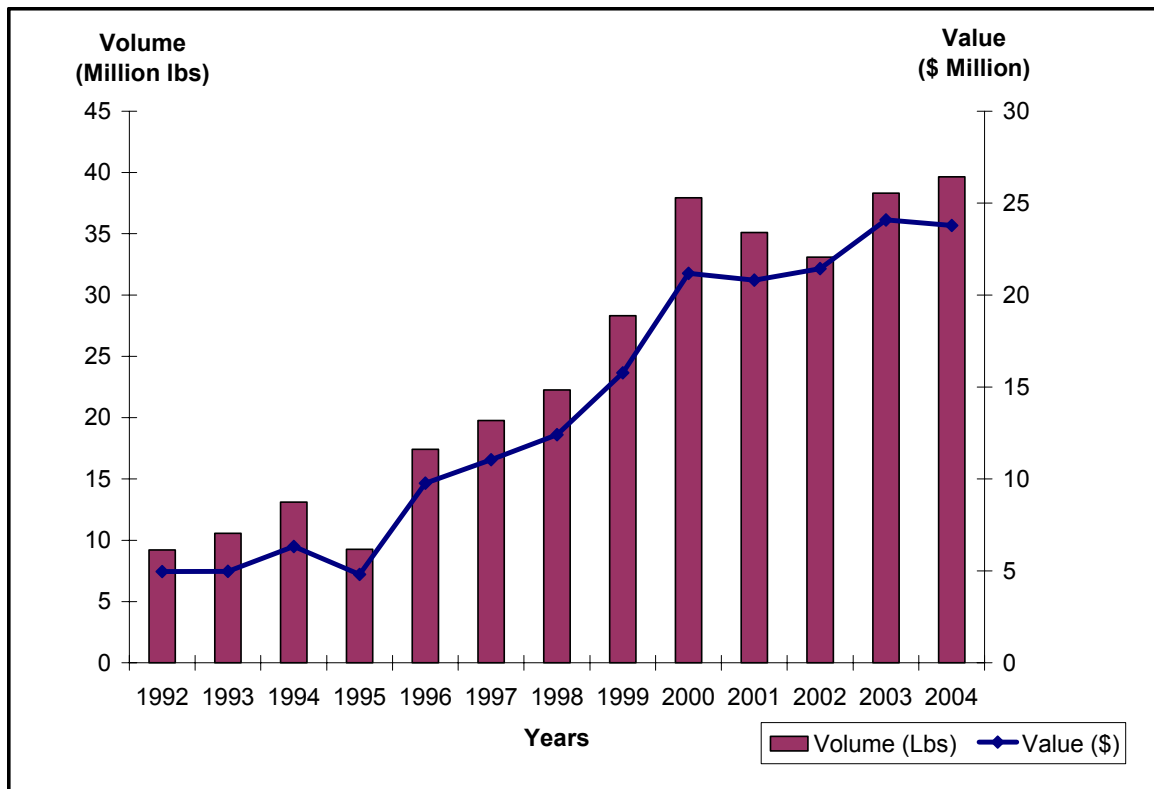
Mussel culture occurs on leases in many of the rivers and estuaries in PEI, but the majority of the culture areas are concentrated along the Northern and Eastern coasts (see figure 4). In total, the 291 mussel leases in PEI account for a total of 10,831 acres, where 123 growers harvest their mussels. These mussels are purchased by eight processing companies, with most of them also holding leases.

**Figure 4 - Mussel Leases in Prince Edward Island**



PEI is the largest producer of mussels in Canada, accounting for close to 77% of all production in 2004, followed far behind by Newfoundland and Nova Scotia with 10% and 9% of mussel production respectively. The provinces of New Brunswick and Quebec are also involved in the aquaculture of mussels. The mussel industry in PEI has grown intensively during the last 13 years; increasing its production from 9.2 million pounds in 1992 to approximately 40 million pounds in 2004 (see figure 5). As shown by the following graph, production has however been relatively stable in the last five years.

**Figure 5 - Mussel Production in PEI from 1992 to 2004**



Source: DFO Gulf Region Policy & Economics, Statistics Division

Table 4 shows the number of growers & leases (2005) and production by bay/estuary for 2004. The production shows the quantity and value of mussels that are purchased from the processors.

