Proceedings of the Southern Gulf Scallop Fishery Workshop: Moncton, New Brunswick, March 30-31, 2006

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Table of Contents

List of Figures

List of Tables

Abstract

The Department of Fisheries and Oceans – Gulf Region convened a workshop on March 30 and 31, 2006 to discuss the future of the Southern Gulf Scallop Fishery. The scallop fishery, like most other mobile gear fisheries, has been receiving increased media attention concerning its alleged effects on the habitat and ecosystem. The workshop was organized to identify progressive management practices for the traditional scallop fishery, while also exploring new harvesting methods. The key themes were 1) The Evolution of the Traditional Scallop Fishery and 2) New Scallop Harvesting Methods. To provide pertinent information, guest speakers from Canada and the United States gave presentations on various subjects: habitat, biology, aquaculture, harvest methods and enhancement. Each presentation was followed by a question and answer period. The workshop was well attended and included members of the following groups: fishing industry, aboriginal, academia, media and provincial and federal government.

Résumé

Le Ministère des Pêches et Océans - Région du Golfe a convoqué un atelier le 30 et 31 mars, 2006 pour discuter du futur de la pêche aux pétoncles dans le sud du Golfe. La pêche aux pétoncles, comme la plupart des autres pêches à engins mobiles, a suscité de l'intérêt des médias dernièrement en raison des effets présumés sur l'habitat et l'écosystème. L'atelier a été organisé afin d'identifier les méthodes progressives de gestion pour la pêche traditionnelle aux pétoncles, tout en explorant de nouvelles méthodes de récolte. Les thèmes principaux de discussion étaient 1) L'évolution de la pêche traditionnelle aux pétoncles. 2) Les nouvelles méthodes de récolte du pétoncle. Afin de fournir des informations pertinentes, des conférenciers invités du Canada et des États-Unis ont donné des présentations sur divers sujets, dont l'habitat, la biologie, l'aquaculture, les méthodes de récolte et l'ensemencement. Chaque présentation a été suivie d'une période de questions et réponses. L'atelier a été bien fréquenté par des membres des groupes suivants: l'industrie de la pêche, les regroupements autochtones, le milieu universitaire, les médias et les gouvernements provinciaux et fédéral.

Introduction

Sea scallops are the most important commercial species of molluscan shellfish in Canada and have supported valuable fisheries in eastern Canada for more than 100 years. In the Gulf Region, peaks in scallop landings occurred in 1970 (697 t), and have since levelled off and diminished drastically in recent years.

The scallop fishery in the Gulf has always been a complementary fishery to the lobster, herring and groundfish fisheries. Almost all scallop fishers hold more than one fishing licence; however a few fishers do depend on the scallop fishery as their primary income.

The workshop will be directed towards identifying progressive management methods for the traditional scallop fishery, while also exploring new harvesting methods.

The Department of Fisheries and Oceans (DFO) in Moncton, New Brunswick has organized a workshop intended to provide an opportunity for industry, aboriginal groups, academia, provincial and federal agencies to collectively focus their expertise on how to better manage the scallop fishery and develop new methods for harvesting.

Opening remarks

Laurent Paulin

The decreased scallop landings tell us that it is time to look at other means that would allow the scallop fishery to improve without neglecting the importance of the effect of the dragging on the habitat and the ecosystem in general. This workshop enrolled itself in carrying out the Department of Fisheries and Oceans mission that includes offering to the Canadian population:

- Safe and accessible waterways
- Healthy and productive aquatic ecosystems and
- Sustainable fishery and aquaculture

The last scallop fishery workshop held in 2001, emphasized conservation. Some of the recommendations have since been implemented. For example, the logbook format has been revised.

Status quo of the present scallop management measures is no longer acceptable. Management must be improved to take the habitat into consideration.

Fish Habitat Management Program

Roland Cormier

The fish management program follows the Department of Fisheries and Oceans mission of 1) Safe and Accessible Waterways 2) Healthy and Productive Aquatic Ecosystems and 3) Sustainable Fisheries and Aquaculture. The objective of the program is no net loss of productive capacity for fisheries resources. Our goals are 1) Conservation 2) Restoration 3) Development e.g. improve habitat by creating artificial reefs. A no net loss principle is applied to proposed works and undertakings. Under this principle, the Department will strive to balance unavoidable habitat losses with habitat replacement on a project-by-project basis so that further reductions to Canada's fisheries resources due to habitat loss or damage may be prevented. Relocation, redesign, mitigation and/or compensation are techniques followed to prevent or minimize habitat loss.

Why fish habitat? Why protect it? Habitat is required to maintain the life cycle of plants and animals in all the various stages, larval, juvenile and adult. Each species requires a certain habitat for reproduction and recruitment. Also, each species require specific physical habitat such as rocks for lobster to hide under and flowing rivers for smelts to migrate. The food chain could not continue without habitat maintenance. The bottom line: protecting the habitat allows everything to come together.

Lobster Habitat and Ecology

Michel Comeau

The Canadian east coast lobster fishing grounds are subdivided into various Lobster Fishing Areas (LFA) for management purposes (Figure 1).

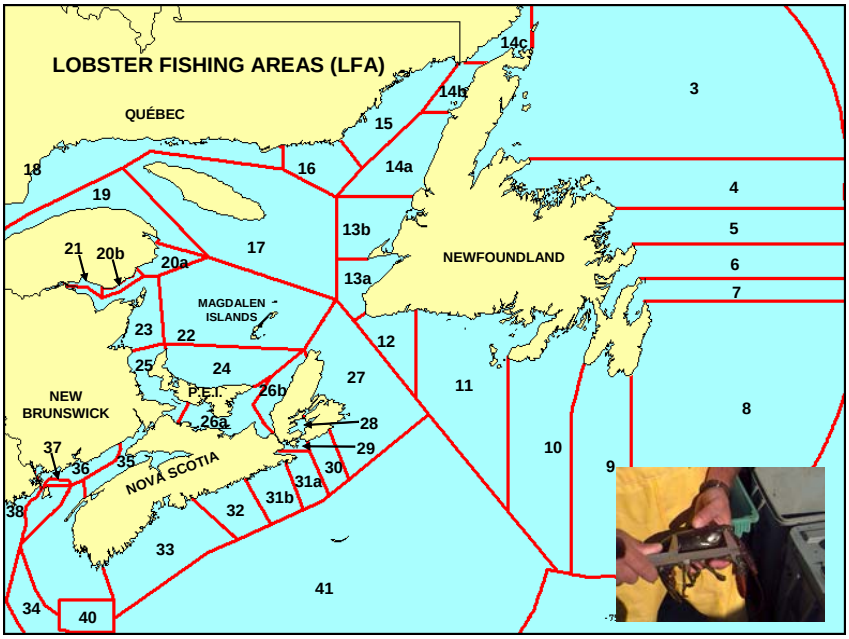


Figure 1. Lobster Fishing Areas in the east coast of Canada.

The life cycle of lobsters has been studied and is very well understood (Figure 2). Female lobsters have a two year reproductive cycle. After the female molts, sometimes between July and September, she will mate with a hard shell male. She will extrude the eggs about one year after mating and carry the eggs 9 to 12 months until they hatch into free swimming larvae. The first three stages are planktonic therefore are found in the water column but during stage IV, the lobster settles to the bottom to begin its benthic life.

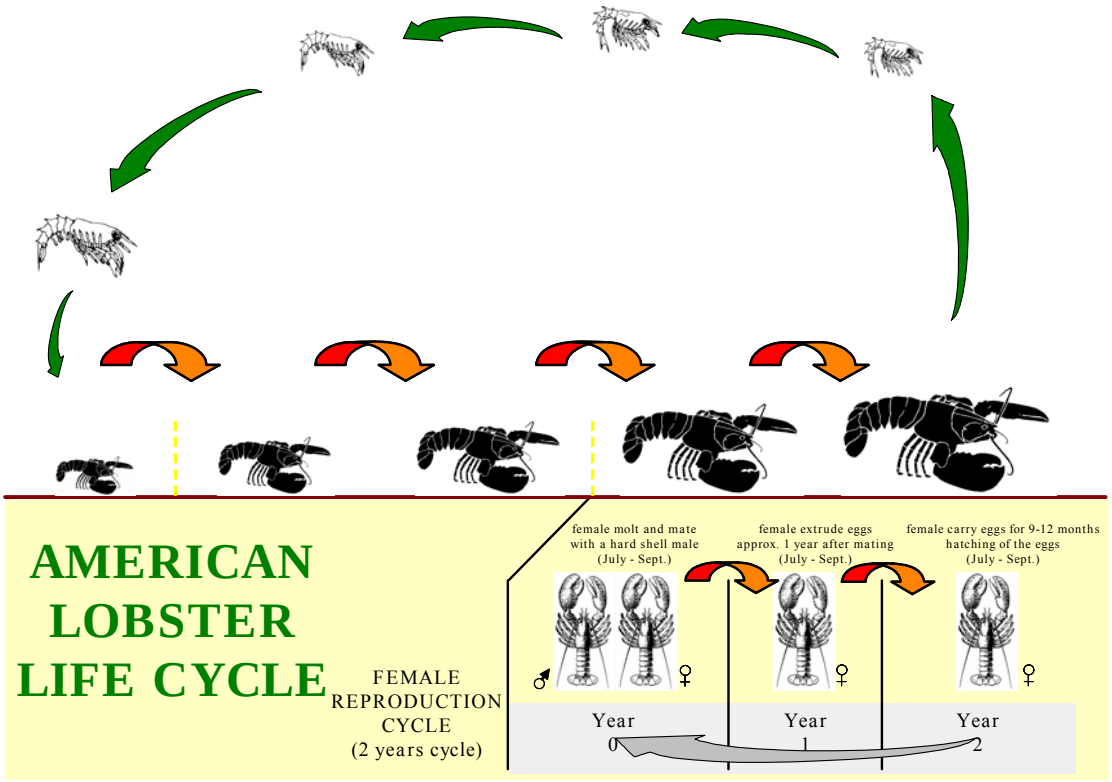


Figure 2. The American lobster life cycle.

The sediment found on lobster habitat has been classified according to its size. The size classification identified by Wentworth (1922) and Pettijohn (1949) are: 1) Hard sandstone or granite sea floor; 2) Boulder*:* Minimum 256 mm (Reef); 3) Cobble*:* 64 mm – 256 mm; 4) Gravel*:* 4 mm – 64 mm; 5) Sand*:* 1/16 mm – 4 mm, and 6) Mud*:* <1/16 mm.

The benthic lobster habitat has been classified as: Type I: Prime lobster ground; Type II: Good lobster ground; Type III: Marginal lobster ground, and Type IV: Poor lobster habitat (Figure 3).

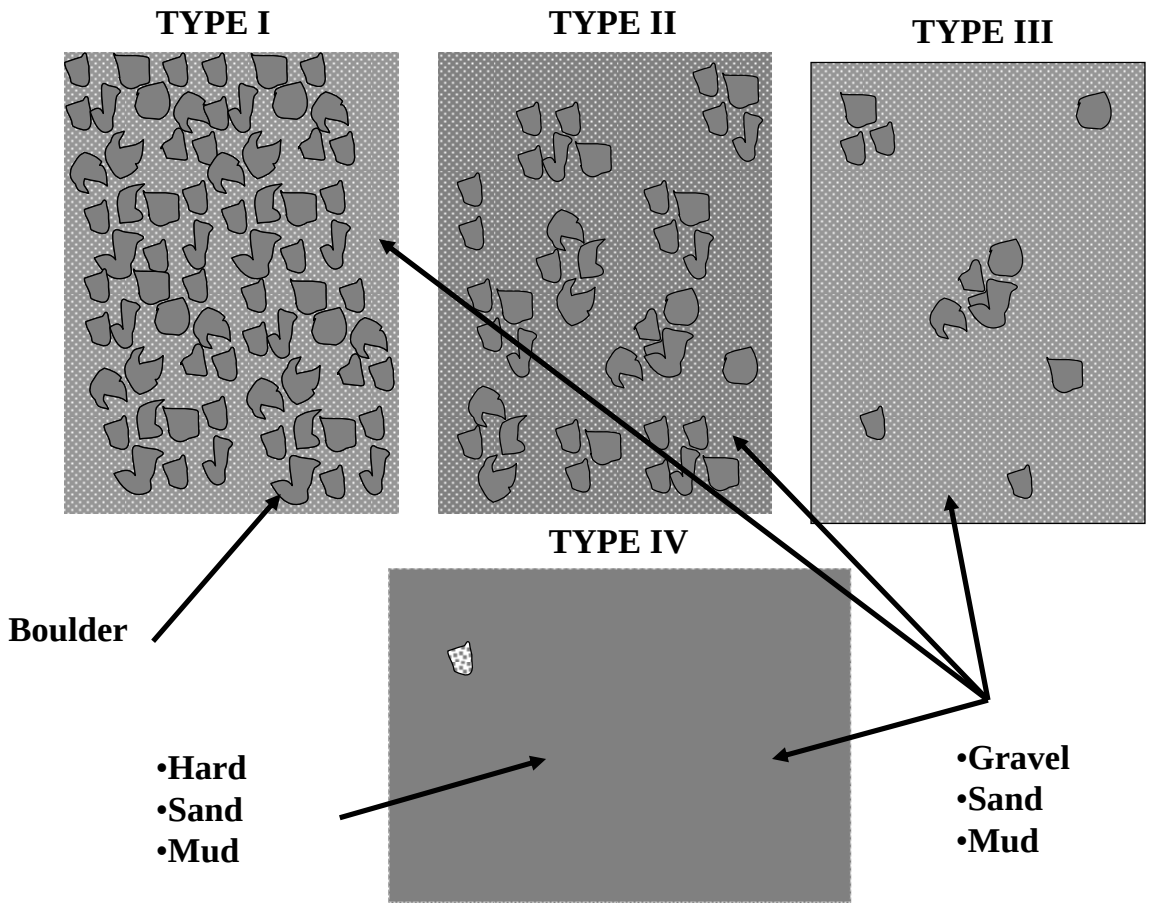


Figure 3. Lobster habitat classification.

Detailed description of the lobster habitat classification

Type I. Prime lobster ground: complex habitat composed of numerous small to middle size boulders (diameter >25 cm) on a gravel or small cobble substrate, or a mixture of gravel-mud-sand.

Type II. Good lobster ground: small to middle size boulders on a softer substrate, but the complex assemblage of small to middle size boulders formed reefs that are separated, but are located at very close proximity.

Type III. Marginal lobster ground: similar to type II but the reef type formations are far apart. Between these reef formations a simple habitat composed of gravel, mud and/or sand or hard sandstone bottom (poor lobster habitat) is observed.

Type IV. Poor lobster habitat: simple habitat composed of soft material (such as gravel, sand and mud) or hard bottom (sandstone or granite bottom) with no boulder size rocks. Lobster might be seen in transition between more suitable habitats (Types I-III), but will not permanently use the Type IV habitat.

The number of lobster found per meter square (density) in each habitat will vary according to the type of habitat (Table 1).

Table 1. Density of lobster on each type of habitat

Habitat	Density
Boulders with gravel	Highest
Boulders with gravel/sand/mud	Good
Boulders with sand or mud or hard sandstone	Poor
Habitat with only gravel sand or mud or hard sandstone	Lowest

Lobsters need a rock on soft, but structured, substrate to dig a burrow. A single layer habitat is important (edge effect).

Immature Lobster

The stage IV larvae will begin it's descent as soon as the temperature reaches 10°C, but no later than mid-September. If it encountered water colder than 10°C it will ascend back into the water column. To successfully make the transition to the benthic habitat the immature lobster requires a rocky habitat (Type I, II, III) which is usually less than 30 feet deep.

Juvenile Lobster

Lobsters are cryptic (hide in burrows) for the first 2 years of their life and are observed at depths of 30 ft (9 m) or less. They will remain cryptic until they reached a carapace length (CL) of 35 mm. After 2 years, they will venture out of their burrows and roam. Lobsters with CL of < than 60 mm are usually seen at depths of less than 60 ft (18 m).

Adult Lobster

Adult lobsters are observed at depths of 120 ft (36 m) or more in the winter months. There is a well documented offshore-inshore movement in the spring and lobsters are observed closer to shore in summer. They require complex habitat (single layer with edge effect) with boulders on softer substrate to dig their burrows.

Summary

Lobster densities are highly correlated with reef formations. Immature lobsters (up to 2 yr old) are cryptic at depths less than 30 ft (9 m). Juvenile lobsters will roam to depths of up to 60 ft (18 m). Adult lobsters are seen at depths of 120 ft (36 m) in the winter and closer to shore in summer. Lobster densities will decrease if there is a reduction of complex habitats and/or the edge effect.

Reference

Pettijohn, F.J. 1949. Sedimentary rocks. Harper & Row, New York, 718 p.

Wentworth, C.K. 1922. A scale of grade and class terms for clastic sediments. Journal of Geology 30: 377-392.

Questions/Comments:

Participant: Do aquatic plants play a role in lobster habitat?
Michel Comeau: Yes, they do. A large variety of plants is an indicator of a complex habitat, which is better for lobster. Plants typically cling to boulders. In the habitat is flat, but includes kelp (seaweed), lobster is usually found hiding under the kelp.

Participant: Does the existence of buffer zones for the scallop fishery have any impact?
Michel Comeau: If there are no alterations to habitat, towards a simpler habitat, it benefits lobster. If the habitat is continuously affected, that harms the lobster because seaweed will not cling to boulders, meaning seaweed will not grow. One must remember that lobster is a dominating species in its territory. At 70mm, it has no predator other that humans, it therefore relies solely on its habitat to survive.

Participant: I have a comment. I find the first photo gives an aggressive tone by showing a scallop drag…
Michel Comeau: If you are referring to the metal part on the bottom, it is actually not a drag, but a piece of wharf. It shows that what humans do sometimes benefits lobster. In this case, it provides a hiding spot for lobster.

Participant: Does habitat IV represent the type where scallops are dragged?
Michel Comeau: Yes, it does.

Participant: At what depth can we find seaweed?
Michel Comeau: It depends on the species. Kelp is found in up to 60 ft (18 m) of water, red algae are in deeper waters, while brown algae are in more shallow bottoms. In up to 30 ft (9 m) deep: we find a greater variety of plants; from 30 to 60 ft (9 to 18 m): there is less diversity but larger plant species; from 60 to 120 ft (18 to 36 m): same as 30 to 60 ft (9 to 18 m). For the first two years of a lobster's life, the environment of the first 30 ft (9m) of water is crucial. If it is a favourable habitat, it actually serves as a nursery.

Participant: Has any study on the effect of ice movement been done?
Michel Comeau: No. However, there is ongoing monitoring in northern New Brunswick, in an area which saw a lot of ice movement. In one part of the monitored site, ice interactions led to a higher number of smaller boulders. We think it means that ice movement will change the habitat.

Participant: Since we know that scallop is harvested in water over 35 ft (11 m) deep, what is the link with ice movement and lobster fishery? And at what time of year can we see it?

Michel Comeau: We have seen lobster in 35 ft (11 m) deep in October, depending on temperature and daylight. That ceases in November. Lobster will then be found around 120 ft (36 m) deep, on the edge of the intermediate cold layer. If there are fishing activities in May, lobster will be found in deeper range, as in October and November. It is essential for lobster to have hibernation grounds.

Participant: Is habitat quality better now than 20 years ago? Is the situation stable or has it changed?
Michel Comeau: We do not hold any direct information to know whether habitat is improving or not. However, we know that if there are toxic chemical products in the environment (on the bottom), habitat becomes irrelevant! We are now doing a study on the quality of habitat and its chemical characteristics. Nevertheless, there are evidences that dragging leaves considerable traces on the sea beds. When an ecosystem is modified, its balance is altered as well and it may never recover.

Participant: I have two questions/comments :
1) At a previous workshop, we were told there was no recruitment in our area of Cape Tormentine. If the scallop is dying, what happens to lobster; the same thing? The bottom is so silted; there is no recruitment within 50 ft (15 m) of the bridge (i.e. the Confederation Bridge). Until we rectify the bridge situation, we're wasting our time.
2) In the mid 80's, we had the best fishery in the Gulf. The Bridge ruined our spring lobster fishery. We had record lobster catches, then two years later we had record scallop catches… There is talk of dredging the Charlottetown harbour, where is that going to go? And what will be the impact on our fishery?
Laurent Paulin: There is a study ongoing on the (Northumberland) Strait situation and it will address several issues, including changes that followed the construction of the bridge. I understand your preoccupations, but let's wait for the results of this study first.

Participant: You say that lobster stops at 120 ft (36 m) deep. In Nova Scotia they catch it in 300 ft (91 m) deep. I fish during the fall season. In the late part, we go around Northern PEI and we catch them in 130 ft (40 m) deep. So where exactly are they?
Michel Comeau: In the Gulf of Saint Lawrence, there are different water masses, in temperature and in density. There is a cold intermediate layer at 130 ft (40 m) and deeper. In Nova Scotia, the lobster thrives in deeper water, but the water temperature is higher. In areas where the cold intermediate layer is close to the shore, lobsters don't like it because it's so close to shore. All lobsters do not leave. They only do so if they have to. Large lobsters dominate their environment, so they do not need to leave. Lobster will be seen on the coast at up to 120 ft (36 m) deep.

Participant: We don't see them (lobsters) in the spring although the water is clear then. In the summer it's all muddy and they're still not there… Where have they gone?
Michel Comeau: Yes there is movement of lobster. But they cannot go everywhere.

Participant: In regards to our scallop enhancement; in the bottom 6 inches of cages, all scallops die. How will stage IV lobsters live in there?
Michel Comeau: Is there less oxygen in the bottom of your cages? Is it at the right temperature? There are many factors affecting scallop growth and it is difficult to establish the cause of death without that data.
Donna Murray: The reason the scallops are not surviving is because they are covered with silt. However, there is a good growth rate in scallop that are placed in cages and set 1 foot from the bottom. But everything in the bottom dies…

Michel Comeau: Do you have any data on dissolving oxygen?
Donna Murray: No we don't.

Overview of the Scallop Fishery

Luc Légère

In the Gulf Region, the scallop fishery is considered to be complementary to the lobster, herring and groundfish fisheries. Scallops are harvested with mobile gear (drag) using 14m vessels. There is a recreational diving fishery off the coast of New Brunswick and Nova Scotia but not off the coast of PEI. For management purposes, the scallop grounds in the Gulf Region have been divided into six Scallop Fishing Area (SFA) (Figure 4). Each SFA select their own management measures.

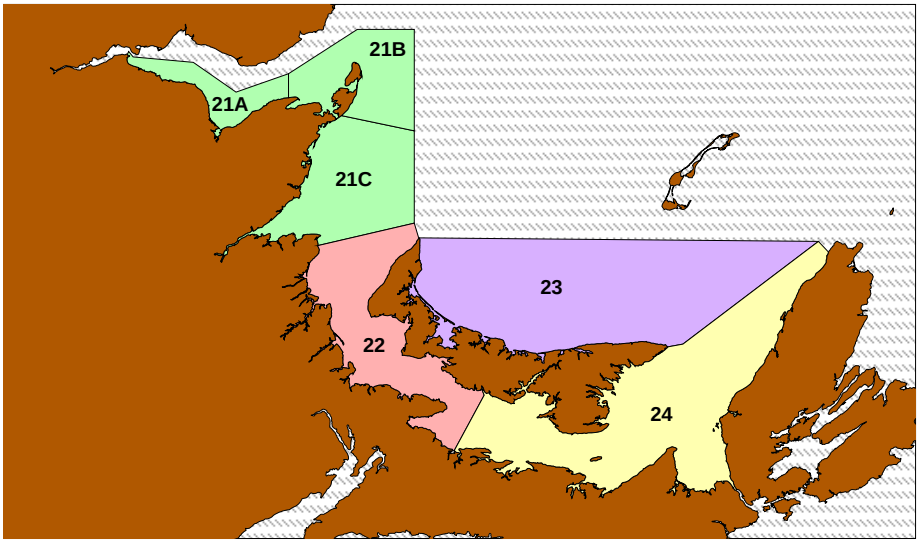


Figure 4. Gulf Region's Scallop Fishing Areas.

Location
Some geographical area contains two management areas. For example, the scallop fishery in the Northumberland Strait is found in SFA 22 and SFA 24 and Baie des Chaleur is divided into SFA 21 A and SFA 21 B. However, the Miramichi Bay is located only in SFA 21 C and the Northside of PEI is in the SFA 23.

First recorded landings were in the early 1900's. The peak landings occurred in late 60's and early 70's. Landings have greatly decreased in last 5 years (Figure 5).

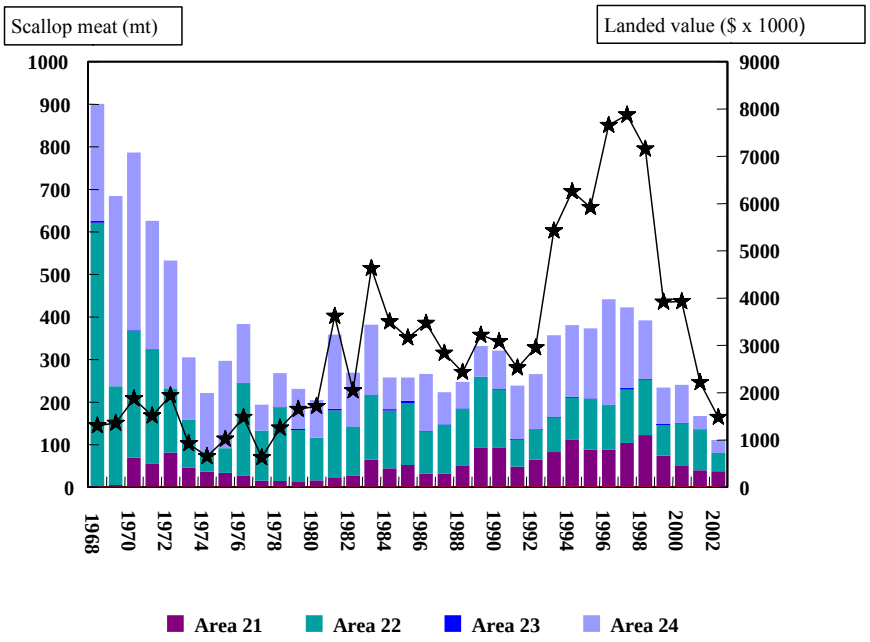


Figure 5. Scallop landings in the southern Gulf of St. Lawrence in Scallop Fishing Areas 21, 22, 23 and 24.

Gear

Most fishers in the Gulf Region use a Digby-type drag (Figure 6) to harvest scallops however the sweep chain drag is sometimes used.

Figure 6. Digby-type drag most commonly used by fishers in the Gulf Region.

Participants

In the Gulf Region there are a total of 774 fishers who hold a commercial scallop fishing license. In SFA 21, 103 fishers (SFA21A, 28, SFA21B, 27 and SFA21C, 48) from

eastern New Brunswick hold licenses. In SFA 22, 142 fishers from eastern New Brunswick and 61 fishers from PEI are licenses holders. In SFA 23, 78 fishers from PEI hold licenses. In SFA 24, 131 fishers from Nova Scotia and another 259 fishers from PEI hold licenses.

Thirteen First Nation's licences have access to the scallop resources. There are 22 licenses granted in eastern New Brunswick, 7 in northern New Brunswick, 7 in Nova Scotia and 7 in PEI.

Current Trends

There is an international pressure to limit or completely remove mobile gear fisheries. Many process control measures ranging from input to output are being discussed. Management strategies, new to Canada, such as rotational fishery, are being considered. Enhancement practices (active or passive) of traditional scallop beds are presently being investigated. Scallop aquaculture activities are being examined.

Habitat Protection Measures

In the Gulf Region, in most SFAs, buffer zones have been implemented in recent years to prevent the scallop fishers from dragging over selected habitat. These buffer zones were established through collaboration between DFO and industry. They were established mainly to protect lobster larval settling areas and surrounding habitat. A total of over 6,000 square kilometres have been established as buffer zones (Figure 7). This area is larger than the total size of Prince Edward Island.

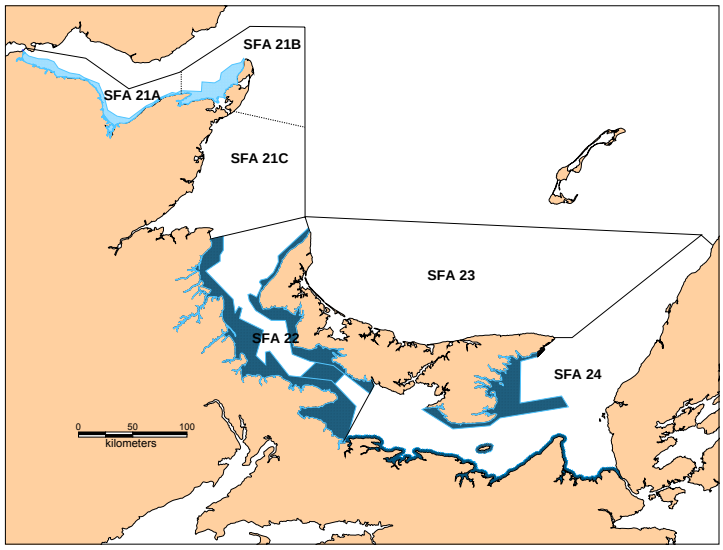


Figure 7. Buffer zone presently established in the Gulf Region.

Questions/Comments:

Participant: Are the landings per zone accurate?

Luc Légère: The information comes from sales slips divided by statistical districts.

Participant: That does not reflect changes in scallop fishing zones and gear…
Luc Légère: No, it does not.
Participant: In 1995, I wrote a letter to Public Works telling them the fishery would suffer because of the upcoming bridge. And it happened… Until that mess is fixed there will be no fishery.

Participant: I hope these statistics are not used to show the condition of the stock…
Luc Légère: No, they are only used to show landings' statistics.

Participant: Area 21B was created in 1998, and we have had problems ever since. For example, in the Bay of Chaleur, the lobster fishery is in difficulty. Some lobster fishers thought they would create artificial reefs by dumping tires! There are more than 5,000 tires that were dumped off the coast of Petite-Rivière-de-l'Île. This was done without a permit. Last summer, I caught 16 tires in four tows. At the very least, they could have told us. To top it all, it was outside the buffer zone.
Laurent Paulin : We are aware that scallop fishers are a minority. I recognize that this situation could have caused a conflict. Now, how do we resolve this problem?

Participant: In the second buffer zone south of Miscou, I warned fishers that if I found more tires on our sea beds, it would not be pretty.
Laurent Paulin: I was not aware of the situation with tires. Thank you. It has been duly noted.

Participant: Enhancement sites should be indicated on the map.
Luc Légère: I took note of that.

Participant: In area 23, there is no buffer zone. Why not put it in there? Fishers agree.
Luc Légère: That was brought to the meeting last year. We are aware there is a gentlemen's agreement, but there were not enough fishers present for a vote.

Participant: According to your map, it shows that stocks are down, in spite of spring closure and buffer zones…
Luc Légère: It does not say that stocks are down but that landings are down.

Biological Overview

Leslie-Anne Davidson

The giant scallop specie has separate sexes. The male reproductive organ or gonad is white and the female gonad is pink (Figure 8).

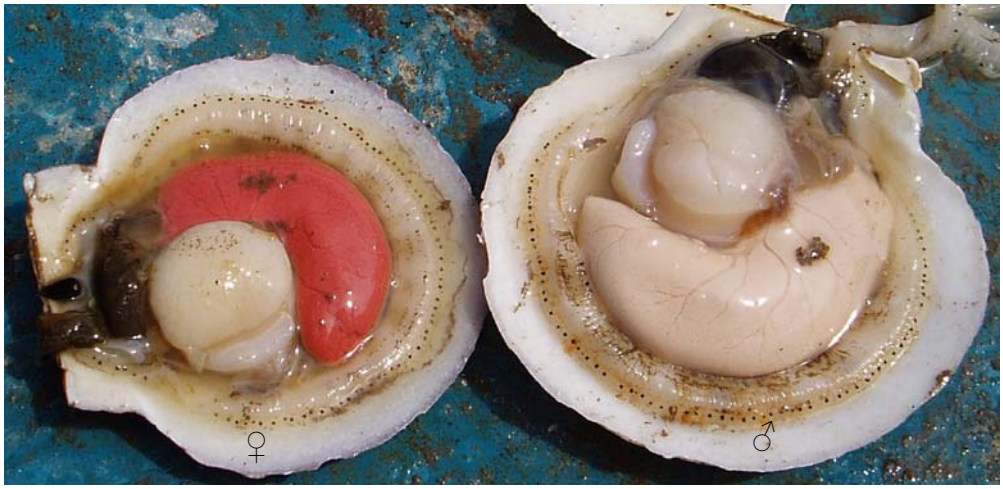


Figure 8. Female scallops have pink gonads and male scallops have white gonads.

To follow the reproductive cycle of the scallop population and to determine when they are spawning, the gonodosomatic index (GSI) is monitored. The GSI is the percentage of the weight of the gonad compared to the total soft tissue weight. Therefore, as the scallop puts more energy in its gonad the GSI increases and when the scallop spawns, the GSI decreases (Figure 9).

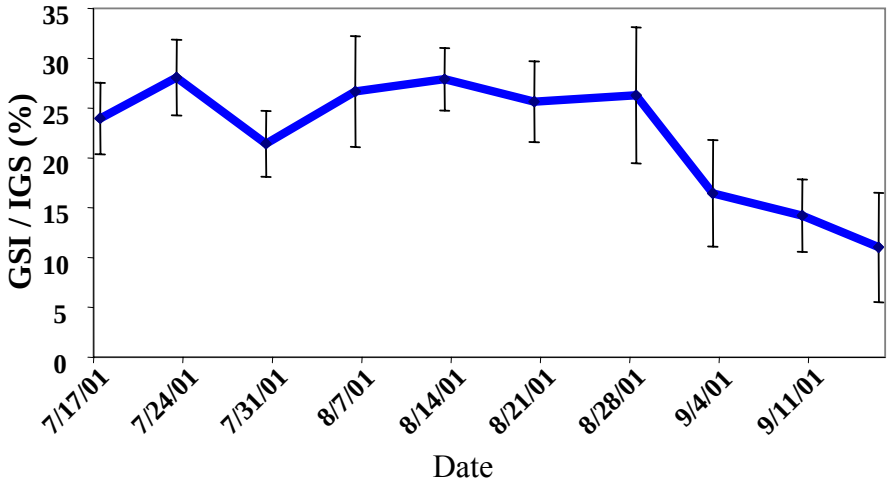


Figure 9. Example of a gonadosomatic index (GSI) of a scallop population.

In the Gulf Region, spawning occurs in the fall as the male and female scallops release their gametes. Fertilization occurs in the water column therefore it is important that males and females are in close proximately. The fertilized gametes become larvae that remain free swimming for up to five weeks as it grows and passes through various stages (Figure 10). During its last stage, it seeks the bottom trying to attach to a suitable substrate. Once on the bottom, it begins its benthic life where it can live up to twenty years. Gonad development can be observed in scallops as young as two years old. However, in the Gulf Region, the scallops do not release the majority of their gametes until they are four year old.

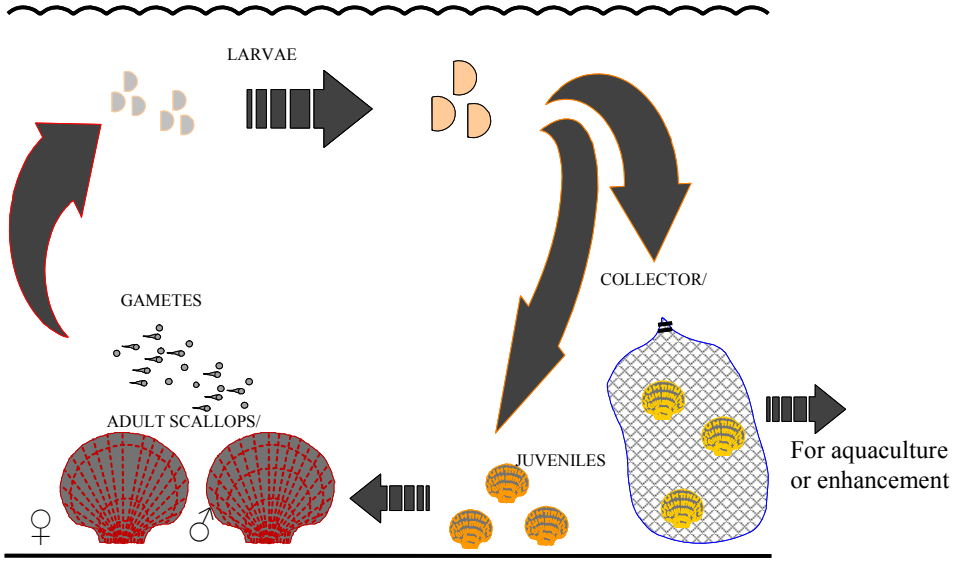


Figure 10. The life cycle of scallops.

When one of the shells is removed the anatomy of the soft tissue of the scallop is revealed (Figure 11). In North America, we usually only eat the adductor muscle however in many European countries, the muscle and the gonad (roe) is often consumed.

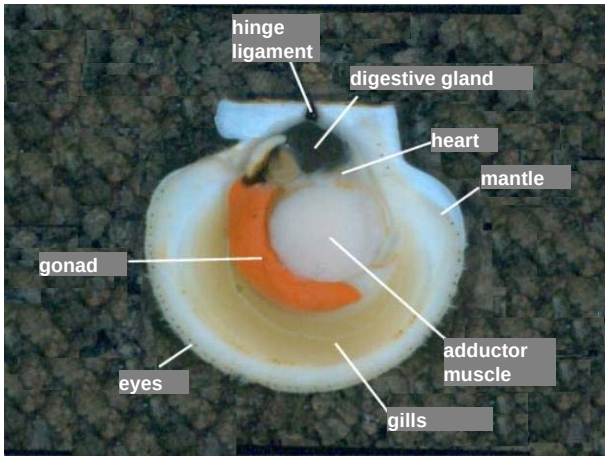


Figure 11. The scallop anatomy.

Environmental Criteria

Giant scallops prefer salinities of 30 to 32 ppt but they can tolerate salinities as low as 25ppt. In the Gulf Region, scallops must often face temperatures ranging from -2 ^{o}C to 20^{o}C. Growth occurs at temperature ranging from 8 ^{o}C to 18 ^{o}C while the ideal temperature is 13.5^{o}C (Frenette, 2004). The giant scallop is stressed at temperatures between 20^{o}C to 23^{o}C yet will survive if acclimated. Mass mortality will occur at temperatures of 23.5^{o}C or greater (Dickie, 1958).

Scallops can be found at depths of 3.6 m to 180 m however in the Gulf Region most scallop beds are found at depths of 15 to 38 m. Scallops seem to prefer gravel/sand bottoms however they are also found on rocky bottoms and sometimes mud or sandy bottoms. Scallops require well oxygenated water of 2-5mg/l with low turbidity of less than 10mg/l and they are most productive when exposed to a current speed of 5-15cm/s (Shumway and Parsons, 2006).

In the Gulf Region, scallops are fished using the toothed Digby-type drag (Figure 12).

Figure 12. Seven bucket Digby-type scallop dredge used in the Gulf Region.

In the Gulf Region, the scallop beds (Figure 13) do not change geographically while the scallop density (scallops/m^2) will vary depending on the recruitment success and fishing effort.

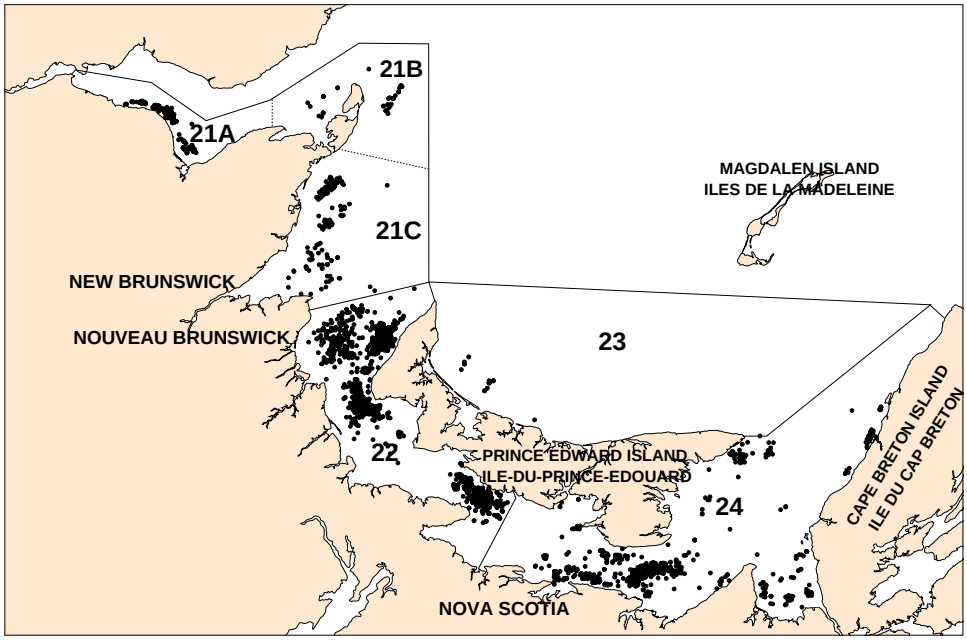


Figure 13. Location of the scallop beds in the Gulf Region according to logbooks.

In the fall of 2002, the presence of scallop larvae (Figure 14) was monitored throughout the Gulf Region.

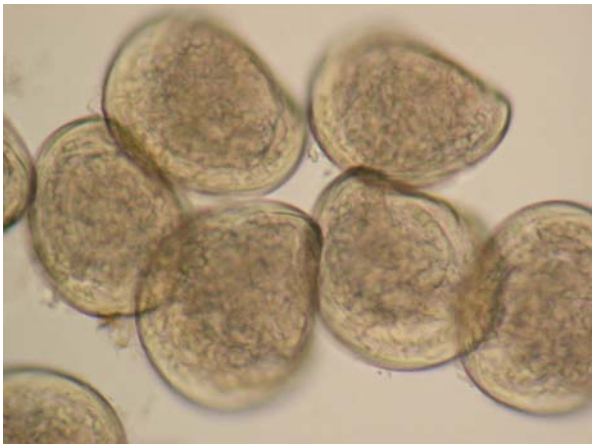


Figure 14. Scallop larvae.

Scallop larvae were found in abundance at all the sample stations (Figure 15).

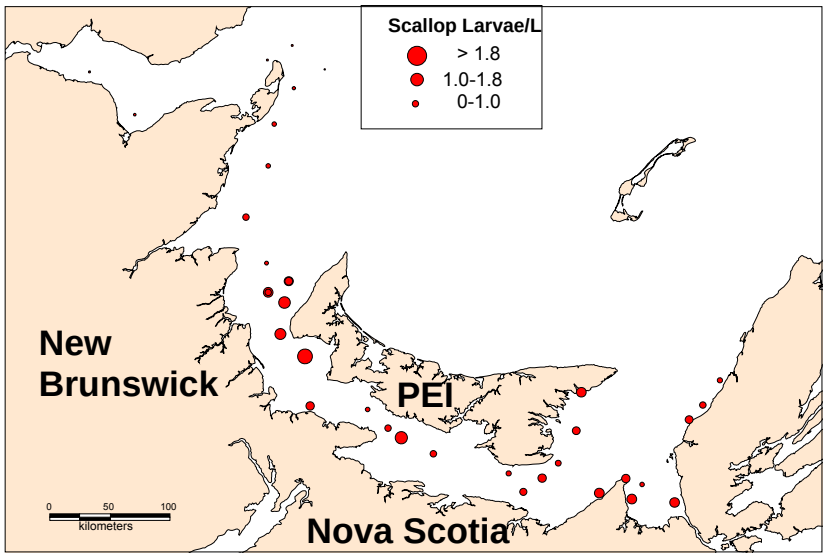


Figure 15. The density of scallop larvae at each sample station.