**<sup>1</sup>Table 4 – Number of growers, leases and production by bay/estuary**

Name of Bay/River/Basin	Number of Growers	Number of Leases	Total Leased Acreage	Production (2004)	
				LBS.	VALUE (\$)
Malpeque Bay <sup>2</sup>	22	32	1,635.14	6,536,491	3,921,895
New London Bay <sup>3</sup>	18	25	701.48	5,535,413	3,321,248
Murray River	10	23	918.22	4,469,812	2,681,887
Tracadie Bay <sup>4</sup>	34	48	1,726.50	4,119,459	2,471,675
Boughton River	4	8	415.72	3,794,030	2,276,418
Brudenell River	7	13	297.15	2,672,874	1,603,724
Darnley Basin	13	14	291.93	2,125,536	1,275,322
Rustico Bay <sup>5</sup>	13	18	622.04	2,060,539	1,236,323
St. Peters Bay	11	27	1,554.43	1,934,157	1,160,494
Cardigan Bay/River	14	18	561.15	1,900,325	1,140,195
St. Mary's Bay	5	13	706.44	1,802,930	1,081,758
Montague River	6	11	191.77	1,473,491	884,095
Savage Harbour	12	13	354.02	598,314	358,988
Hillsborough Bay <sup>6</sup>	10	13	504.11	17,071	10,243
Others <sup>7</sup>	13	15	351.11	605,548	363,329
<b>TOTAL</b>	<b>192<sup>8</sup></b>	<b>291</b>	<b>10,831.21</b>	<b>39,645,990</b>	<b>23,787,594</b>

Source: DFO Gulf Region: Statistical Division (production); PEI Aquaculture Division (leases & growers), and information provided by processors.

<sup>1</sup>Number of growers, number of leases, and lease acreage is as of September 08, 2005.

<sup>2</sup> Malpeque Bay includes Malpeque Bay, Bentick Cove, Bideford River, Chichester Cove, and March Water.

<sup>3</sup> New London Bay includes New London Bay, Southwest River and Stanley River.

<sup>4</sup> Tracadie Bay includes Tracadie Bay and Winter Bay.

<sup>5</sup> Rustico Bay includes Rustico Bay and Hunter River.

<sup>6</sup> Hillsborough Bay includes Hillsborough Bay, Orwell Bay and West River. Hillsborough Bay is mainly used for spat collection.

<sup>7</sup> Others include Cascumpec Bay, Covehead Bay, Enmore River, Mill River, North Lake, Souris River and South Lake.

<sup>8</sup> # Growers: In reality, there are 123 mussel growers in PEI because some growers have more than one lease in more than one bay.

## **Trade**

### **Products and Price**

For the most part, mussels are still sold fresh in the shell although some attention has been directed towards value-added products such as mussel in a prepared sauce, smoked mussels, and blast frozen cooked mussels. In 2004, a little over 9% of the PEI total exports were sold frozen, salted, dried or in brine (Statistics Canada). Traditionally, fresh mussels are placed in mesh bags, which allow for drainage and ventilation before they are packed into master cartons for shipment. As it can be expected, technology is always evolving and the new MAP (Modified Atmospheric Pack) is an example of this.

The price of mussels has remained very stable in the last decade. At the harvesting level, growers receive approximately \$0.60/lb and processors receive between \$1.00/lb to \$1.18/lb for their mussels.

### **Markets and Exports**

PEI is by far the principal exporter in Canada, accounting for over 88% of Canadian mussel exports in 2004. The second and third largest exporting provinces of mussels are Newfoundland and Nova Scotia with 6.5% and 3.0% of mussel exports in 2004.

The amount of PEI mussels that are sold locally and in Atlantic Canada is minimal and only a small percentage of production (around 9%) is sold in Canada, mainly to large Canadian urban centres. The remaining production is sold mainly in the United States (93.5%). Table 5 shows PEI's mussel exports by country of destination.

**Table 5 - PEI Total Exports by Country of Destination – 2000 to 2004 (Dollars)**

<b>Country</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>% in 2004</b>
United States	19,036,052	21,403,890	21,274,537	21,256,415	19,819,042	93.5%
Japan	396,693	1,077,832	823,498	409,754	1,236,685	5.8%
Israel	-	-	25,816	58,598	117,012	0.6%
Hong Kong	-	4,463	4,4019	-	25,900	0.1%
Others	96,648	4,363	24,000	82,024	435	0.0%
<b>TOTAL</b>	<b>19,529,393</b>	<b>22,490,548</b>	<b>22,151,870</b>	<b>21,806,791</b>	<b>21,199,074</b>	<b>100%</b>

Source: Statistics Canada: [www.strategis.gc.ca](http://www.strategis.gc.ca)

# Macro-Economic Impact of the Mussel Industry on the PEI Economy<sup>9</sup>

The objective of this section is to quantify the economic impact of Prince Edward Island's mussel industry on the province's economy. The analysis focuses on the processing component of the industry. It nevertheless indirectly includes the impact of the growers since we took into consideration all purchases of the processors, including the purchases of mussels. Unfortunately, the information related to the expenditures made by the growers was not available.