Scallop spat studies were conducted throughout the Gulf Region from 1997 to 2001. Spat bags made with mesh bags stuffed with Netron™ were used to collect the scallop spat (Figure 16).

Figure 16. Spat collector bag with a high number of juvenile scallops.

High numbers of scallop spat were found throughout the Gulf Region except in the central part of Northumberland Strait (Figure 17). In this area, silt accumulated in spat bags. This silt may have prevented the scallop spat from settling in the collectors or smothered them after they settled.

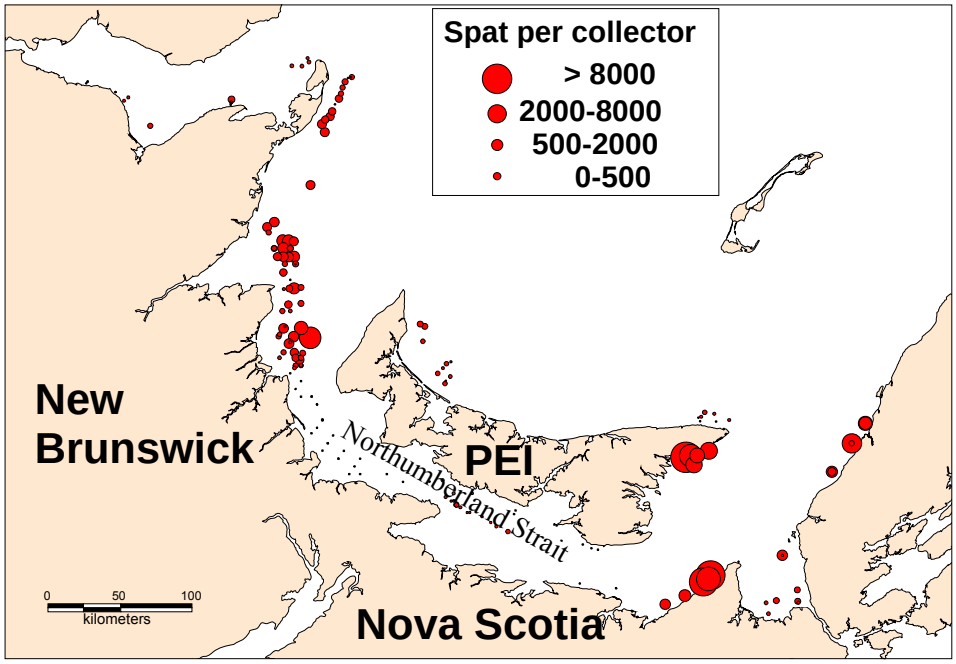


Figure 17. Number of scallop/collector bag at sample stations in the Gulf Region.

Reference

Dickie, L.M. 1958. Effects of high temperature on survival of the giant scallop. J. Fish. Res. Bd. Canada. 15(6):1189-1211.

Frenette, B. 2004. Environmental factors influencing the growth and survival of juvenile sea scallops, *Placopecten magellanicus* (Gmelin, 1791). M.Sc. Thesis, Memorial University of Newfoundland, St. John's, NL, Canada. 142 p.

Shumway, S.E. and Parsons,G.J. (eds.). 2006. Scallops:Biology, Ecology and Aquaculture 2nd Edition, Elsevier, Amsterdam, The Netherlands, 1460 p.

Scallop Stock Characteristics in the Southern Gulf of St. Lawrence

Monique Niles

In the Gulf Region, the Sea Scallop, *Placopecten magellanicus*, (Figure 18a) is commercially fished however almost all scallop fishermen fish other species, mostly

lobster and herring. There are over 700 licenses but only around 200 were active in 2004. The fishermen use 45' boats (Figure 18b) and Digby drag or rock drag (Figure 18c) which has anywhere from 5 to 15 toothed buckets.

a) b) c)

Figure 18. a) Sea Scallop, *Placopecten magellanicus*; b) 45' boat; c) Digby or rock drag.

The bucket rings are held together with steel washers and rubber washers on the vertical (Figure 19a). Some fishermen place rubber mats on the outside of the drag when they fish over rocky bottoms (Figure 19b). In one area, runners are used to prevent the tow bar from dragging on the bottom (Figure 19c). In area where the fishing season extends into the cold winter, fishermen have shucking shelters (Figure 19d).

a) b) c) d)

Figure 19. a) Steel and rubber (vertical) washers; b) Rubber mats under the drag; c) Runners on the tow bar; d) Shucking shelters.

In the past, research surveys were conducted annually to assess scallop stocks in our region but at a high cost and high manpower. In the Gulf Region, the scallop fishery is a relatively small fishery dispersed over a large area and is managed without quotas. In 1988, when the budgets were reduced, those surveys ended. Meanwhile, the fishermen still wanted information on their fishery. A sea sampling project was conducted, on a very modest budget, from 2001 to 2005. The purpose of the sea sampling was to better understand the scallop stocks and the fishery in order to provide science advice to fishery managers and industry. The sea sampling project was a collaboration between the Dept. of Fisheries and Oceans and the industry. It was also a tool to document special observations such as parasites, diseases, mortalities and beds of small scallops.

The sea sampling involved two biologists spending one fishing day on each major scallop bed in each of the Scallop Fishing Areas (SFA): 21A, 21B, 21C, 22, 23 and 24. The sea sampling sites visited annually from 2001 to 2005 are presented in Figure 20.

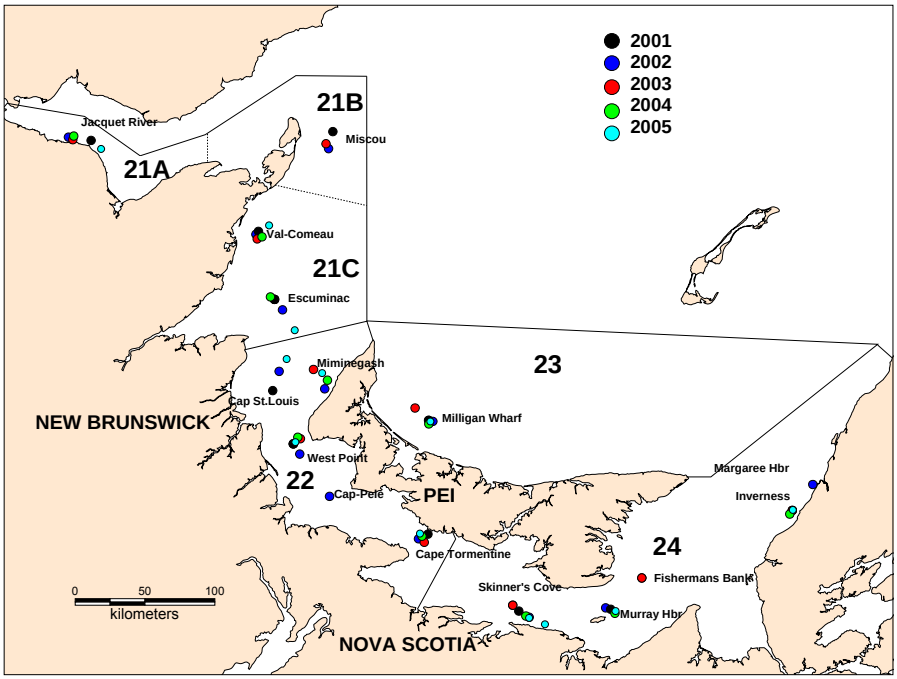


Figure 20. Sea sampling sites from 2001 to 2005 in Scallop Fishing Area (SFA): 21A, 21B, 21C, 22, 23 and 24.

A sea sampling day consists of taking the shell height measurements (Figure 21) of every scallop from every second tow. The fishing and effort data such as geographical position, towing speed and gear configuration were also recorded. Also, a sample of 200 scallops was taken to the laboratory for further analysis of size, weight and age.

Figure 21. Measuring a scallop using a caliper.

Effort information such as catch rate and the catch per unit effort (CPUE) was obtained from the sea sampling data. Also the catch density which is the number of scallops in the catch per m^2 of fished area was calculated. Using the effort information and assuming that the drag efficiency is around 10%, the scallop density on the bottom for that bed could be estimated (Table 2).

Table 2. Sample site and the corresponding effort information calculated from the sea sampling data: Catch Rate, CPUE and Catch Density**.**

Scallop Fishing Area	**Site**	**Catch Rate**	**CPUE**	**Catch Density**
(SFA)		**Kg/hr**	**Kg/hr*m**	**Scallop/m^2**
21A	**Jacquet River**	4.5	0.97	0.014
21B	**Miscou**	7.1	1.10	0.010
21C	**Val-Comeau**	2.6	0.68	0.013
21C	**Escuminac**	5.4	0.90	0.011
22	**Miminegash**	6.0	1.26	0.041
22	**West Point**	7.4	1.51	0.042
22	**Cape Tormentine**	4.7	1.27	0.036
23	**Milligans Wharf**	2.7	0.52	0.009
24	**Skinners Co**	5.7	1.20	0.011
24	**Murray Hbr**	5.3	0.98	0.019
24	**Inverness**	9.2	2.14	0.047

The size frequency distributions for each sampling site is plotted to show the variation from one scallop bed to another or the variations that occurs on the same bed from one year to the next (Figure 22).

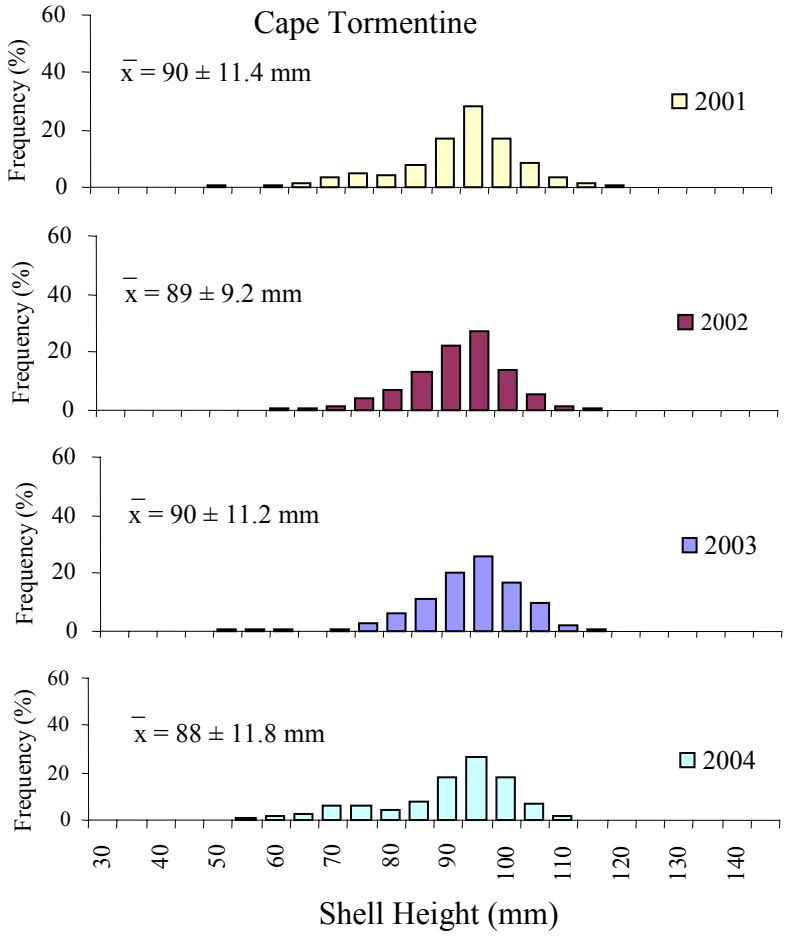


Figure 22. Size frequency distribution of scallops fished off the Cape Tormentine Bed in 2001, 2002, 2003 and 2004**.**

The shell height/meat weight relationship of scallop from each bed can be calculated from the measurement data obtained from the sample analysed in the laboratory (Figure 23).

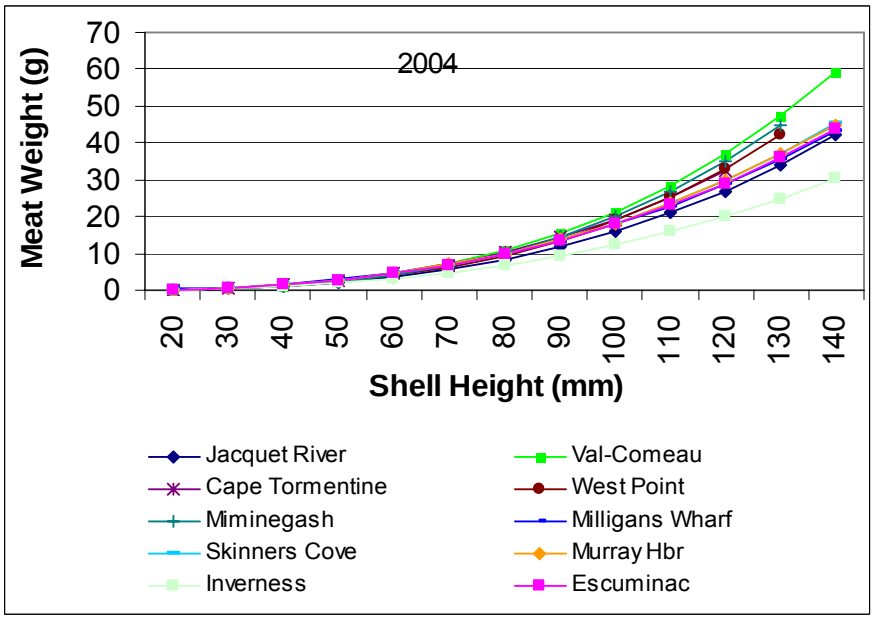


Figure 23. Meat Weight / Shell Height relationship of scallops sampled in 2004.

In 2002, the fishermen expressed a lot of concern over the small meats of the scallops and the data obtained from sea sampling confirmed their observation. The scallops were screened for diseases by DFO's aquatic animal health laboratory and when that came out negative, fishermen speculated that pollution was the problem. However, when the water temperature trends over the same years were compared to the average meat weight of a 90mm, there seemed to be an inverse relationship. The average meat weight of a 90 mm scallop in the Gulf Region was plotted against temperature over the 4 years of the study. The average was lower in 2002 compared to the other years (Figure 24). Also, ice departure from the fishing areas was earlier in 2002 than the other years.

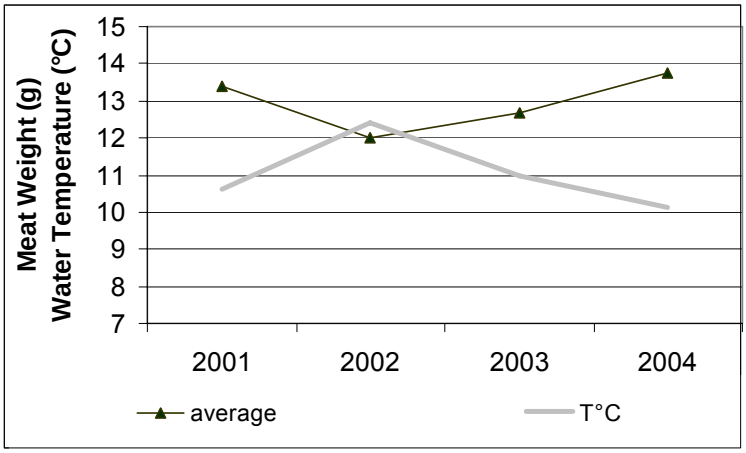


Figure 24. The average meat weight of a 90mm scallop in the Gulf Region plotted against the average temperature in 2001, 2002, 2003, and 2004.

With the data obtained from the laboratory samples, the following information can be obtained for each scallops bed sampled: scallop growth rate (Figure 25), shell height at age (Figure 26) and meat weight at age (Figure 27).

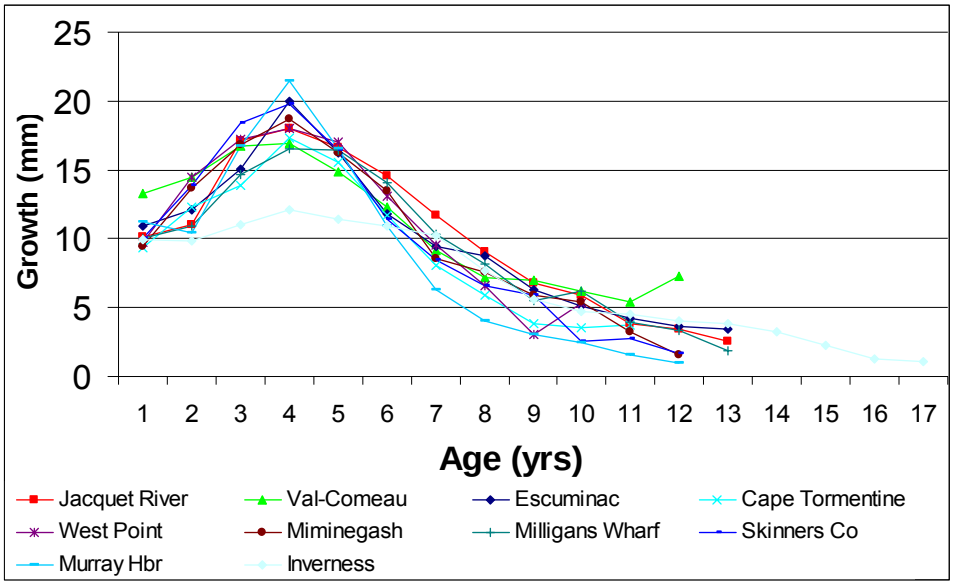


Figure 25. Growth rate of scallops harvested from various sites in 2004.

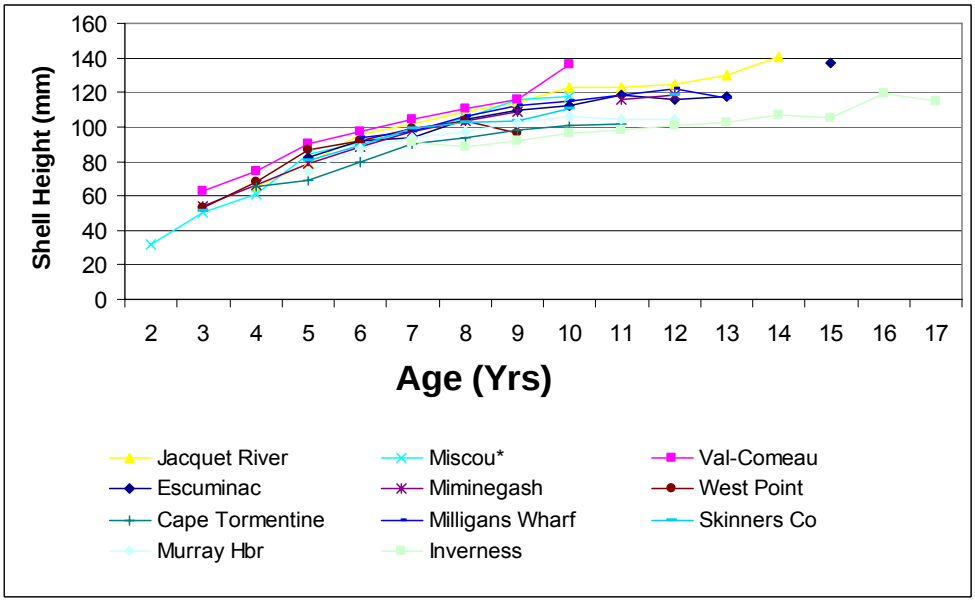


Figure 26. Shell height at age of scallops harvested from various sites in 2004.

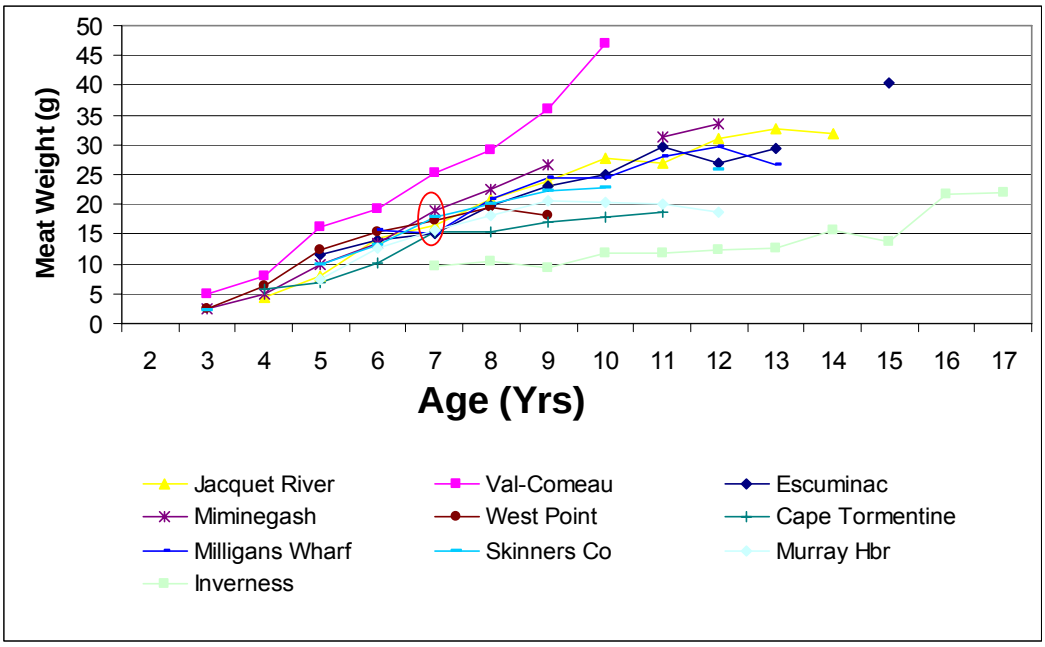


Figure 27. Meat weight at age of scallops harvested from various sites in 2004.

The average meat weight of scallops at each age can be determined and related to the shell height. Also the meat count per 500g can be calculated. An example of this information obtained from samples taken in SFA 22 can be found in Table 3. Clearly we can see how the yield can be doubled by harvesting a 7 year old instead of a 5 yr old.

Table 3. Information obtained laboratory samples from SFA 22.

Site	Age	Shell Height (mm)	SD	Meat Weight (g)	Meat Count/500g
Miminegash	3	53.5		2.4	208
	4	66.7	2.4	4.9	102
	5	78.9	3.3	9.8	51
	6	88.1	4.0	13.4	37
	7	97.5	5.2	19.0	26
	8	103.2	4.6	22.7	22
	9	108.3	4.6	26.8	19
	10				
	11	116.2	4.5	31.5	16
	12	118.3	10.8	33.5	15
West Point	3	53.3		2.4	208
	4	68.4	11.0	6.3	79
	5	86.5	4.9	12.3	41
	6	92.1	4.4	15.5	32
	7	99.3	7.4	17.4	29
	8	103.1	5.2	19.5	26
	9	96.2	20.8	18.1	28
Cape Tormentine	4	65.4	5.6	5..8	86
	5	69.1	6.1	6.8	74
	6	79.4	8.0	10.1	50
	7	90.0	4.7	15.5	32
	8	93.9	3.8	15.4	32
	9	97.7	3.6	17.1	29
	10	100.9	5.5	18.0	28
	11	101.5		18.6	27

Data obtained from samples measurements conducted in the laboratory, can also yield corresponding age and meat weight for the average shell height measured during sea sampling (Table 4). The average age at harvest (all sites) is 7.7 years and the average shell height is 99.6 mm while the average meat weight is 18.5 g.

Table 4. The average shell height of scallops measured at each sampling site and the corresponding age and meat weight calculated using the laboratory data**.**

Scallop Fishing Area	Site	Age	Shell Height (mm)	Meat Wt (g)
(SFA)				
21A	**Jacquet River**	7.6	105.1	18.3
21B	**Miscou**	6.1	98.1	20.1
21C	**Val-Comeau**	7.1	104.1	22.9
21C	**Escuminac**	8.1	104.9	19.1
22	**Miminegash**	6.2	94.3	16.2
22	**West Point**	5.9	92.9	15.9
22	**Cape Tormentine**	6.2	88.7	12.3
23	**Milligans Wharf**	7.8	105.3	20.9
24	**Skinners Co**	8.5	102.9	18.5
24	**Murray Hbr**	8.8	103.8	15.6
24	**Inverness**	11.2	98.9	12.6

Summary

- Sea sampling has given us information on the Southern Gulf of St. Lawrence stocks
- Density estimates in SFA22 and Inverness stocks are higher ($0.36 – 0.47/m^2$) than other stocks ($<0.2/m^2$)
- Some stocks (Cape Tormentine, Inverness, Murray Hbr) have slower growth rates than others
- For the same size and for the same age scallops the Val-Comeau and Miminegash stocks have bigger meat weights than other stocks
- Average age during sea sampling was 7.7 yrs
- A 7 yr old scallop is a good target to obtain meat weights between 15 and 20g per animal

Questions/Comments:

Participant: How many pounds of scallops were caught per day?
Monique Niles: According to log books, it varied from 50 to 200-300 lb/day. Average catches were 70 lb/day, for a 12 hour period.

Participant: What explains the great differences? Are there genetic differences?
Leslie-Anne Davidson: A researcher from the Québec Region has looked at the genetic component of different scallop beds in Gulf of St. Lawrence. According to preliminary results, there are no genetic differences from on bed to another in our Region, so variations are probably due to environmental conditions.

Participant: Regarding the slower rate of growth around Murray Harbour and Cape Tormentine, is it due to a nutrient shortage? Since it is never mentioned, maybe it would be interesting to study.
Leslie-Anne Davidson: Ghislain Chouinard has indeed studied this and has documented that the scallops on Cape Tormentine grow slower. It is most likely an environment issue. Temperature varies and sometimes it reaches high values.

Participant: It is worth studying scallop in the (Northumberland) Strait if it is not an optimal location for them?
Monique Niles: These are still good recruitment territories.

Participant: Do suspended sedimentation rates influence the growth rate of scallop?
Monique Niles: We have not studied that yet. However, Wildish (DFO Research Scientist) studied it and he says that if the scallop cannot filter, there is no growth.

Paticipant: How many days before we see the effect of sedimentation?
Monique Niles: I will come back to you on this question.

Scallops Enhancement in Îles-de-la-Madeleine, Québec

Madeleine Nadeau (speaker) and Georges Cliche, MAPAQ

The scallop fishery off the shores of Îles-de-la-Madeleine, Québec, Canada was once lucrative for about 20 fishers. The rapid decrease of the stocks that began in the early 70's was associated with over-fishing. Since then, the landings have not been above 65 T (Figure 28).

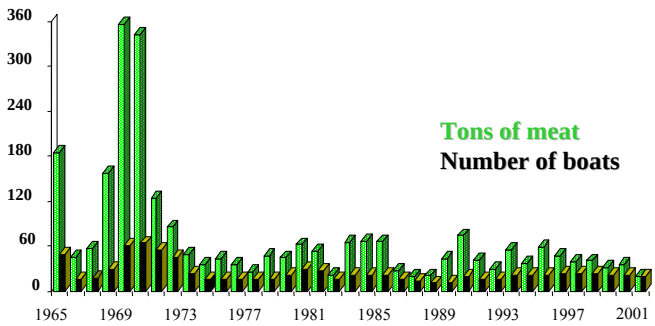


Figure 28. Scallop landings in meat weight and number of fishing boats in Îles-de-la-Madeleine, Québec, Canada from 1965 to 2001 (IML-DFO data).

Following the example of countries like Japan and New Zealand that have successfully increased their scallop landings by enhancement, a program for "*RE*search on *PE*ctinid *RE*stocking" (REPERE) was launched. The REPERE project was conducted in two phases. In Phase 1 (1990 -1998), the work was carried out only in Îles-de-la-Madeleine. The main objective was to fine tune the scallop enhancement technology on the scallop beds and increase the stock densities and production. In Phase 2 (1999-to present) the work was conducted in Îles-de-la-Madeleine and in other areas of the Québec Regions. The objective of Phase 2 was to establish the scientific conditions and techniques necessary to bring scallop culture in Québec to a commercial level.

In the early 90's, the program (Phase 1) brought together two levels of government (provincial and federal), the local scallop fishers association (21 fishers) and two scallop processors. A pilot scale scallop enhancement project was conducted between 1993 and 2000. The first harvest that was carried out in 1997 on the zones that were enhanced in 1993, 1994 and 1995, demonstrated encouraging results. Harvesting results from the scallop beds enhanced in 1996 and 1998 will be presented in this report.

Since 2000, commercial enhancement has been conducted by the company, Pétoncles 2000, on 5 culture sites which allows a 5 years production cycle. The majority of the company is owned by the scallop fishers and has purchase credits from the local scallop fishers association.

Financial structure of Pétoncles 2000

Pétoncles 2000 is a joint-stock company. Twenty one of the 23 licenced scallop fishers own 51% of the company's stocks and the rest is owned by private investors. The company is responsible for; 1) the scallop spat collection, 2) scallop grow-out in the lagoons, 3) scallop enhancement, 4) management of the seeded beds, 5) distribution of the quotas to the fishers, 6) fishing plans and 7) monitoring the landings. Pétoncles 2000 employs ~30 seasonal workers for 4 to 7 months and 3 year round employees. Fishers return 30% of the landed value of the catch harvested from the seeded beds to the company.

Management practices of Pétoncles 2000

Pétoncles 2000 has aquaculture leases for their spat collection sites, their grow-out sites and their enhancement sites. The fishers have accepted a significant reduction of their traditional fishing grounds. Enhancement is done by rotating the fishing zones on a five year plan (~13 km²/zone) (Figure 29). Juvenile scallops with shell height of 25-35 mm are seeded in the spring at a density of 5 scallops/m². The objective of the enhancement plan is to seed 30 million scallops/year. Sea star control can be conducted before enhancing the beds. There are opportunities to sell scallop spat to other users.

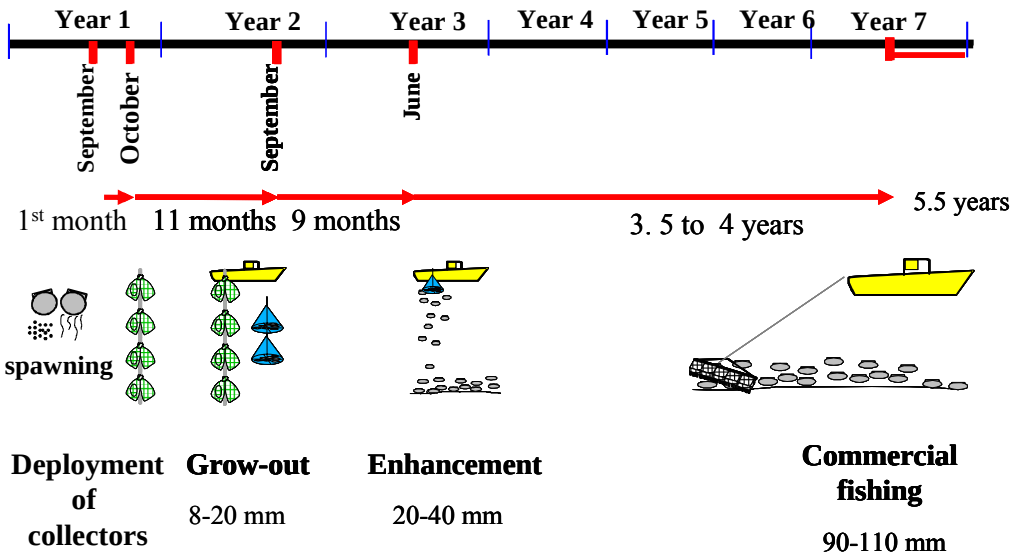


Figure 29. Schematic of the scallop enhancement operation.

In the last 10 years, an average of 3,935 scallops/collector has been documented (Figure 30). The collected scallop spat are kept in the collectors for one year at sea. About 75% are lost because of fouling, predation, storms, handling, presence of large abundance of undesirable species and collectors rubbing the bottom (Table 5). The scallops are maintained in pearl nets for 6 to 8 month in the lagoon where they experience a 75% survival. Experimental and pilot scale projects were conducted between 2003-2005 to retrieve the collector bags from the sea earlier and therefore increase the scallop's recovery rate.

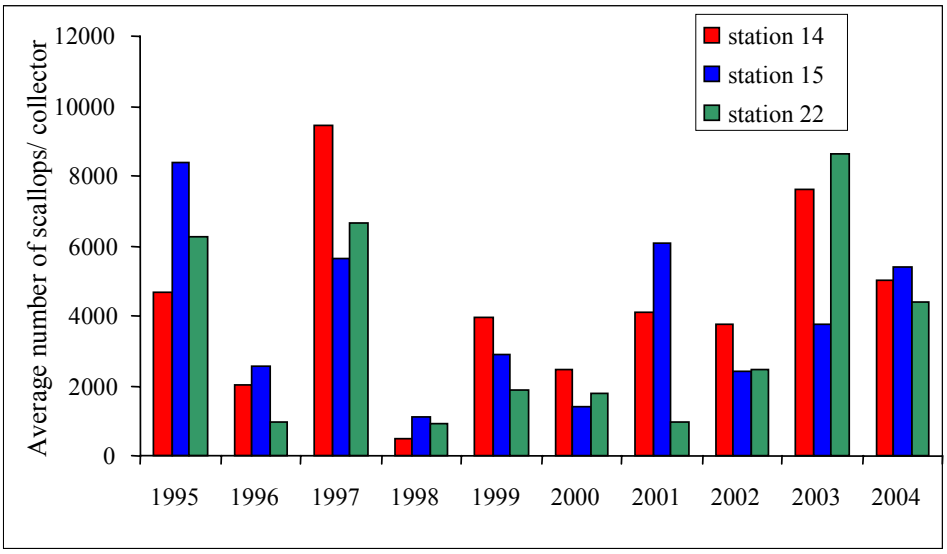


Figure 30. Average scallop spat per collector from 1995 to 2004 in 3 sites.

Table 5. Results of commercial, experimental and pilot scale projects.

	% of scallops recovered from collectors	% of scallops recovered from grow-out in lagoon	% of scallops recovered in total
Commercial scale			
Mid-sept. to mid-nov.	10 to 30 %	75%	8 to 23%
Experimental project			
August 1, 2003	53%	85%	45%
July 19, 2004	81%	65%	54%
August 23, 2004	88%	74%	65%
Pilot project			
July 21, 2005	56%	42% (starfish predation)	24%
July 28, 2005	59%	34% (starfish predation)	20%
September 6, 2005	100%	60%	60%

Seeding performed during experimental and pilot scale activities (1993 to 1999) were between 35,000 to 12 millions juvenile scallops per year. At commercial scale, seeding reached 18 millions scallops.

Bio-physical variables affect the success of enhancement activities. Variables related to the seeded scallops include; their size and the number of scallops seeded, along with the density at which they are seeded. Also, handling techniques and the scallop vitality when they are seeded affect their survival rate. Other important variables at the enhancement

sites include: type of substrate, temperature, current speed and abundance of predators. Management variables that come into play for enhancement success include: predators controls programs, fishing strategies (seasons, fishing gear) and planning and preparing sites. Since many variable effect survival of the seeded scallops, conducting a yearly monitoring of an enhancement stock help to understand its status (Figure 31).

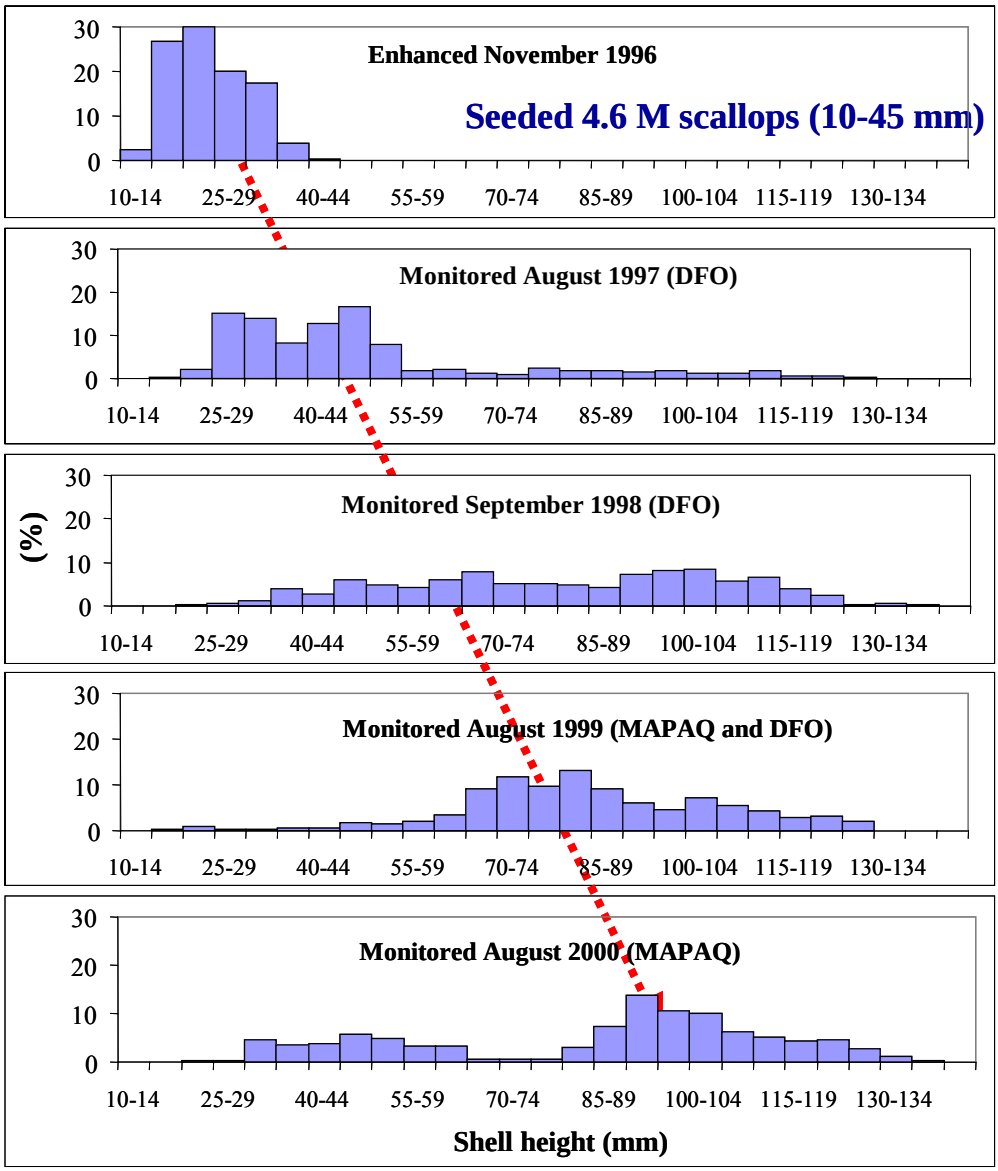


Figure 31. Shell height distributions of seeded scallops monitored from 1996 to 2000 by dredging on a selected scallop beds off Îles-de-la-Madeleine.

Surveys are also conducted using a video camera. The video images (Figure 32) are analysed to determine the density of the scallops.

Figure 32. Image taken from video camera survey.

Also, to determine the number of seeded scallops that have been recaptured a selected number of scallops are tagged just before they are seeded. Futhermore, scallops from the Îles-de-la-Madeleine form annual marks during the winter. These marks are often referred to as growth rings. The growth rings of tagged scallops (Figure 33) are compared to those of untagged scallops to determine if the untagged scallops have similar growth ring patterns. If the patterns are similar, the scallops are most likely seeded scallops. The percentage of recaptured can be calculated by comparing the number seeded to the number re-captured.

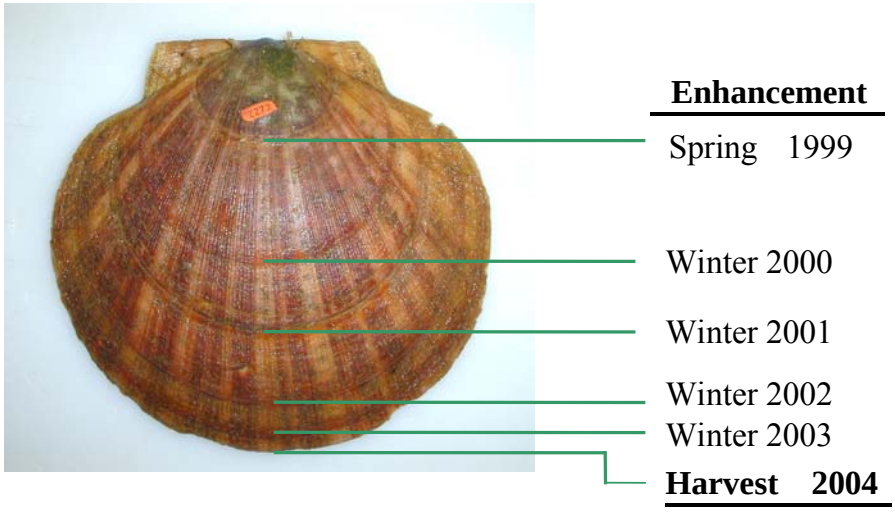


Figure 33. Growth rings of a tagged seeded scallop.

The growth rate of scallops seeded in the fall of 1998, spring 1999 and spring 2000 were monitored (Figure 34). The average growth is about 1.5 cm/year for every group. Interestingly, a 100 mm scallop that has been seeded is 5 1/2 years while a wild scallops of the same size is 6 1/2 years old.

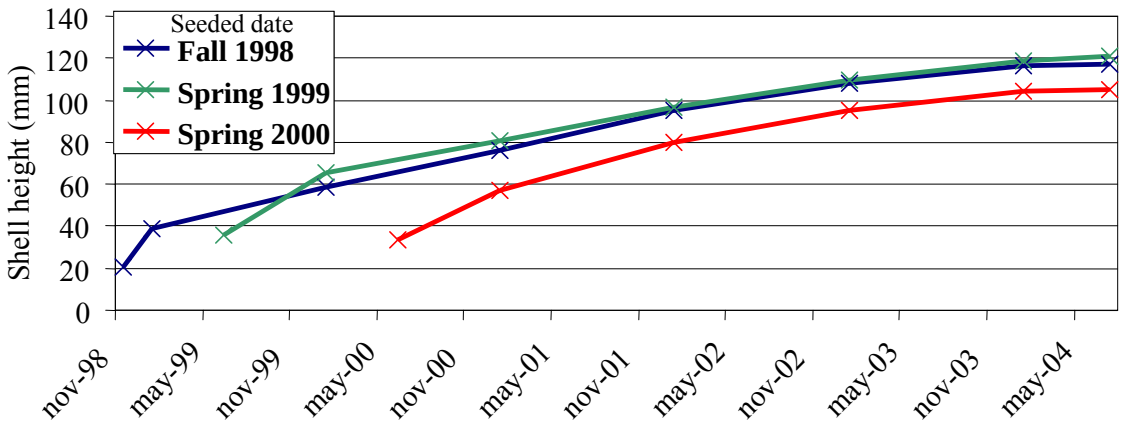


Figure 34. Growth rates of scallops seeded in the fall 1998, spring 1999 and spring 2000.