The data used in the present study is for the year 2004. It is extrapolated from information received from processors representing over 99% of the sector's production.

## Methodology

An analysis like this one can only be done using a proven economic model, in this case an input-output model. Information for our analysis came directly from the processing sector. Of the 8 mussel processing plants in PEI, 7 of them were interviewed and provided information concerning their operations in 2004.

The principle behind the input-output model is essentially to "follow the money path." For example, processing equipment used by a plant will be purchased from a manufacturing plant which in turn may offer its employees more work which in turn will increase their expenditures, pay more taxes, etc. The input-output model incorporates all these components.

We present the direct, indirect and induced impacts that result in the total economic impact. Direct impacts represent the total expenditures of processors for goods, services and salaries. Indirect impacts are the result of the expenditures by processors, except for salaries. Induced impacts are the impact of expenditures of employees of processors.

In other words, the direct impacts are the expenditures made by the processors to acquire goods such as the processing equipment, boxes, etc., the services of electricians, truck drivers etc., and the salaries of the individuals on their payroll.

The indirect impacts are generated by the companies that supply the processing equipment and boxes as well as the electricians and truck drivers that receive a contract to offer such goods or services to the processors. In the case of the company that builds and installs the processing equipment, they buy goods and services to build this piece of equipment and pay salaries to their employees.

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<sup>9</sup> This section was completed with the collaboration of Dr. Pierre-Marcel Desjardins from L'Université de Moncton.

The induced impacts represent the impact of the expenditures made by the employees hired by the processors. For example, each employee will spend a part of his wages on goods and services such as food, housing, insurance, clothing, transportation etc. This pattern of consumption is based on the census data collected from the consumer habits of PEI.

Finally, we need to remind the reader that such an analysis aims to present a relatively accurate picture of the situation but one should always be reminded that the results are not an “exact” measure of the impacts, but rather an “acceptable approximation”.

## **Results**

### ***Sales Generated***

We first estimate the value of sales generated by the mussel processing sector (Table 6). For example, the direct impact on sales corresponds to the value of mussels sold by processors.

Indirect sales correspond to the value of the sales generated as a result of the processors purchases (e.g. purchases of mussels from growers, packaging, processing equipment, etc.). In other words, the economic activities of the various parties that supply or service the processors (mussel growers, electricians, truck drivers, equipment builders, supplier of boxes etc.) generate sales from their suppliers. In the case of the mussel growers, they will buy boats, buoys, cables, winches, boxes etc. These acquisitions represent the indirect sales.

Induced sales correspond to the sales generated by the salaries paid by processors to his employees (ex: vehicles, groceries, clothing, etc., purchased by employees).

The sector was directly responsible for nearly 50 million dollars in sales. Another 36 million dollars in sales were indirectly generated and a further 21 million were induced. We thus have a total of more than 106 million dollars in sales generated in Prince Edward Island as a result of the presence of the mussel sector.

<b>Table 6 - Sales Generated (million \$)</b>	
	PEI
Direct	\$48.7
Indirect	\$36.4
Induced	\$21.6
Total	\$106.7

### ***Employment***

Turning to employment, we use the concept of person-years to analyze the impact of the sector. For example, if two persons each worked 26 weeks during the year, this would correspond to 1 person-year, i.e. 52 weeks of employment. Our results



consequently do not correspond to the number of individuals involved in the sector. It rather corresponds to the level of full-time equivalent employment.

<b>Table 7 - Employment in Person-Years</b>	
	PEI
Direct	281.0
Indirect	253.0
Induced	88.2
Total	622.2

The sector was directly responsible for 281 person-years of employment, indirectly responsible for 253 person-years and induced a further 88.2 person-years of employment (Table 7). We thus have a total employment equivalent to 622.2 person-years. Taking into account the seasonal nature of the economy, we know that the number of persons involved is significantly greater than 622.