Fishing management strategies of Pétoncles2000

Pétoncles 2000 evaluates the exploitable biomass and determines a global fishing quota before opening a fishing site. The distribution of quotas per fisher is related to the amount each individual has invested in the company. The fishing plan (season, number of days; time and size, etc) is prepared with the fishers. When the quota has been reached, a new quota can be issued if it is judged appropriate. The tagged scallops and a sample of scallop shells are recovered to estimate the number of seeded scallops vs wild scallops in the landings.

The percentage of the total landings from the Îles-de-la-Madeleine scallop fishery that were harvested from enhanced sites varied from 28 to 65% in 2001 to 2005 (Figure 35). The harvest from enhanced sites was examined to determine the percentage of scallops from seeded scallops and from the wild. Incidentally, some tagged scallops were reported to be among the harvest from the wild beds.

The enhanced sites not only provided over half the landings in some years but also the yield for each hour of work or catch per unit effort (CPUE) is two to seven times higher than yield from the wild beds. This means, fishers pay less for fuel and manpower for each pound of scallops harvested from an enhanced site than from a wild bed.

As the seeded scallops mature, they contribute to the egg production especially to the number of fertilizing eggs because of the higher density of scallops. Increasing the density of scallops on the enhanced beds has inadvertently increased the number of fertilized eggs. The seeded scallops have contributed to stabilizing the scallop spat collection rate and to the recruitment to wild beds. When large numbers of scallop spat are collected per bag, an increase of scallops is also observed on wild beds three or more years later.

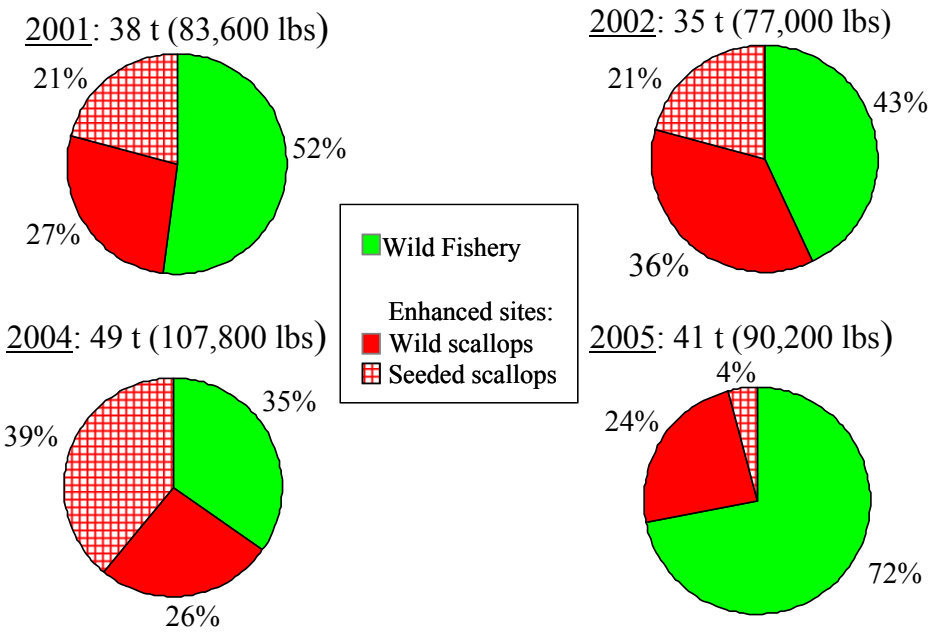


Figure 35. The percentage of scallop landings from wild beds and enhanced beds.

Conclusion

- Results from the enhancement activities are positive and demonstrate the bio-technical feasibility of the practice.
- The experience gained in Îles-de-la-Madeleine is noteworthy and can nearly all be transferred.
- Patience and perseverance are necessary pre-requisites for embarking in such an endeavour.
- Financial support from the governments and capital risk programs are necessary.
- Gaining biological and technical knowledge along with its financing remains essential.
- It is difficult to combine fishers' interest to that of investors'; it is advised to dissociate fishing activities from production activities.
- In spite of benefits associated with scallop enhancement, an efficient infra structure for this type of activity does not presently exist; efforts should be aimed in this direction to insure the future of enhancement activities.
- Enhancement can be part of management strategies to stabilise and in the best situation to increase scallop stocks.

Questions/Comments:

Participant: Before opening sites for harvesting, do you set harvest predictions?
Madeleine Nadeau: It is difficult to assess. We have already over-estimated and under-estimated. Now, we know it is better to under-estimate the biomass.

Participant: What is the harvestable rate compared to the resource?
Madeleine Nadeau: The idea is to recuperate everything and then to re-enhance. The best harvestable rate has been 80%.

Participant: Do you know what was the average meat count?
Madeleine Nadeau: 20 muscles per pound.

Participant: What was the temperature at the enhanced areas?
Madeleine Nadeau: It was –1 °C, but the ideal would be 12 °C in the collectors. In the lagoons, it went as high as 20 °C. There is a lot of algae in the lagoons.

Participant: Did you ever try intermediate aquaculture, with a fuzzy rope for example?
Madeleine Nadeau: It was done in New Zealand. We tried but we lost the collector!

Participant: What is the most favourable temperature for harvesting?
Madeleine Nadeau: That depends if you are looking for gonads: if so, it would be in August. Lobster fishers prefer to fish scallops in April, before their lobster fishing season.

Participant: Do you have a technique to control star fish?
Madeleine Nadeau: Some boats land only star fish. For a while, *Pétoncle 2000* bought the star fish and composted them.

Pecten I – Scallop Enhancement Project

Bruno Frenette

Pecten UPM/MFU Inc. is a non profit corporation managed by the Maritime Fishermen's Union (MFU). Their mission is to develop techniques that promote the scallop (*Placopecten magellanicus*) resource and find means to stabilize the scallop fishers' revenue. Up to date, all the activities have been conducted as research and development, and have been authorized by a scientific permit. Pecten UPM/MFU Inc. coordinates the activities of three local companies: 1) Pétoncle Chaleurs Scallop Ltd. 2) Pétoncle NET Scallop Ltd. 3) Pétoncle Nord du Détroit-Northumberland Strait Scallop Ltd.

The objectives are to: 1) Develop practical and effective approaches to improve the scallop stocks in our coastal waters; 2) Increase the scientific knowledge concerning the scallop biology and habitat; 3) Serve as an educational tool to demonstrate to users the

importance of conserving the resource, protecting the habitat and rebuilding the scallop stocks.

The first phase of the Pecten UPM/MFU Inc. project is called Pecten I. The mandate of of Pecten I is to improve the scallop enhancement program on the east and the north-east coast of New Brunswick. Also, the project is developing scallop spat collection techniques and enhancing marine bottoms. These marine bottoms are closed to commercial scallop fishing by the Department of Fisheries and Oceans (DFO) by variation order at the requested of Pecten UPM/MFU Inc.

Enhancement activities are conducted at three sites: Baie des Chaleurs, Miramichi Bay and the Northumberland Strait (Figure 36).

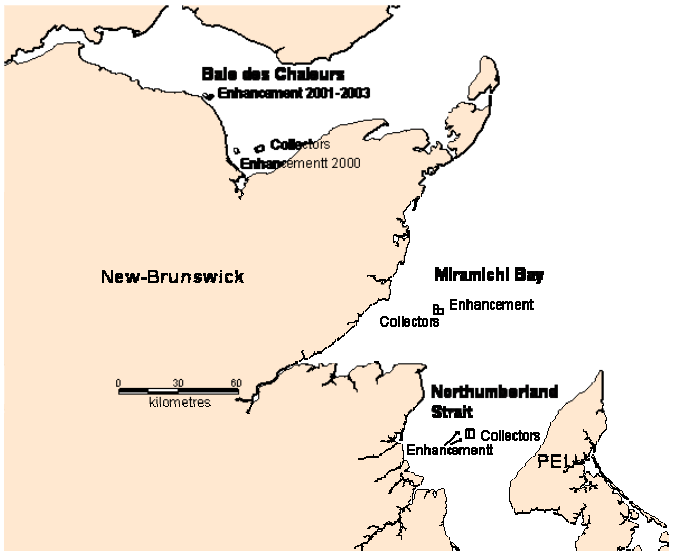


Figure 36. Study site of Pecten I.

Collectors are fastened to a long line (Figure 37) and deployed in the fall to collect the scallop spat required for the enhancement activities.

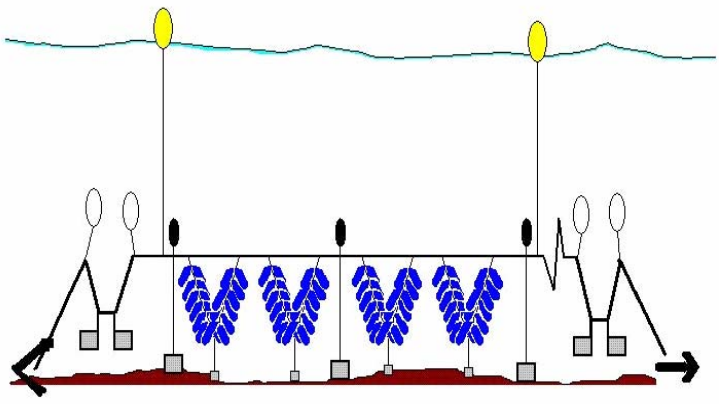


Figure 37. Collectors fastened to longlines and deployed on the collection site.

Summary of spat seeding activities from 1999 to 2005 and predictions of the 2006 seeding in Baie des Chaleurs, Miramichi and Northumberland Strait are presented in Table 6, 7 and 8 respectively.

Table 6. Summary of the yearly enhancement in Baie des Chaleurs**.**

Deployment date	Enhancement date	Number of collectors	Number of scallop spat/collector	Number of scallops (x 1,000,000)
Automne 1999	June 2001	1 100	2725	2.99
	May 2002	4 655	424	1.97
Sept. 2001	May 2003	5 256	590	3.10
Sept. 2002	Oct. 2004	10 800	196	2.12
Oct. 2003	June 2004 June 2005 Oct. 2005	720 2 880 1 800	150 102 *102	0.11 0.29 0.18
Total				**10.76**
Oct. 2004	**Predicted for 2006**	**6 016**	**1 232**	**7.41**
Oct. 2005	**Predicted 2006**	**5 000**	******	**(?)**

* based on June 2005 sample ** Samples were not taken.

Table 7. Summary of the yearly enhancement in Miramichi Bay.

Deployment date	Enhancement date	Number of collectors	Number of scallop spat/collector	Number of scallops (x 1,000,000)
Fall1999	June 2001	1 550	246	0.38
Oct. 2001	May 2003	5 040	67	0.34
Sept. 2002	May 2004	11 520	713	8.21
Oct. 2003	Oct. 2004 June 2005 Oct. 2005	2 880 5 040 3 600	2 715 70 *(70)	7.82 0.35 0.25
Oct. 2004	June 2005 Oct. 2005	2 880 1 440	1 468 1 048	4.23 1.52
Total				**23.10**
Oct. 2004	**Predicted for 2006**	**4 320**	**1 048**	**4.53**

* Based on sample taken June 2005.

Table 8. Summary of the yearly enhancement in the Northumberland Strait.

Deployment date	Enhancement date	Number of collectors	Number of scallop spat/collector	Number of scallops (x 1,000,000)
Fall 1999	June 2001	1 075	680	.73
Oct. 2001	May 2003	8 640	1 044	9.00
Sept. 2002	May 2004	8 640	366	3.16
Oct. 2003	Oct. 2004 June 2005	2 880 2 160	1 749 266	5.04 0.57
Oct. 2004	June 2005	2 880	7 291	21.00
Total				**39.50**
Oct. 2004	**Predicted for 2006**	**3 240**	**2 645**	**8.57**
Oct. 2005	**Predicted for 2006**	**5 000**	**1 547**	**7.74**

Up to date, over 80 millions scallops have been seeded between 2001 and 2005 and there is a potential of seeding another 28 millions in 2006 (Table 9).

Table 9. Summary of the total amount of scallop spat seeded from 2001 to 2005 and the predicted amount that could be seeded in 2006**.**

Site	Number of scallop spat seeded from 2001 to 2005 (Number of scallop spat to be seeded in 2006)
Baie des Chaleurs	10.8 millions (7.4 millions)
Miramichi	23.1 millions (4.5 millions)
Northumberland Strait	39.5 millions (16.3 millions)
Total	**80.8 millions** **(28.2 millions)**

In 2006, it will be the first year of harvest. The sites targeted for harvest were seeded in 2001.

Scientific data such as the gonosomatic index (GSI) and spat collector content was monitored. The GSI which is the percentage of the weight of the gonad (reproductive organ) divided the total weight of the soft tissue is monitored to document the spawning

activities of the scallop population. The GSI of scallops from the Baie des Chaleurs was monitored from July to September in 2001 to 2005 (Figure 38). Usually, 4 weeks after the adult scallops initiate their spawning (as indicated by the rapid decrease in the GSI); it is time to deploy the collectors. In 2001, 2003 and 2005 the scallops began to spawn at the end of August while in 2002 and 2004 spawning occurred one week and two weeks later, respectively.

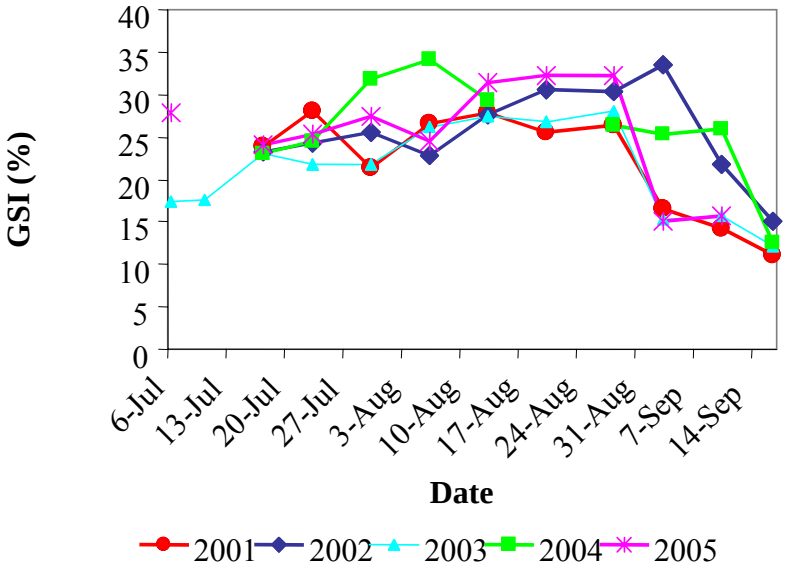


Figure 38. The gonadosomatic index of adult scallops from 2001 to 2005.

Every year spat collector bags are sampled shortly after they are deployed in the fall, and then in the spring and the following fall. The content of spat collector bags is analysed to measure and count the various species that accumulate in the bags. The percentage of scallops and other species found in the bags vary from one year to another and from area to another. For example, in 2004, more than 50 % of the content in the bags sampled from Baie des Chaleurs were giant scallop, but in bags from the Miramichi Bay only 1/6 of content was composed of the giant scallop spat and 1/3 of content of samples from the Northumberland Strait were giant scallops (Figure 39).

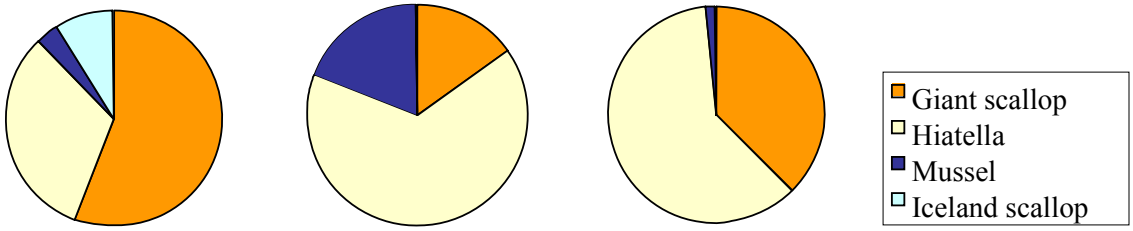


Figure 39. Species content percentage of spat collector bags in Baie des Chaleurs, Miramichi Bay and the Nortumberland Strait in 2004.

The average number of scallop spat and their average shell height are monitored to evaluate the mortality and to determine when the spat is large enough to be transferred to culture gear or to be seeded. For example, in 2002 the scallops count in bags deployed in Baie des Chaleurs and the Miramichi were initially very high however by May 2004 the numbers were relatively low (Figure 40).

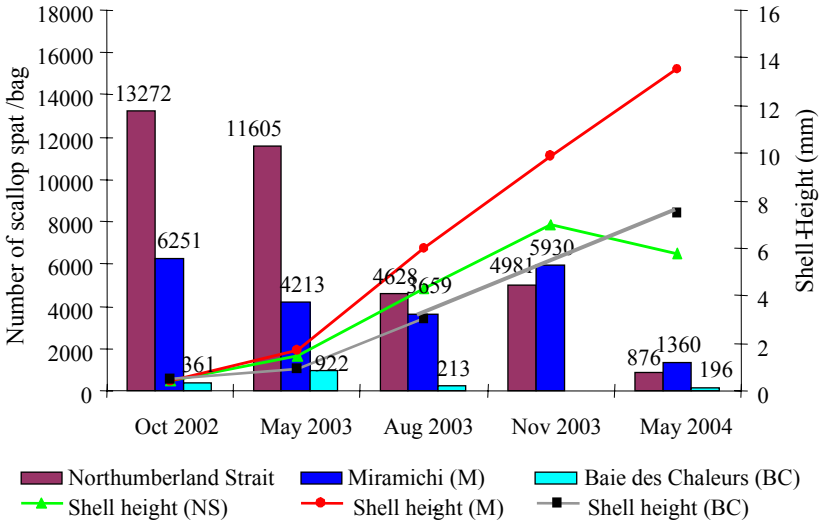


Figure 40. The number of scallop spat per bag and their average shell height found in collectors deployed in 2002 and monitored over time.

Pecten UPM/MFU Inc. also conducts other studies such as the "Mussel Spat Depth Study" that has just been completed. Fuzzy mussel collector ropes were deployed at sites 90 to 100 feet from June to October, 2005. Mussel spat can actually be collected up to depths of 70 ft (21m) (Table 10). The average size of the collected mussel decreases as the depth of the collector rope increases (Figure 41 and Table 10).

Table 10. Depth, % coverage and average shell height of mussel spat collection.

Depth- feet (m)	Coverage (%)	Average shell height (mm ± standard error)
0 – 10 (0-3)	100	12.69 ± 1.03
10 – 20 (3-6)	70 – 60	11.26 ± 0.89
20 – 30 (6-9)	50	8.67 ± 0.88
30 – 40 (9-12)	50	6.17 ± 0.30
40 – 50 (12-15)	80	5.28 ± 0.28
50 – 60 (15-18)	10	3.18 ± 0.17
60 – 70 (18-21)	5	4.08 ± 0.72
70 + (21+)	0	------

Figure 41. Fuzzy rope that was deployed vertically to capture mussel spat.

Pecten UPM/MFU Inc. is also investigating collection site in Baie des Chaleurs for future requirements. Experimental collectors have been deployed in a new area that is free of fishing activities (Figure 42). Experimental collectors were tagged and their location, depth, deployment and retrieval date recorded. An area is considered to be a potential commercial collection site, if at least 1000 to 2000 scallop spat/ bag can be collected and giant scallop is the dominant species in the bags. Presently, data from this experiment has yet to be analysed.

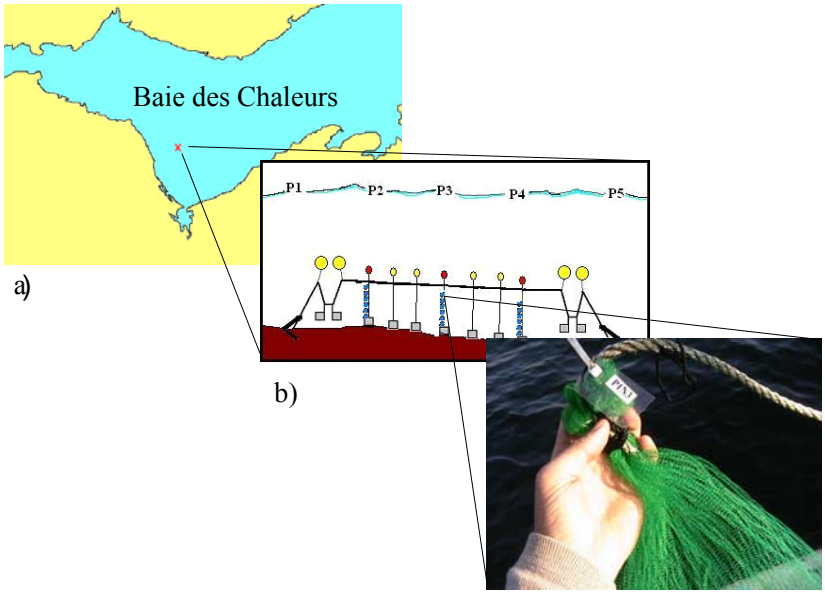


Figure 42. a) Exploratory site for scallop spat collectors in Baie des Chaleurs , b) Set-up for exploratory collectors, and c) tagged exploratory collector bag.

Pecten UPM/MFU Inc. has proposed several projects that may be funded. For example funding may be granted to compensate for habitat destruction. In the construction that is required at the Petit Rocher wharf, fish habitat destruction will be unavoidable (Figure 43) and therefore needs to be compensated. Under section 35 of the Fisheries Act, subsection 35(1) is a general prohibition of harmful alteration, disruption or destruction (HADD) of fish habitat. Pecten MFU/UPM Inc. has submitted a project proposal that could offer a suitable compensation measure in this area.

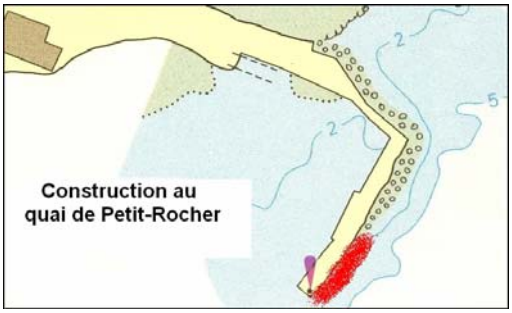


Figure 43. Diagram of Petit-Rocher wharf: red color marks area that may be destroyed.

For the purpose of compensation, Pecten UPM/MFU Inc. has submitted four potential projects: 1) Scallop enhancement project based on purchasing spat; 2) Scallop enhancement project based on collecting and seeding scallop spat following the traditional methods; 3) Passive scallop enhancement project (using fuzzy ropes); 4) Passive scallop enhancement project (using fuzzy ropes) and creation of scallop brood stock refuge site (holding adult scallop in cages in a selected area) for the purpose of increasing reproductive output.

Questions/Comments:

Participant: Why are there variations per collector each year?
Bruno Frenette: We do not know.

Participant: A question regarding compensation on refuge sites… now or later?
Bruno Frenette: For the sites closed by variation order, it is now. They will be later reopened to reinvest in Pecten.

Participant: In relation with HADD, what is the impact to create the brood stock?
Bruno Frenette: We are aiming for no-net-loss, with a replacement ratio of 1 to 6. Creating a brood stock or adding seed to a habitat that in near the area that was harmfully altered, will produce a net benefit to compensate for the loss. Even if there is only one seeding it produces many spats.

Participant: Regarding the passive collection with a fuzzy rope, how many spats fall to the bottom?
Bruno Frenette: We work with open collectors, but we don't know that yet.

Survey of seeded scallop beds in New Brunswick and an overview of rotational fishery

Leslie-Anne Davidson and Monique Niles

In the southern Gulf of St. Lawrence, the scallop fishery is divided into 6 Scallop Fishing Areas (SFA): 21A, 21B, 21C, 22 23 and 24. The mandatory logbooks that are filled in by the scallop fishers provide information on the locations of commercial beds (Figure 44).

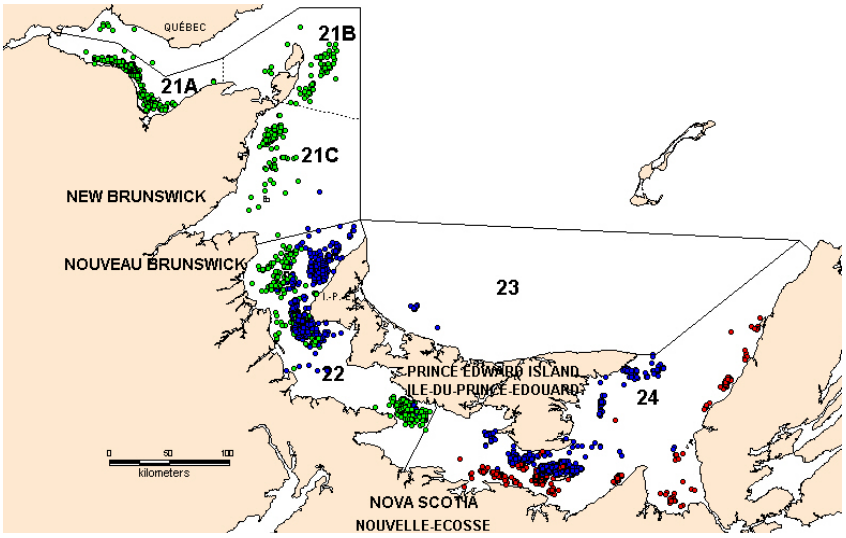


Figure 44. The 2003 and 2004 fishing location of scallop fishers from New Brunswick (green), Prince Edward Island (blue) and Nova Scotia (red) based on reported logbooks.

Pecten UPM/MFU Inc., a non profit company of the Maritime Fishermen's Union, is leading an enhancement project off the coast of New Brunswick. Their project sites are indicated in Figure 45.

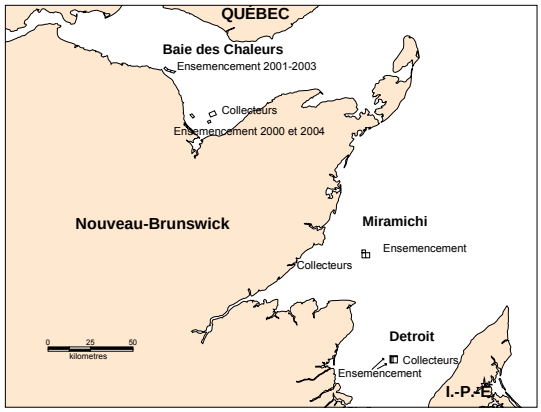


Figure 45. Scallop enhancement project sites off the coast of New Brunswick.

The project sites are located near or within the commercial scallop fishing grounds (Figure 46). Indicator buoys are placed around the sites during the fishing season to indicate to the fishers that dragging should not be conducted in these sites.

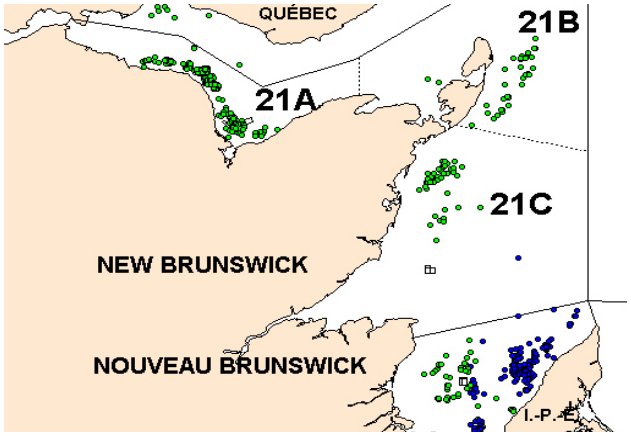


Figure 46. The project sites and the 2004 fishing locations based on logbooks from New Brunswick (green) and Prince Edward Island (blue) fishers.

The Oceans and Science branch of the Department of Fisheries and Oceans (DFO) works co-operatively with Pecten UPM/MFU Inc. to evaluate the density of scallops and other species on the beds before and after enhancement activities. Surveys are conducted using a video camera that is mounted on a sled called the troika. The troika is towed by the DFO research vessel, Opilio. A mini DV recorder is used to capture the images along with the geographical position that are relayed by a differential global positioning system (GPS) located on the vessel (Figure 47).

Troika with camera and lights

Recording system and GPS

Figure 47. Troika (sled) with camera and video recording system.

The black and white camera records video images (Figure 48) that are later analysed in the laboratory to determine the densities of scallops and other species and the bottom type.

Figure 48. Image of a scallop bed captured by the video camera.

In October 2003, a video camera survey was conducted over two commercial fishing beds: Pte Verte in Baie des Chaleurs and West Point in the Northumberland Strait. The density of scallops on commercial beds in the southern Gulf of St. Lawrence was found to vary between 0.10 to 0.16 scallops/m^2 (Figure 49).

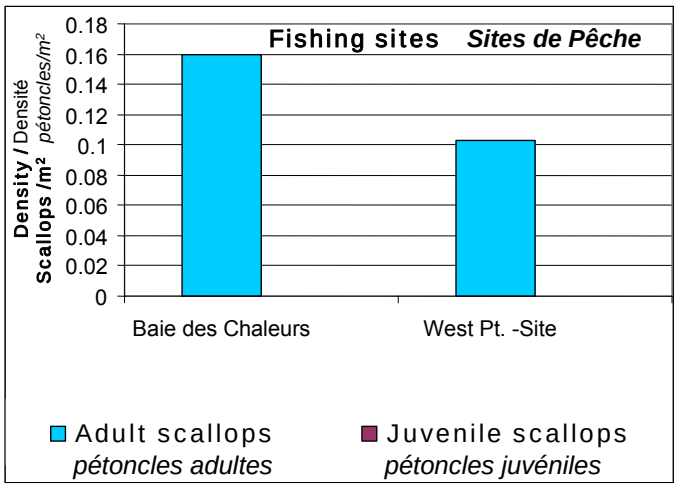


Figure 49. Density of scallops on two commercial scallop beds based on analysis of video camera survey conducted in 2003.

The analysis of the video camera surveys conducted on the scallop enhancement sites before seeding revealed that the densities at those sites were considerable lower than the commercial fishing beds (Table 11). After these sites were enhanced, they were closed to dragging by variation order.

Table 11. Density of scallops before seeding at the sites selected for enhancement.

Seeded sites	Year seeded	Density (scallop/m^2) Before seeding
Baie des Chaleurs	2001	0.042
	2002	0.078
	2003	0.026
	2004	0.021
	2005	0.077
Miramichi	2001	0.009
	2002	-----
	2003	0.001
	2004	0.001
	2005	0.019
Détroit//Strait	2001	0.020
	2002	-----
	2003	0.002
	2004	0.036
	2005	0.036

The analysis of the video camera survey conducted on the enhanced bed before and five year after seeding revealed that scallop densities had increased at all sites: a five fold increase since 2001 at the Baie des Chaleurs site, a ten fold increase at the Miramichi site and an eight fold increase at the Northumbeland Strait site (Table 12).

Table 12. Summary of scallop densities found on commercial sites and on seeded sites, at seeding and just before harvest.

Sites	Density of scallop/m^2		
Commercial fishing beds	0.1 to 0.16		
	Before (2001)	After (2005)	Increase
Seeded in 2001			
Baie de Chaleurs	0.04	0.20	5X
Miramichi	0.009	0.09	10X
Northumberland Strait	0.02	0.16	8X

The Baie des Chaleurs, Miramichi and the Northumberland Strait sites were enhanced in 2001 with 3 million, 0.4 million and 0.7 million scallop spat respectively. The small

scallops are not visible on the video camera just after seeding. The scallop density at the Baie des Chaleurs, Miramichi and the Northumberland Strait sites were monitored periodically throughout the five year closure (Figure 50, 51 and 52).

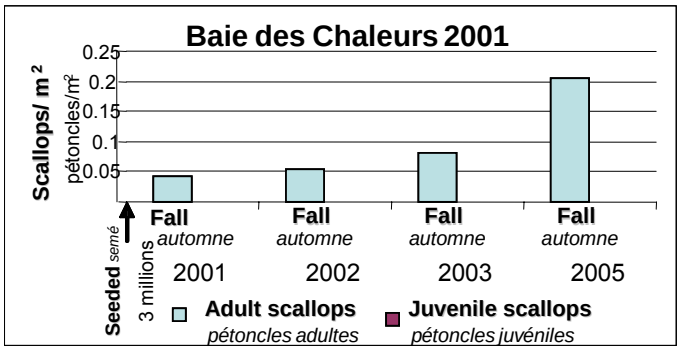


Figure 50. Yearly scallop density/m^2 on the site in Baie de Chaleurs that was enhanced and closed to dragging in 2001.

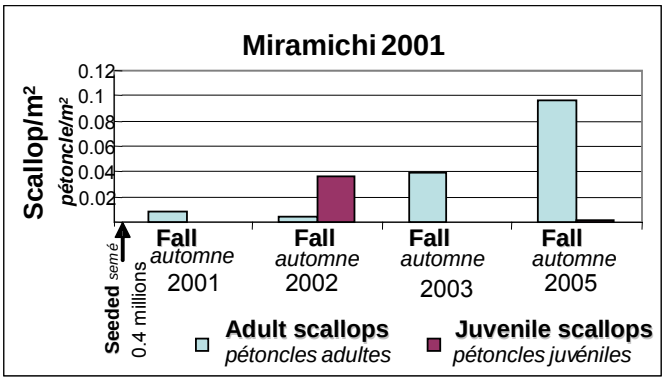


Figure 51. Yearly scallop density/m^2 on the site in Miramichi that was enhanced and closed to dragging in 2001.

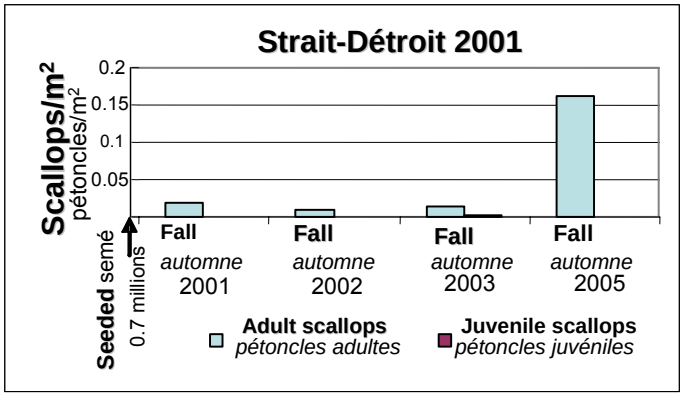


Figure 52. Yearly scallop density/m^2 on the site in the Northumberland Strait that was enhanced and closed to dragging in 2001.

The density of other species found on the enhanced beds was also determined. In 2005, the seastar, a scallop predator, had reached a density ten times greater than scallops in the Baie the Chaleurs site and was slightly less dense than scallops in the Miramichi and the Northumberland Strait (Figure 53, 54 and 55).

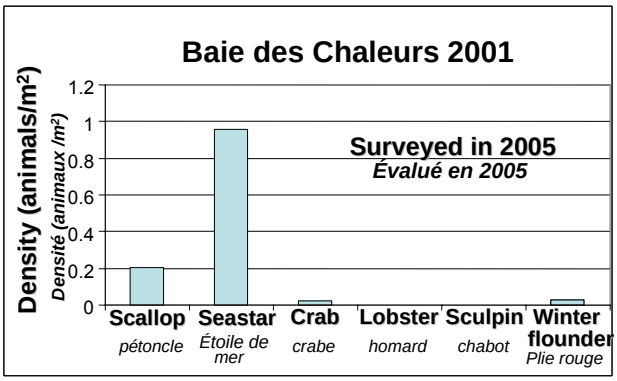


Figure 53. Density of species documented in 2005 on the Baie des Chaleurs bed that was seeded in 2001.

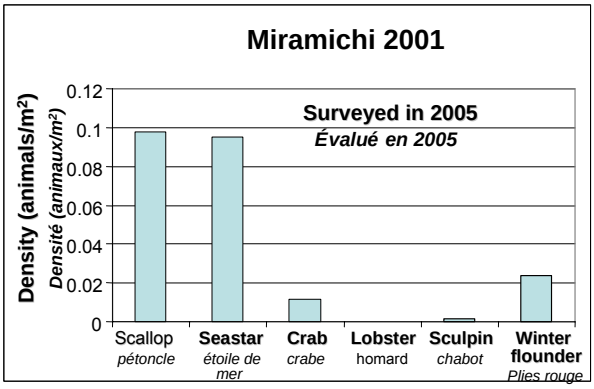


Figure 54. Density of species documented in 2005 on the Miramichi bed that was seeded in 2001.

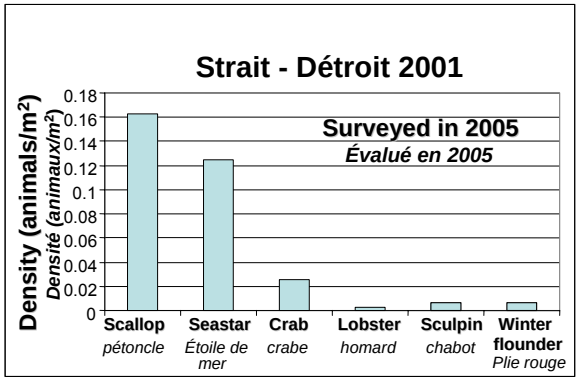


Figure 55. Density of species documented in 2005 on the Northumberland Strait bed that was seeded in 2001.

The sites in Baie des Chaleurs, Miramichi and Northumberland Strait that were seeded in 2001 are scheduled to be harvested in 2006. The number of scallops on this site was estimated from the density evaluations that were obtained from the 2005 video camera survey. The relationship between the density documented on the wild beds and the catch rate obtained from a previous sea sampling studies was used to calculate harvest rate predictions. The predicted initial daily harvest rate for a scallop dragger, fishing 12 hours at the Baie des Chaleurs, Miramichi and Northumberland Strait sites, are 41 to 45Kg, 20 to 34 Kg, and 36 to 45 Kg of scallop meat, respectively (Table 13). These harvest rates are similar to those of the commercial wild fisheries in the southern Gulf of St. Lawrence.

Table 13. The density, number of scallops and predicted harvest rate for the 2001 sites in Baie des Chaleurs, Miramichi and Northumberland Strait.

Site	Density of scallops ($/m^2$) (Evaluated in 2005)	Number of scallops on the site (Estimated in 2005)	Predicted harvest rate for 2006 (12 hr fishing day)
Baie des Chaleurs 2001	0.205	247,640	41-45 Kg/day (91-99 lbs/day)
Miramichi 2001	0.968	140,747	20-34 Kg/day (45-75 lbs/day)
Northumberland Strait 2001	0.163	354,525	36-45 Kg/day (80-100 lbs/day)

Rotational fishery – A Japanese example

The Japanese scallop fishery collapsed in the 1960's. The Japanese started to experiment with scallop enhancement and aquaculture (Yamaha Motor Co. Ltd, 1990). After many trials and errors, they have succeeded to increase the landings many times over what nature could have provided (Figure 56).

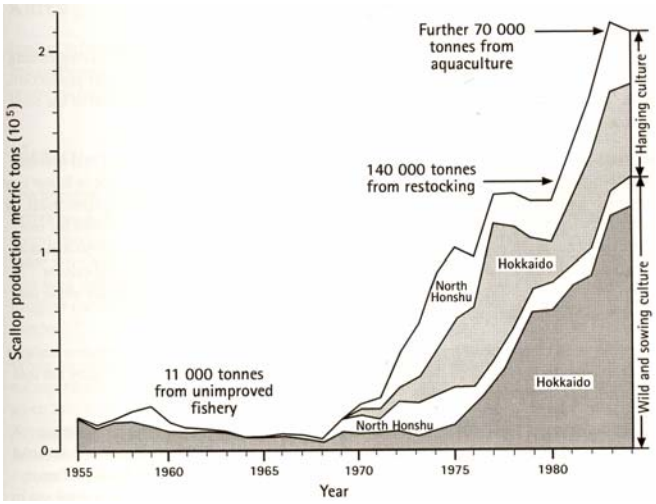


Figure 56. Japanese scallop landings.

The scallop enhancement activities, North of Hokkaido Island in the Okhotsk Sea (Figure 57) include seeding beds that must be closed to dragging for five years.

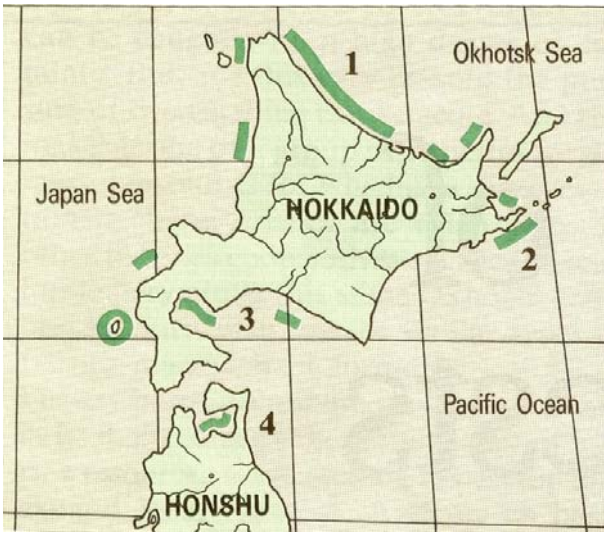


Figure 57. Scallop enhancement/rotational fishery is located north of Hokkaido Island in the Okhosk Sea (Indicated by the number 1).

In the 1970's, the Japanese seemed to randomly select beds for closure and enhancement (Figure 58).

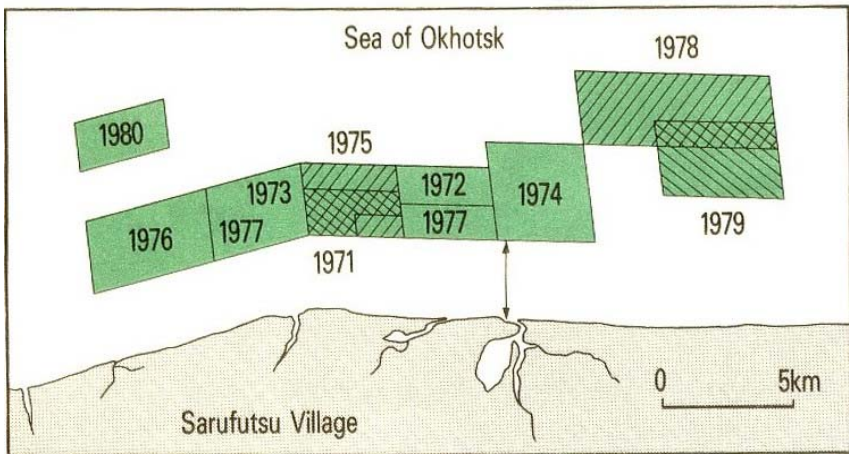


Figure 58. The sites selected by the Japanese from 1971 to 1980 for scallop enhancement.

Today, an area is dedicated to enhancement/rotational fishery in a very systematic organised fashion (Figure 59).

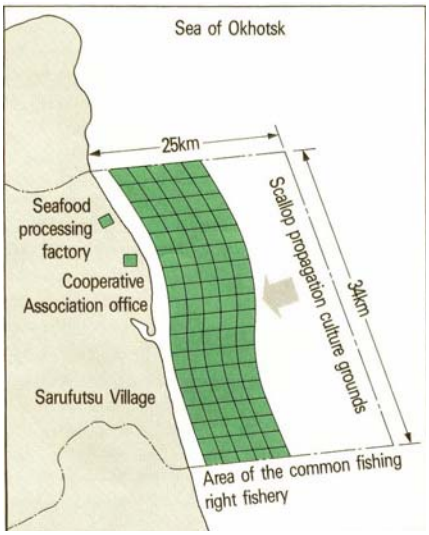


Figure 59. Dedicated Japanese scallop enhancement sites in Sea Okhotsk.