### ***Gross Domestic Product (GDP)***

The gross domestic product measures the value of the economic activity generated within a given territory. For example, if a processor purchases a truck for which he paid \$40,000 from a local retailer which purchased it from the manufacturer in Ontario for \$35,000, the contribution to the gross domestic product of the province of Prince Edward Island was \$5,000. We can therefore see how the contribution to the gross domestic product is much smaller than the value of sales generated. The difference between the two will tend to be greater for smaller regions – or provinces – than for bigger ones. In other words, a province that builds and supplies most of the equipment and services required to a specific economic activity will generate a greater impact on its GDP than one where many of the equipment have to be imported from outside the province.

We should mention that because we do not have the information for the location of the growers' suppliers, we have to assume that the location corresponds to the provincial profile for similar sectors. Given that mussel growing is concentrated in Prince Edward Island, most suppliers are probably from the province. Therefore we are probably underestimating the contribution to the gross domestic market as a result of not having detailed information for the growers.

The mussel processing sector directly contributed nearly 15 million dollars to the province's gross domestic product, indirectly contributed a nearly equivalent amount to Prince Edward Island's gross domestic product and induced more than 6.5 million dollars (Table 8). The total contribution of the sector to the province's gross domestic product was more than 36 million dollars. Considering that the GDP of the province amounted to \$4,023 M in 2004, the mussel industry represents approximately 1% of the GDP (0.9%).

<b>Table 8 - Gross Domestic Product at Market Price (million \$)</b>	
	PEI
Direct	\$14.9
Indirect	\$14.7
Induced	\$6.7
Total	\$36.3

### **Government Tax Revenues**

In Tables 9 and 10, we present our estimates of the federal and provincial governments' tax revenues generated from the activities of the mussels processing sector. The federal government receives nearly 4 million dollars in revenues as a result (direct, indirect and induced) of the presence of the sector. The provincial government, for its part, receives 3.5 million dollars.

<b>Table 9 - Federal Government Tax Revenues (million \$)</b>	
	PEI
Direct	\$1.5
Indirect	\$1.3
Induced	\$1.2
Total	\$3.9

<b>Table 10 - Provincial Government Tax Revenues (million \$)</b>	
	PEI
Direct	\$1.2
Indirect	\$0.9
Induced	\$1.4
Total	\$3.5

### **Summary**

To conclude, we have found that the mussel processing sector generated a total of more than 106 million dollars in sales, the equivalent of 622 person-years of employment, a contribution of more than 36 million dollars to the province's gross domestic product, nearly 4 million dollars in revenues for the federal government and 3.5 million dollars in revenues for the provincial government (see Table 11).

<b>Table 11 - Summary of Results – Total Impact</b>	
	PEI
Gross Production (Sales) or Expenditure Generated (million \$)	\$106.7
Employment in Person-Years	622.2
Gross Domestic Product at Market Price (million \$)	\$36.3
Federal Government Tax Revenues (million \$)	\$3.9
Provincial Government Tax Revenues (million \$)	\$3.5

## **Aquatic Invasive Species: Tunicates<sup>10</sup>**

### ***Historical background of tunicate species in PEI waters***

Four species of tunicates have been identified in PEI waters. The Clubbed tunicate (*Styela clava*) was the first invasive tunicate species identified in PEI waters in 1998. More recently, the colonial tunicates; Violet tunicate (*Botrylloides violaceus*) and Golden Star (*Botryllus schlosseri*) have been observed, as well as the solitary tunicate, Vase tunicate (*Ciona intestinalis*). All species have the potential to become pests in the marine environment and to the fishing and aquaculture industries.

The distribution of each species is presently limited to certain areas on PEI. Although it is likely these species will eventually spread to other areas by natural means, areas could be affected sooner by organisms being accidentally transported by the hulls of barges, fishing boats, recreational craft, cruise and cargo ships, bilge water and possibly through the transfer of seed and/or other stocks from one area to another.

### ***Types of tunicates***

#### **Solitary tunicates**

##### **Clubbed tunicate**

The clubbed tunicate was first found in PEI in the Brudenell River in 1998. It is a cylindrical body that can reach lengths up to 15 centimeters (six inches) long. It attaches by means of a thin stock which protrudes from one end. It has a warty surface with mottled color. The smaller clubbed tunicates appear as miniature versions of the large ones with a smoother surface. It is typically found in dense clumps growing on substrate below the low water level such as docks, buoys, hulls of boats, etc.

<sup>10</sup> Source: Prince Edward Island Department of Agriculture, Fisheries and Aquaculture and Department of Fisheries and Oceans.

The clubbed tunicate can live for several days out of the water. The spawning period for the clubbed tunicate in PEI waters is from the middle of June to the middle of October. The adults can spawn and the offspring can potentially infest substrate within a period of a few days.

### **Vase tunicate**

The vase tunicate was first found in PEI in October 2004 in Montague River growing on mussel aquaculture gear. It has a soft cylindrical body with a smooth transparent surface, and can reach lengths of up to 15 centimeters (six inches). There is often a red area inside the tunicate which makes them easier to identify.

The vase tunicate attaches to and fouls the shells of invertebrates, shellfish gear, hulls of boats and other floating structures, making them very difficult to clean. This tunicate has caused severe difficulties to mussel growers and processors in Nova Scotia and is a great concern to the aquaculture industry on Prince Edward Island. Effectively it has forced them to a fall to spring window for processing as it seems the Vase tunicate gums up the processing equipment in warmer summer months.

### **Colonial tunicates**

The violet and golden star tunicates, unlike the solitary clubbed or vase tunicate, are colonial and considered a greater fouling challenge to the mussel industry. They not only reproduce sexually, spreading larvae through the water column, but they also bud or fragment, producing new colonies which drift and may spread the tunicate further into the estuaries.

### **Violet tunicate**

The violet tunicate was first found in PEI during the summer of 2004 in Savage Harbour. It is a colonial tunicate that grows like a mat over the substrate on which it is growing. The sizes of the colonies are only limited by the space provided to them by the substrate. It has several different color variations that vary from tan to bright orange. It has an obvious ridge of track-like pattern through the colony.

The violet tunicate attaches to and fouls the shells of invertebrates, shellfish gear, hulls of boats, floating structures and marine plants including eel grass. Small pieces of colony can easily be transported on pieces of plant material within a body of water, or to new bodies of water by natural means, or inadvertently by water users.

### **Golden Star tunicate**

The golden star tunicate was first found in PEI in 2001 in St. Peter's Bay. It is also a colonial tunicate that grows like a mat over the surface of the substrate on which it is growing and which the sizes of the colonies are only limited by the space provided to them by the substrate. It is dark in color with a lighter star shaped pattern.

The golden star tunicate can attach to and fouls the shells of invertebrates, shellfish gear, hulls of boats and other floating structures, making them very difficult to clean. The colonies are generally easy to pull off the substrate which increases their potential to spread.

## Establishment factors

Tunicates have been very successful at establishing in new areas worldwide. Their general success can be attributed to several factors.

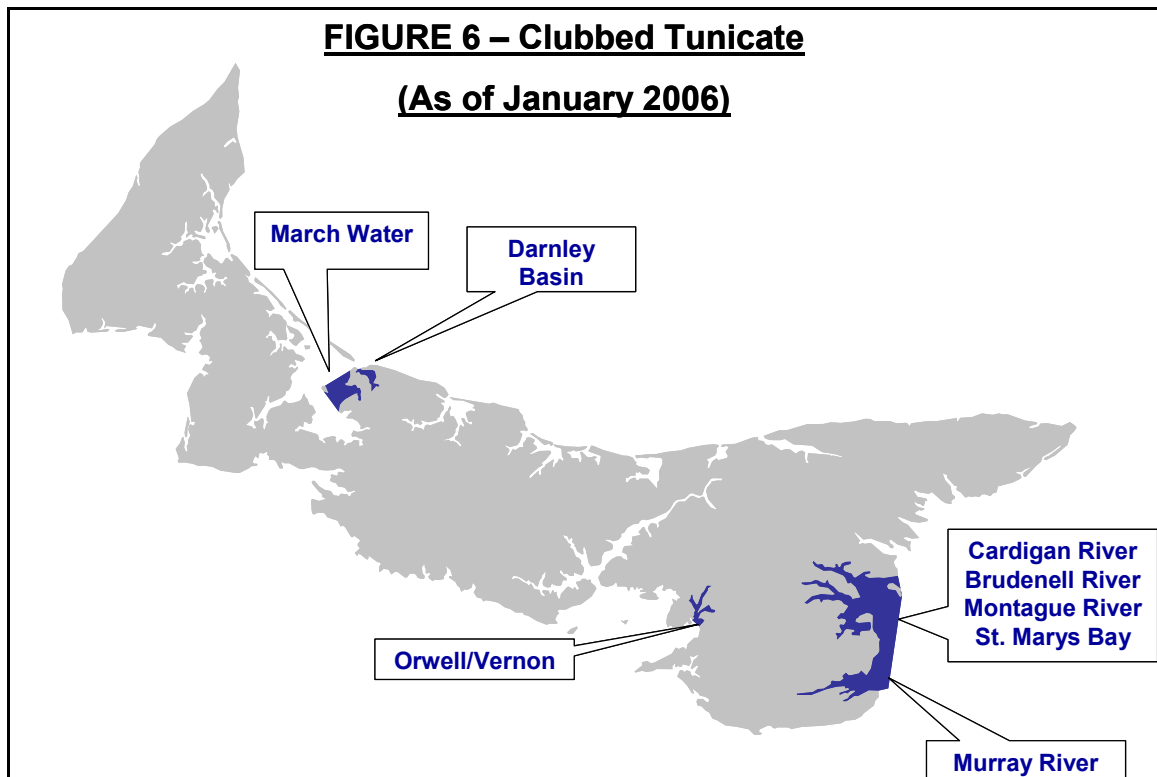
1. Rapid growth and early maturation.
2. Frequent spawning activity (every 24 hours or so).
3. Long reproductive season on PEI, from mid-June to early October.
4. Artificial structures such as mussel lines, provide an excellent attachment and grow out substrate.
5. Tunicates have little or no natural predators that we know of in PEI.