Reference

Yamaha Motor Co. Ltd. 1990. Solving the mystery of good and poor harvests. Public Relations Division, Yamaha Fishery Journal 34.

Questions/Comments:

Participant: Are there any plans to enhance west of the bridge?
Leslie-Anne Davidson: Not now. There is no funding at this time.

Participant: How do the Japanese estimate catches of wild scallop versus those from enhanced sites?
Leslie-Anne Davidson: To my knowledge they do not try to conduct this estimate. They have established permanent enhancement practices because they tried stopping enhancing and harvests plummeted. So they resumed enhancement.

Participant: What did you do with the starfish in zone 22?
Leslie-Anne Davidson: We never retrieved any starfish. We know they are there because we conducted video recording of the bottom using an underwater camera.

Participant: How do you get rid of the starfish?
Leslie-Anne Davidson: We can pass a mop-like fishing gear on the bottom, the starfish clings to the mop material like objects clings to Velcro™.

Participant: Do the Japanese work with hatcheries or collect wild scallop spat?
Leslie-Anne Davidson: They capture the wild scallop spat.

Participant: I have a comment regarding the territory west of the bridge (Confederation): Are there other ways than seeding? It seems like a good place for passive collectors with fuzzy ropes.
Leslie-Anne Davidson: Yes, it would be interesting to try passive collectors in that area.

Participant: How did you estimate catches of 100 lbs per day in the (Northumberland) Strait?
Leslie-Anne Davidson: The harvest was estimated at 100 lb per day based on the video camera survey analysis.

Participant: If enhanced sites had been cleaned of star fish, would the density rate have been any better?
Leslie-Anne Davidson: Yes, of course when you remove a predator, it improves the situation for the concerned species.

Participant: Do you plan to continue to study this?
Leslie-Anne Davidson: It depends on the fishers. The financing comes from partnerships applying for funds.

Participant: I fished around an enhanced bed and got 120 lbs per day. Would it be higher inside the enhanced area?
Leslie-Anne Davidson: Yes, it should be, however our estimate is 100 lbs per day.

Participant: Are there still scallops on the beds? And what about starfish?
Leslie-Anne Davidson: Yes there are still scallops on the bed and the starfish are still there as well.
Madeleine Nadeau: First comment, not all starfish are bad. The largest are not the most dangerous. Second, maybe you should compare your results to the New Zealand technique where they seed directly from collectors which is not the Japanese technique.

Participant: Are there beds, part of the BPFA project, that are to be opened this summer?
Leslie-Anne Davidson: The beds that will be opened in 2006 are beds that were seeded by Pecten UPM/MFU Inc in 2001. Nobody will get rich fishing them because they are small areas ($1Km^2$).

Commercial Scallop Diving in Maine

George Freeman

Commercial scallop diving has been conducted off the coast of Maine for the past 30 years (Figure 60). I've been involved commercially for the past 25 years. I started out dragging for scallops inshore on a 42 ft vessel and have also worked on Georges Bank on a 100 foot vessel. After seeing first hand the damage done to the bottom by dragging I decided that hand harvesting was the way to go.

Figure 60. Commercial diver, George Freeman (left) and his diving buddy.

When I first started in southern (western) Maine, there was minimal dragging pressure inshore in depths of 60 to 70 feet. In the early 80's it was not uncommon to catch 20-30 lbs of meat per tank while using 3 and sometimes 4 tanks in a day. My best tank at that time yielded 36 lbs and the scallops were stacked up on top of each other against a ledge and almost 2 feet thick! The meat counts were generally 15 to 20 per lb and we would commonly harvest 120-150 lbs daily at 3.00 to 3.50$US /lb. In 2005 we averaged about 10 lbs per tank and did 5 tanks per day. The 2005 price was 16.00 $US/lb for 10 count (Jumbos), 13.00 $US/lb for 10-20 count (Large) and 10.00$US/lb for 20-30 count (Mediums) (Figure 61).

Figure 61. Scallop meat sold according to count.

In Eastern Maine, prices are much lower due to no competition between the buyers. Prices in 2006, were as low as 6.00-8.00 $US/lb for run scallops (not culled by size). The season used to be November 1st thru April 15th but was shortened to December 1st thru April 15th around 1999.

In Maine there are approximately 1,000 recreational permits for hand harvesting which allow 8 lbs of meat per day. There are 400 commercial scallop licenses but in 2005 only 134 fished. This includes divers and draggers. The draggers have increased their ring size to 4" as the minimum legal size is now 4". They are also running much heavier drags than in past years and are fishing in areas that they traditionally never fished (diver areas). This allows them to fish on rocky bottom and on and over ledges that they could never access before.

The density of scallops has decreased with both divers and draggers blaming each other. In reality it is a combination of both. In the mid 90's, Maine gave out 3,000 urchin licenses almost all of whom obtained either recreational or commercial scallop licenses. This had an enormous impact on the shallow water biomass. A lot of beds that I fished were wiped out due to over harvesting of all sizes of scallops. Places that I used to leave all the 31/2" scallops alone and concentrate on the larger sizes were now barren. This, in combination with other natural environmental factors that we have yet to determine has severely impacted the fishery. It is entirely possible that the overfishing of the urchin population has resulted in throwing off the natural balance of the ocean floor, resulting in more algae, moss and seaweeds. This in turn gives more cover for scallop predators such as crabs and starfish. I don't believe that crabs are a problem on small scallops but when they get larger and more sedentary and can't swim away then they are impacted.

In the 80's and 90's Maine divers were allowed to dive in Massachusetts commercially for scallops but the permits have been rescinded. We were allowed to dive year round with a 31/2" shell size and no possession limits. Draggers in Massachusetts are not allowed within 3 miles of shore so there was no other pressure on the resource except for

recreational divers. Nobody dove commercially! We initially were paid 8.00$US/lb but lately it is around 13.00$US/lb. It was quite common to harvest 100 lbs of meat on 5 tanks per diver with our best day being 186 lbs on 7 tanks! It was very lucrative! Around 2001 a pipeline was laid thru some of our best areas there and 2 entire beds were destroyed by siltation from the dredging process, similar to what is happening around the PEI bridge from what I'm hearing. Scallops can tolerate a wide variety of bottom types but silt is certain death on scallops. Scallops can be found here in Maine on many bottom types including sand, shells and cobble, muddy gravel but hardly ever in silty or gungy mud. However, if you can find the edge of where the silty mud and gravel (or muddy gravel) meet, then that's where the best settlement will occur for juveniles to grow out.

There are several limiting factors when diving for scallops. Depths of 60 ft are perfect; 70-80 ft is still doable but limits your diving to under 100 ft for safety reasons. Silt and water runoff from storms will affect the visibility and strong tides will limit your direction. You can try to grab the scallops as you are pulled by the current but you will be stirring up the sediment which will move along at the same rate as the current pulls the diver, leaving you in a cloud with no visibility. It is better to swim into the current to keep the silt behind you. If the current is too strong to swim into it, wait until the 2 hour "window" surrounding high and low tide to dive. It is possible to make money with scallops 10 to 15 feet apart but it is preferable to find them about a foot apart. Good luck and safe diving!

Questions/Comments:

Participant: Are there many scallops around salmon farms?
George Freeman: Yes, because the larvae attach to the cages.

Participant: Have you ever done any experiment with fuzzy ropes?
George Freeman: No, not yet. But an experiment with spat fishery permits may be organized.

Participant: Are you using Nitrox?
George Freeman: No, only air.

Participant: Does dragging change the type of bottom?
George Freeman: Yes, I would say it goes from a 2-3 to a 3-4.

Pecten II – Scallop Aquaculture Project

Bruno Frenette

In 2004, Pecten UPM/MFU Inc. initiated a study off the coast of New Brunswick to develop guidelines for commercial scallop aquaculture in open water. This study is called Pecten II. The study was conducted in three sites: two in Baie des Chaleurs (Pointe Verte (1) and Bathurst (2)) and one in Northumberland Strait (3) (Figure 62).

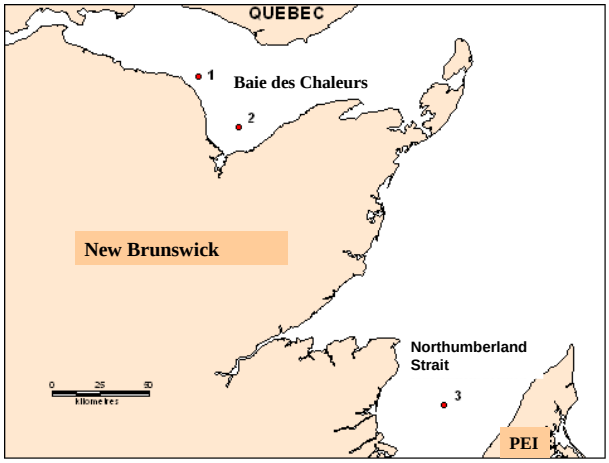


Figure 62. The study sites.

Presently, the study is on-going. One of the first steps is to evaluate the efficiency of different types of culture gear and the viability of different sources of scallop spat. The scallop spat that have been placed in various culture gears (Figure 63) are being monitored.

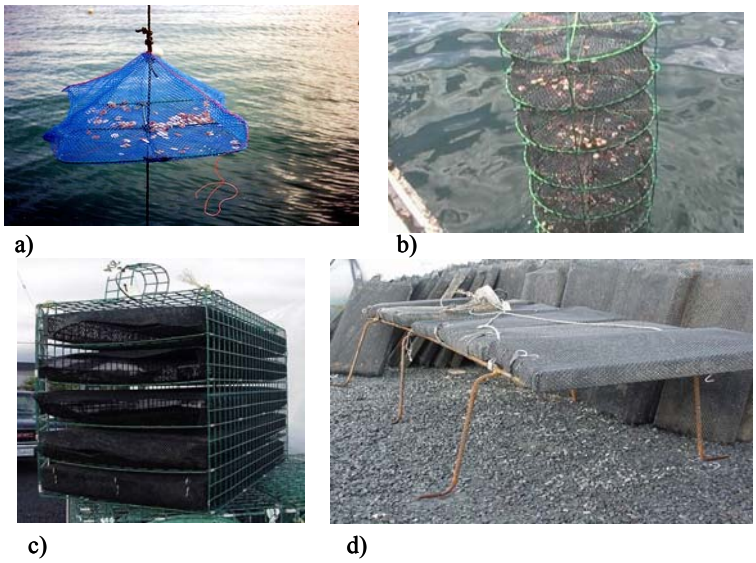


Figure 63. Various culture gears being evaluated: a) Pearl net; b) Lantern net; c) Vexar™ bag in Aquamesh™ cage and; d) Vexar™ bags on bottom oyster type tables.

The scallop spat were obtained from three different sources: Baie des Chaleurs, NB Miramichi Bay, NB and Chedabucto Bay, NS (Figure 64).

Figure 64. The geographical locations of scallop spat sources: Baie des Chaleurs, Miramichi Bay and Chedabucto Bay.

The shell height of the scallop obtained from Baie des Chaleurs, Miramichi Bay and Chedabucto Bay were monitored (Figure 65). Up-to-date, the growth rate is similar between the different spat sources.

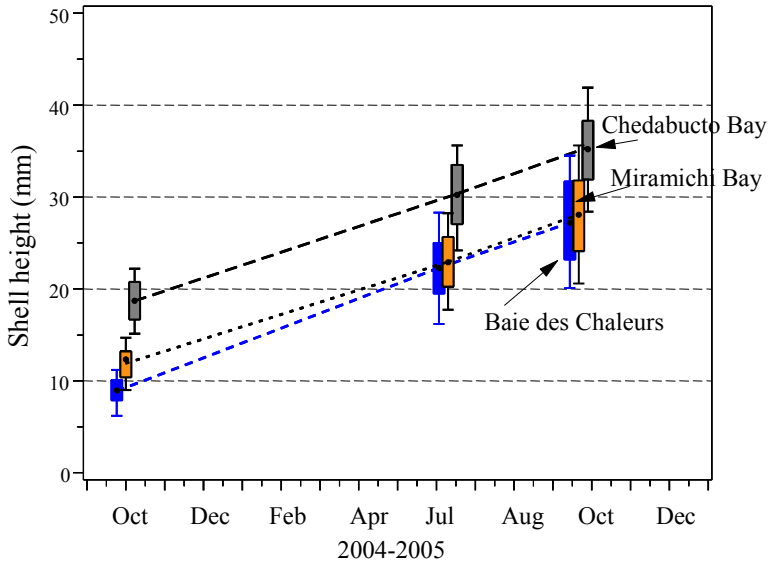


Figure 65. The average shell height of the scallops spat from Baie des Chaleurs, Miramichi Bay and Chedabucto Bay from 2004 to 2005 from all culture gear.

Current data indicate that the scallop spat from Chedabucto Bay experienced the lowest mortality rate (Figure 66).

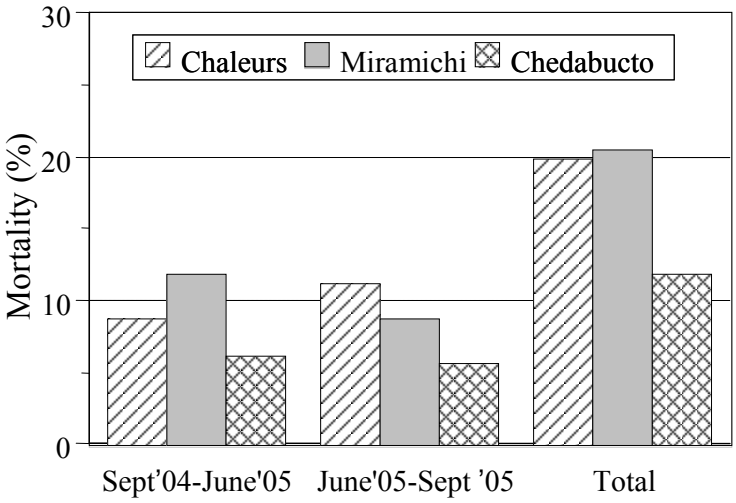


Figure 66. The mortality (%) of the scallop spat from Baie des Chaleurs, Miramichi Bay and Chedabucto Bay from 2004 to 2005, all culture gears combined.

The mortality rate of the scallop spat varied from one culture gear to another (Figure 67). The tables gave such poor results that they were removed from the study.

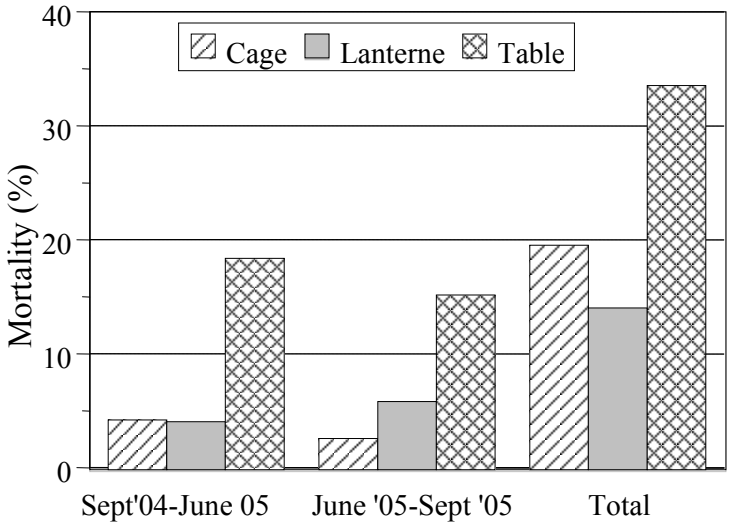


Figure 67. The mortality (%) of the scallop spat cultured in Vexar™ cages, Lantern nets and Tables from 2004 to 2005, from spat sources combined.

The Pointe Verte, Site 1 (in Baie des Chaleurs) experienced large temperature changes which often rose above 12°C and reached highs of 20°C. Large temperature variations were also observed at the Bathurst, Site 2 (in Baie des Chaleurs) and Nothumberland Strait, Site 3 however the temperature at both sites did not rise above 12°C (Figure 68).

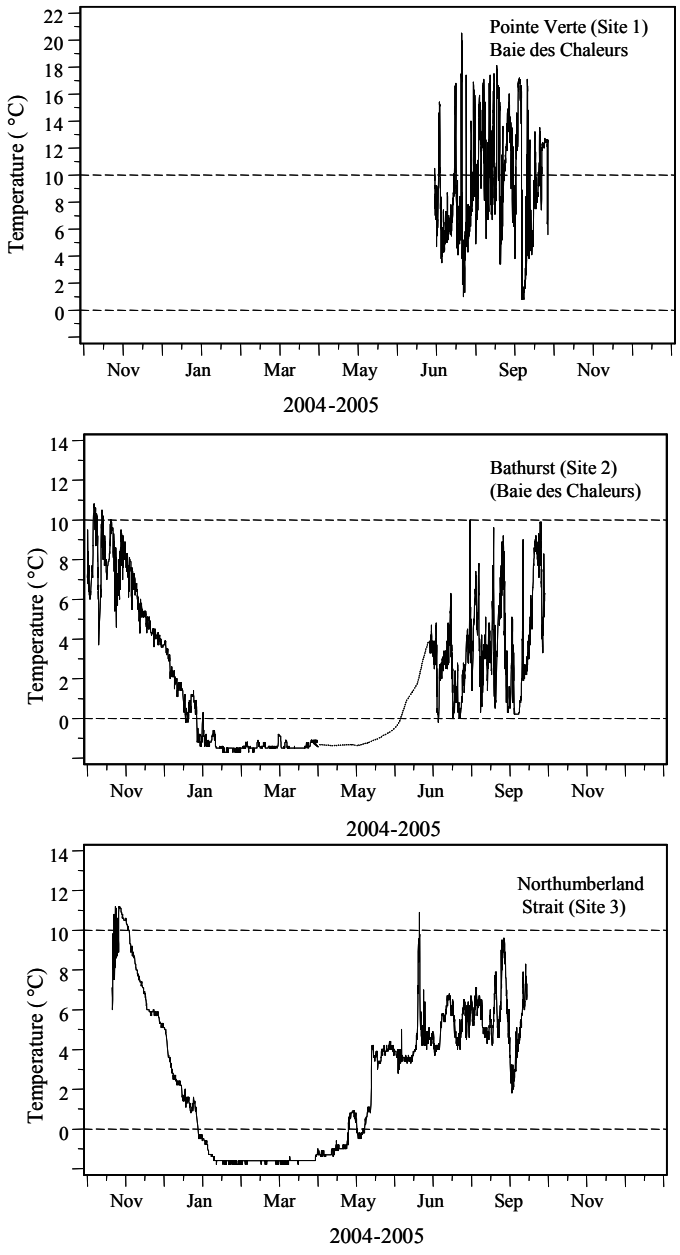
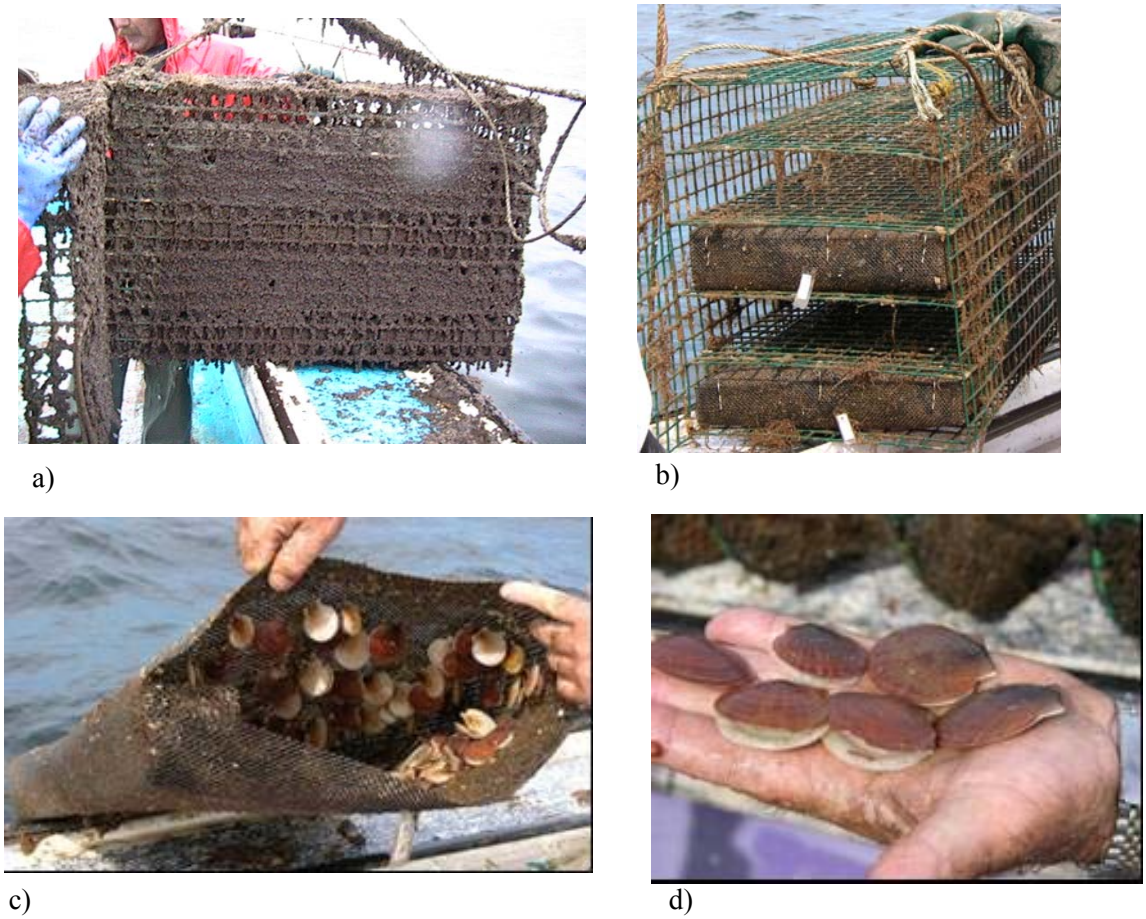


Figure 68. Bottom temperature from 2004 to 2005 at the three culture sites: Baie des Chaleurs: Pointe Verte (site 1) and Bathurst (site 2), and Northumberland Strait (site 3).