Several treatment agents have been tested on tunicate colonies at various concentrations, vinegar (5% acetic acid, household strength) has proven to be the most effective to date.

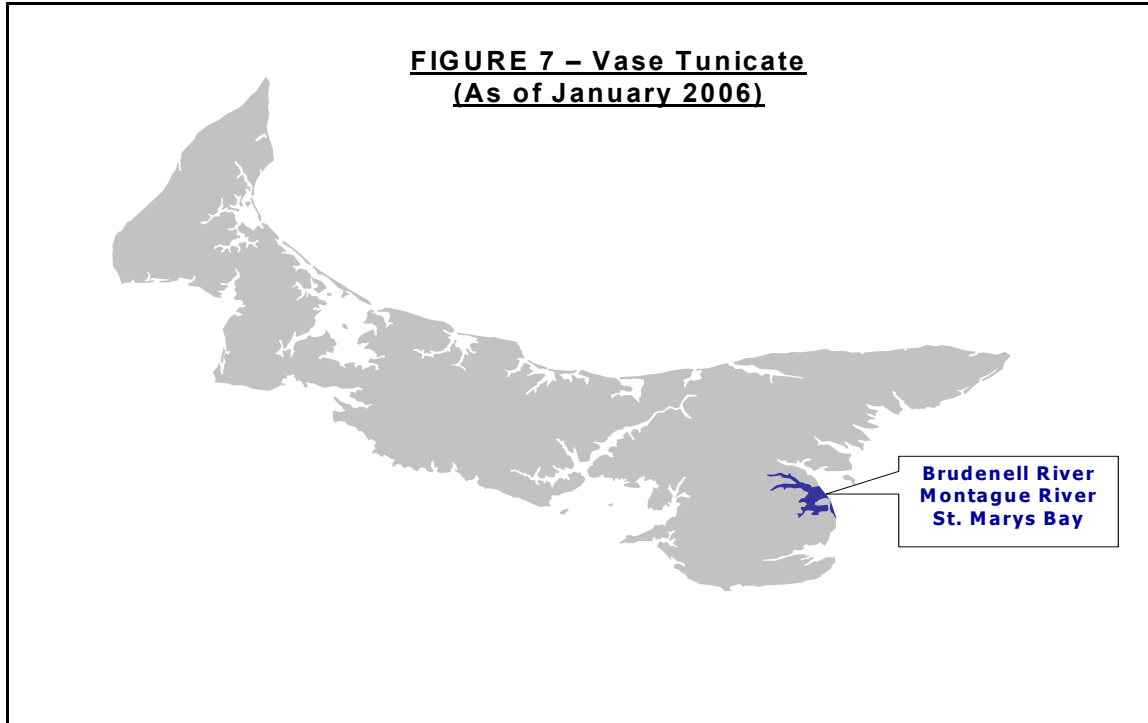
## Distribution of tunicates

Figures 6 to 9 show the location of each specie of tunicate on Prince Edward Island, however, the spread of the species changes regularly. As of January 13, 2006, their presence has been confirmed in the following locations:

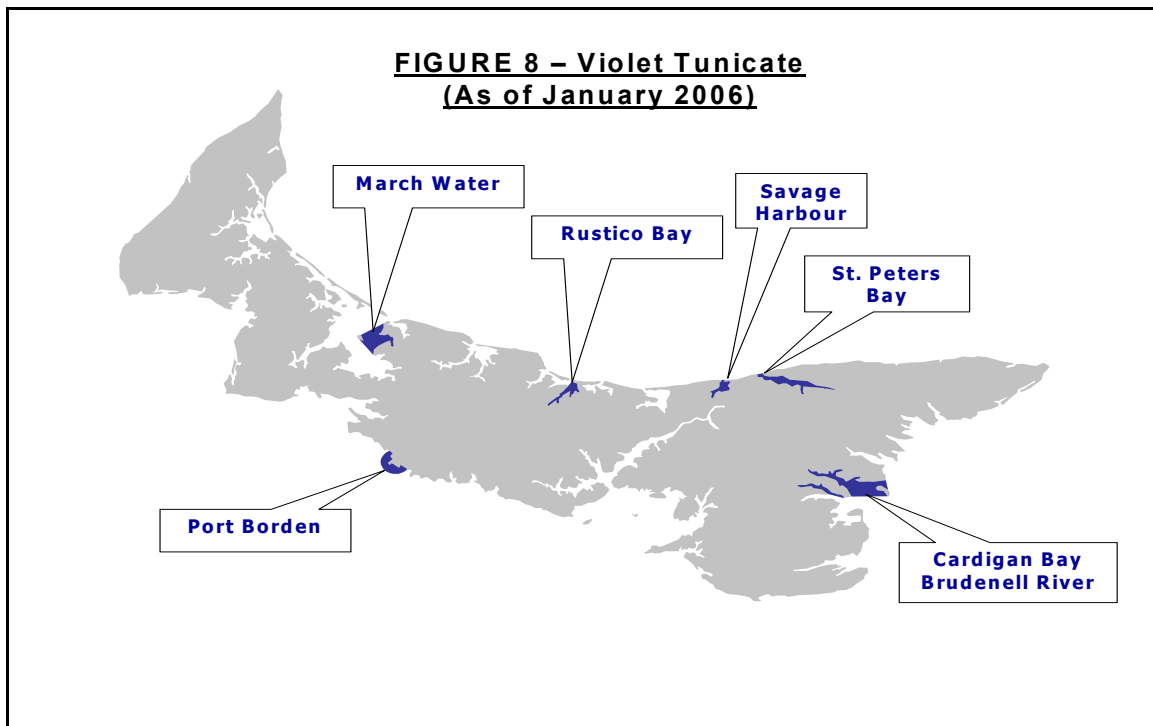
The Clubbed tunicate is in Murray River, Brudenell River, Cardigan River, Montague River, St. Mary's Bay, Orwell/Vernon, March Water (Malpeque Bay), and Darnley Basin.



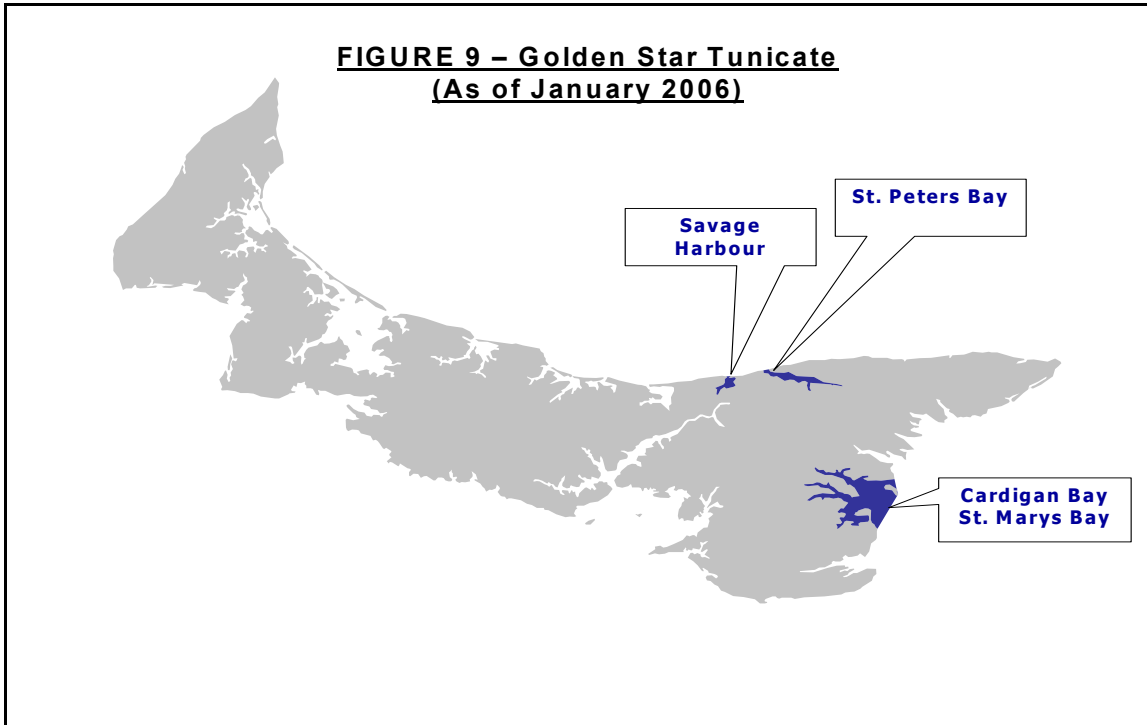
The Vase tunicate is in the Montague River, Brudenell River, and St. Mary's Bay.



The Violet tunicate is in Savage Harbour, Port Borden area, Rustico Bay (Hunter River), Cardigan, St. Peter's Bay, March Water, Brudenell River.



The Golden Star tunicate is in Savage Harbour, St. Peter's Bay, Cardigan Bay, St. Mary's Bay.



The following seed and mussel growing areas remain “clean”/tunicate-free: Boughton River, Souris River, Hillsborough Bay, (Nine Mile Creek), South Lake, North Lake, Malpeque Bay, Covehead Bay, New London Bay, and Cascumpec.

### ***Effects of tunicates on the mussel industry***

- Higher maintenance costs for growers, as socks need to be treated or sprayed.
- More labour-intensive to harvest mussels (heavier).
- Additional trucking costs (larger volumes).
- More labour intensive to clean mussels before processing.
- More labour intensive to clean vessels, tanks, ropes, buoys etc.
- Additional costs to install screening systems in plant's water lines to control effluents.
- Clutters or gums up the plant's processing equipment.
- Tunicates may significantly impact the ability of the industry to collect mussel seed (fouling of seed collectors).
- Additional costs to processing plants for waste disposal.
- Affects employee morale - much more demanding on employees to harvest and process tunicate - infested mussels (dirty, slimy and difficult to handle).
- Tunicates are cutting into the growers and processors profit margins.

Presently, there is no evidence that invasive tunicates have a significant impact on the growth period or the meat yields of mussels. In some bays of PEI, the production capacity has reached its optimal level. Stakeholders are concerned that the arrival of invasive tunicates will have an impact on the growth period and meat yields of mussels grown in these bays. Invasive tunicates could prevent many of these bays from ever attaining their optimal production capacity.



## Conclusion

The development of the blue mussel (*Mytilus edulis*) industry during the last decade could easily be termed a success story for Prince Edward Island. This industry has grown from a production of 9.2 million pounds in 1992 to 40 million pounds of mussels in 2004. The Prince Edward Island mussel industry accounts for 80% of the blue mussels consumed in North America.

The method of culture and the price received by growers for their mussels has remained relatively unchanged in the last 10 years. However, for the processing sector, during the last few years, more emphasis has been directed towards value added products.

With 123 growers operating 291 leases and 8 processing companies (with most of them also holding leases), the industry has become a vital sector of the Island's economy creating directly and indirectly the equivalent of 622 full-time jobs and generating sales of \$107 million in 2004. In terms of the contribution to the Gross Domestic Product (GDP) of the province, the mussel industry accounted for \$36.3 million in 2004.

The arrival of aquatic invasive species certainly represents a huge challenge for the industry. When the first clubbed tunicate showed up in 1998, growers and processors were able to adjust and cope with this invasive specie. The subsequent arrival of three other types of tunicates in recent years has created additional challenges for growers, processors, biologists and stakeholders involved in this industry. What will be the economic impact of these new types of tunicates is surely one of the biggest concerns of the industry.