The suspended cages with Vexar™ bags resist the wave action and provide an excellent growing environment for the young scallop (Figure 69). They must be retrieved once a year to be cleaned. The cleaning is usually done in the fall when the mortality rate due to handling is lowest.



a) b)

c) d)

Figure 69. Cage retrieved after one year (a); Removing the Vexar™ bags from the cages (b); Attached scallops (c); Cultured scallops (d).

One of the mandates of Pecten II is to determine the cost and the operation time of various scallop aquaculture activities. One of the steps of the spat collection activity is retrieving the collectors and sorting their contents and transferring the scallops to culture gear. To document this process a sorting station was set-up in Cap Lumière, NB. The station was installed in two days (October 30 and 31, 2005). From November 1 to 2, 2005, the collectors were retrieved and a team of four people sorted 234 collectors at a rate of about 24 collectors/ hour using a sorting machine. The scallops were then placed in the new culture gear (Figure 70).

a)

b)

c)

d)

Figure 70. Retrieving the scallop spat collectors (a); installing the sorting machine (b); sorting the scallop spat (c); and placing scallop in new culture gear (d).

Questions/Comments:

Participant: During your sorting trials, did you log the mortality rates?
Bruno Frenette: We will see this spring when we reel in the gear.

Participant: Is the mortality due to the strain or to environmental conditions?
Bruno Frenette: Environmental conditions certainly have an influence, but mortality could also be caused by the fact that the starting stock of spats was a bit bigger.

Participant: Did you experience infestations of predators in your cages?
Bruno Frenette: No, we did not notice any great concentration of predators.

Scallop Cage Culture Pilot Project: 2001- 2004

Donna Murray

In 2001, the Botsford Professional Fishermen's Association Inc. (BPFA) embarked on a pilot project to determine if the technology developed by Hillsburn Basin Scallop Group Inc. could be adapted in the Northumberland Strait to grow scallops. DFO's science conducted the scientific monitoring of this project. Cages similar to those used by Hillsburn Basin (Figure 71) were built and deployed with scallops purchased from Sea Perfect Cultivated Products.

Figure 71. Scallop culture cage designed by Hillsburn Basin Scallop Group Inc.

The following year we had trouble hooking onto the cages and raising them to the surface. The cages were easily located and the fishermen marked each site with anchor lines and buoys prior to grappling them. They were hard to grapple due to the fact that the cages were wound up with the anchors and rope, plus a number of them were tipped over. The only way to get a hold of the cage was to grapple the cage itself which was tedious and took numerous attempts. Another problem was the trays were flimsy and protruded on both sides of the frame and the rope used to secure the trays in the cage was too heavy and therefore the fishermen were unable to draw the rope tight enough to keep the trays from moving. The retrieved trays were badly bent on the ends that protruded from the cages (Figure 72).

Figure 72. Badly bent trays occurring when cages tipped over.

Unfortunately, most of the cages were not retrieved after the first year. The cages that were retrieved two years after the deployment date, were heavily fouled (Figure 73). Scallops can suffocate due to this heavy fouling. It is recommended to clean trays once a year.

Figure 73. Heavily fouled tray that were left in the water for two years.

Once the scallops reach the average shell height of 75mm, they are ready for market as a Cocktail or Princess Scallop as they are called (Figure 74). Princess scallops are scallops that range between 65mm and 85mm and are to be prepared like mussels with a little wine, a real treat.

Figure 74. Scallops cultured to an average size of 75mm.

The scallop growth and survival rate in Cage 1 was monitored from October 27, 2000 until June 8, 2003 (Table 14). According to DFO biologist, the growth rate of the scallops cultured in theses bottom cages is slightly faster than the growth of the local wild scallop population.

Table 14. Growth and survival rate of scallops

	October 27th, 2000	May 27th, 2001	Daily Growth Rate	September 26th, 2001	Daily Growth Rate	June 6th, 2002	Daily Growth Rate	June 8th, 2003
Cage 1	Shell Height 36.4 (mm)	Shell Height 41 (mm)	.02 mm/day	Shell Height 47.2 (mm)	.05 mm/day	Shell Height 62 (mm)	.06 mm/day	Shell Height 75 (mm)

One of the retrieved trays contained a cod, proving that there is some cod still in the area (Figure 75). The cod was released after it was photographed.

Figure 75. Cod that was found in a scallop tray.

Some of the trays had to be retrieved by divers. There was a lobster under one of the trays, which proves our cages are creating a natural habitat for various species of fish (Figure 76).

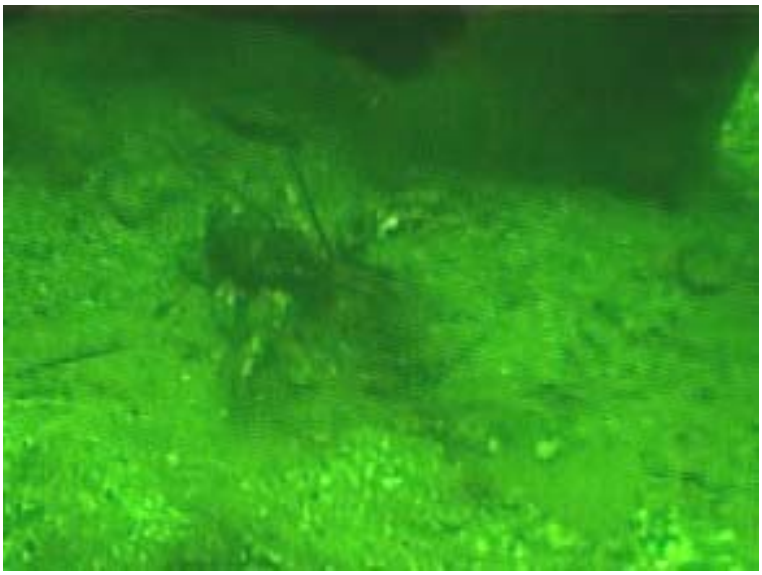


Figure 76. Lobster that was hiding under a tray.

The temperature at the bottom of the study site was monitored from June 2001 to May 2002 using an electronic thermometer; Vemco™. The temperature never was warmer than 18°C however it did drop below 0 °C in the winter (Figure 77).

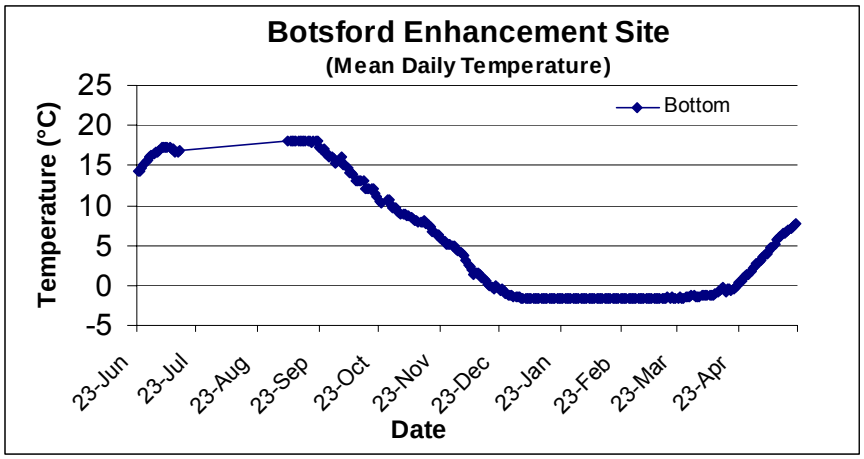


Figure 77. Water temperature at the study site from June 2001 to May 2002.

In 2003, three new cage designs were tested: 1) large cage made of wire mesh 2) small rectangular cage made of wire mesh and 3) a conical cage. The large wire mesh cage (Figure 78) has outside measurements of 66" (167.6 cm) x 66" (167.6 cm) x 40" (101.6 cm). Three of these cages were purchased from Bouctouche Bay Industries Ltd. (Figure 8a) Each of these cages was put in a frame made out of 2" x 3/8"(5 cm x 1 cm) angle iron, which encompasses the cage and give it weight and stability (Figure 8b). Two of the frames were made by Gordon Dean and the third one was made by Leigh Stright. Each cage holds 48 Vexar™ bags that were purchased from Enterprise Shippigan Ltd. The cages were anchored down with 150' (46 m) anchor lines with two 50 lbs (23 Kg) anchors at each end. A buoy line was attached to each cage with a 50 lbs (23 Kg) weight.

a)

b)

Figure 78. a) Large cage made of wire mesh purchased from Bouctouche Bay Inc. Ltd b) Three large cages with angle iron frame.

Three small wire mesh rectangular cages with 6 Vexar™ bags in each cage measure approximately 33" (83.8 cm) x 54“ (137.16 cm) x 13.5" (34.3 cm) (Figure 79). These cages and Vexar™ bags were fabricated at Enterprise Shippigan Ltd.

Figure 79. Small rectangular cages made of wire mesh.

The conical scallop cages (a.k.a. RV Cages, named for Réjean Vienneau, who thought of the idea) have a bottom diameter of 36" (91 cm) and a top of 18" (46 cm) and are approximately 20" (51 cm) high (Figure 80). The frames were made by Olympic Metals Ltd. Inserted inside the frame is a two compartment lantern-type net created by I.M.P. Group Ltd. (Sam Boucher).

Figure 80. Conical scallop cages.

One year old scallop spat were obtained from the Pecten UPM/MFU Inc. The Vexar™ bags have a 9 mm mesh while the scallop spat were 5 mm so the spat were placed in a 1mm orange mesh bag. A piece of rigid Vexar™ lining was inserted in the orange mesh bag to prevent it from collapsing and therefore giving some space for the scallops (Figure 81). One orange mesh spat bag containing about 200 scallop spat were place in each Vexar™ bag of the large wire mesh cages and the small wire mesh rectangular cages and the compartments of the conical cages.

Figure 81. Adding scallop spat to orange mesh bag.

The fishermen volunteered their time to get the cages ready and put them out. All costs for putting the cages out were donated by all those who were involved. Three of each new cage design was put out in 60 feet of water off of the Botsford Wharf (Figure 82).

Figure 82. Site where the three new cage designs were deployed.

In 2004, when the cages were retrieved, (Figure 83) all three new cage designs appeared to have remained on the bottom at the locations where they were deployed the previous year. They were easily reclaimed using a reversible hauler. Also, no damage to any of the cages was detected. Mud which can be detrimental to scallops, accumulated only in the bottom compartments of the cages. In the large cage, mud did not accumulate as badly as in the conical and small rectangular cages.

a) b)

Figure 83. a) Retrieving the large cage and b) Accessing the Vexar™ bags.

The scallop spat were removed from the orange mesh bag and put directly into the Vexar™ bag or compartment (Figure 84). The scallop were larger and more abundant that expected for having spent one year inside a 1mm onion bag. The folded piece of Vexar™ had succeeded in preventing the onion bag from collapsing. The live scallop shell height ranged from 15 to 47 mm.

a) b)

Figure 84. a) Content of orange mesh bag one year after deployment b) Samples of scallop spat to compare size to a nickel, dime, quarter and a toonie**.**

All scallops from the selected Vexar™ bags and levels were measured and counted (Table 15). In the fall of 2003, the number of scallop placed in each Vexar™ bag or compartment was only estimated therefore it is not possible to give an accurate survival rate.

Table 15. Counts, shell heights, and growth rate of scallops retrieve after one year in new cage designs.

		October 18, 2003		October 26, 2004				
Cage design	Compart-ment measured	Initial # estimated	Initial size (mm)	# live	# dead		size (mm)	Growth rate mm/day
conical	Top	200	5.2±1.5	181	3		29.9±3.9	0.07
small	Top	200	5.2±1.5	91	37		32.5±4.5	0.07
Large	Top	200	5.2±1.5	89	1		28.5±4.5	0.06
Large	2nd from top	200	5.2±1.5	104	5		26.4±4.9	0.06
Large	bottom	200	5.2±1.5	78	9		30.9±4.8	0.07

The cages can be washed down with a high pressure hose on board the boat to remove the fouling that accumulates throughout the year (Figure 85).

Figure 85. Washing a large cage with a high pressure hose.

In November 2005 the new cage design were re-visited. The scallops from selected Vexar™ bag were retrieved and measured. At first glance, it was obvious that the scallops had experienced an important growth (Figure 86).

Figure 86. Visual growth comparison from 2003-2005.

The counts, measurements, growth rates and size ranges of scallops are listed in Table 16. According to the DFO biologist the growth rate is still greater than the scallops on the neighboring commercial bed.

Table 16. Counts, measurements, growth rate and size range of scallops retrieved from selected Vexar™ bag.

November 1, 2005						
Cage design	Compartment measured	Count (live)	Size (mm)	Growth rate mm/day	Max size (mm)	Min size (mm)
small	Top	41	46.5±3.7	.04	55	37
small	Top	66	50.3±4.6	.05	63	39
large	Top	132	44.7±5.3	.04	58	30
large	Middle	76	47.4±4.5	.06	57	34
large	bottom	74	43.7±3.7	.04	52	35

Conclusion

- The scallop cultured by the BPFA Inc. achieved excellent growth
- The three new cage designs were stable and easily located and retrieved one year after deployment.
- There is easy access to the cages with the use of a reversible hauler.
- The BPFA would prefer to employ the large new cage design because of the greater capacity.
- Each cage creates its own eco-system and acts as artificial reef for lobsters and other species.
- Scallop aquaculture could supplement the current scallop dragging fishery.

- This would help stop damage to the bottom and other species of fish.
- This could help commercial fishermen keep afloat in SFA 22 until solutions are found for the downfall of the fisheries in their area.
- Your feedback would be appreciated by the BPFA Inc.
- Thanks.

Questions/Comments:

Participant: Why is there a high mortality rate in the bottom of the cages?
Donna Murray: When the cages hit the bottom, they did not lay flat. So if a tray fell out, it would lie in high siltation. In the trays that are one foot above the floor, there is no siltation.

Participant: You mentioned that you tested four cage designs. Have you settled on one?
Donna Murray: Not exactly. We are discussing that with the Department of Fisheries, Agriculture and Aquaculture of New Brunswick (DAFANB). It may be a larger cage, which is OK for a 65' boat where we can have the large crane needed to lift them because they are heavy. So if we settle for the larger cages, we would need to get a 65' boat. That will be part of future discussions with DAFANB and DFO, in view of submitting a proposal to the Atlantic Canada Opportunities Agency (ACOA).

Participant: Do you have any partners from P.E.I.?
Donna Murray: No, we do not have specific people. We are looking for the same type of partners as the one from the first year, from Cap-Pelé down to the border, and on the P.E.I. side, from Egmont Bay to Victoria. We will ask them all.

Participant: How long does it take for siltation to take place?
Donna Murray: We clean everything in the Fall. We don't know if it's worse in the Spring.

Participant: Is the shell from your scallops thinner than wild scallops'?
Donna Murray: No, it's the same.

Participant: You say you absolutely need a 65' boat but we, lobster fishers, all have 44 footers.

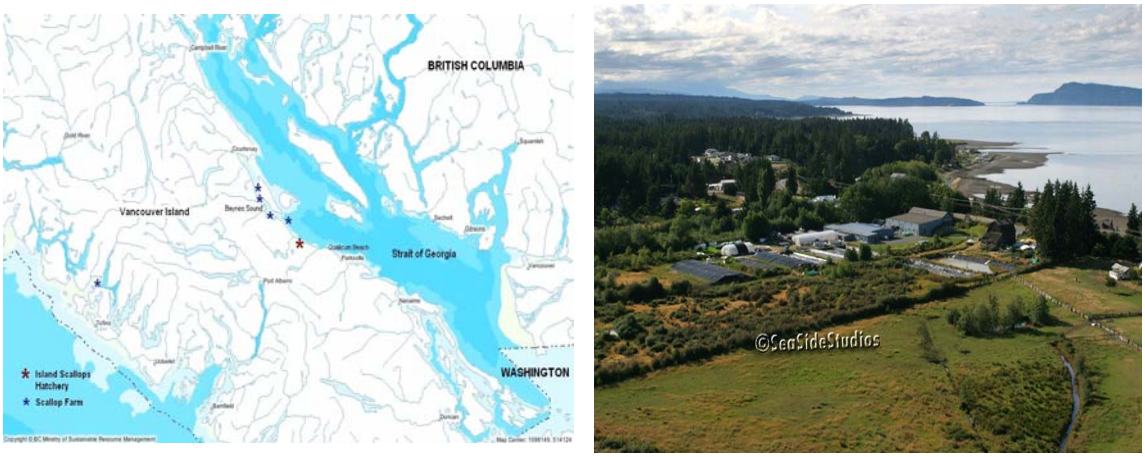
Donna Murray: We have 44 footers as well but ideally we would need a 65' boat.

Participant: Would it be feasible for half size cages to fit on 44' boats?
Donna Murray: ACOA wants cages large enough so that, in the future, the number of cages on the bottom can be controlled. All fishers would prefer smaller cages but we have to deal with this requirement. It should be noted that if all fishers had their cages (the half sizes) there would be way too much coverage of the bottom, if you also include all the lobster gear.

Island Scallops Ltd. -A Canadian West Coast Version of Scallop Farming

Bruce Evans

Island Scallops Ltd is Canada's largest private marine research hatchery and first fully integrated cultured shellfish and marine fish producer. Dr. Neil Bourne, a DFO research scientist who is now retired, studied the culture potential of several species. He found that the Japanese scallops (*Patinopecten yessoensis*) could easily be cultured on the west coast of Canada. Since this species is not native to Canada, the spat must be obtained from a hatchery. Island Scallops Ltd. was established in 1989 near Qualicum Bay, British Columbia (Figure 87) to develop the hatchery technology for producing Japanese scallop seed for cultivation. It has been involved in shellfish processing and marketing since 1991.



a) b)

Figure 87. a) Map situating hatchery (*) and farm sites (*) in British Columbia and b) Arial view of hatchery near Qualicum Bay, BC.

The main hatchery contains ten 10,000 gal tanks. Food for the scallops is produced in green houses and there are nursery ponds for settlement of the scallop larvae. The life cycle of the scallop and the various stages of culturing are presented in Figure 88. Adult scallops are spawned in the hatchery. The male and female gametes are released in the water and the fertilized eggs form larvae (Figure 89a) that are free-swimming in the water column for 21days before they settle. Continuous bag culture is used for producing algae to feed larvae (Figure 89b).

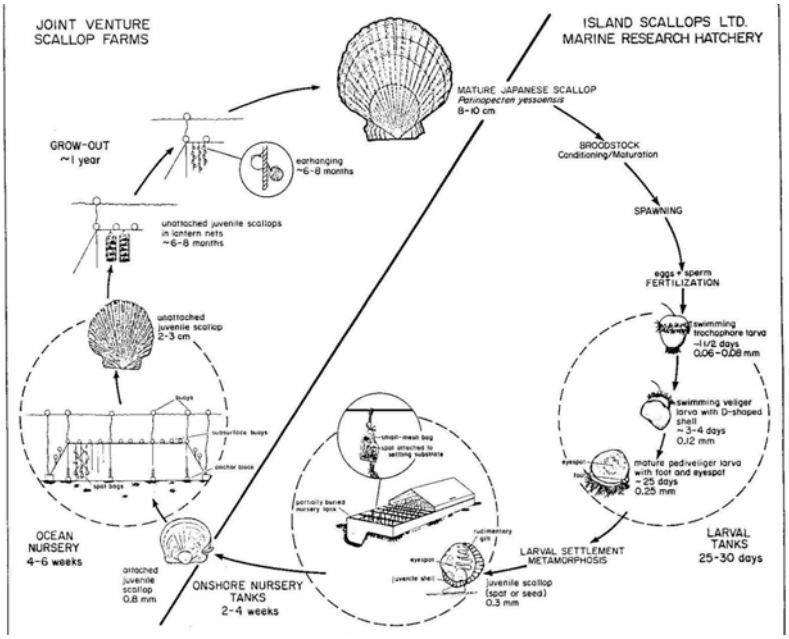


Figure 88. Life cycle of the scallop and culturing stages.

a) b)

Figure 89. a) Scallop larvae and b) Continuous algae bag culture.

The larvae are ready to settle when the foot starts to protrude. They are then put in a pond with 200 strings that are suitable substrate to which larvae can attach (Figure 90a) . Paddle wheels placed at the surface keep the food circulating throughout the pond (Figure 90b). When the scallops reach a shell height of 10mm, they are ready to come out of the nursery pond (Figure 91).

a) b)

Figure 90. a) Nursery ponds with strings are settlement substrate for larvae; b) Paddle wheel running in pond to keep the food (algae) moving.

a) b)

Figure 91. a) Scallop spat attached to string; and b) Scallop spat with 10mm shell height.

The grow-out is conducted on long lines at farm sites at sea. Presently, Island Scallops Ltd has three principal farm sites that total approximately 200 hectares. Two other sites are being developed. Locations which offer a depth of 100 ft (30m) of water with a flat bottom are desired criteria when selecting sites. Not many surface structures are utilised because in British Columbia it is important to minimize the visual pollution. The culture gear is placed at 5 to 10 meters under the surface to get away from fresh water which is detrimental to scallops. Two ton concrete blocks are used to anchor the 100 to 120 meter length long lines that are attached to a few surface markers. The long lines are placed perpendicular to the currents. The long lines run parallel to each other with 30 meters between each line. This might allow enough space for lobster fishing to co-exist with the scallop culture. A submerged long line can hold up to 200 drops of pearl nets (15 tiers deep) or it can have ear hung scallops attached to it (Figure 92).

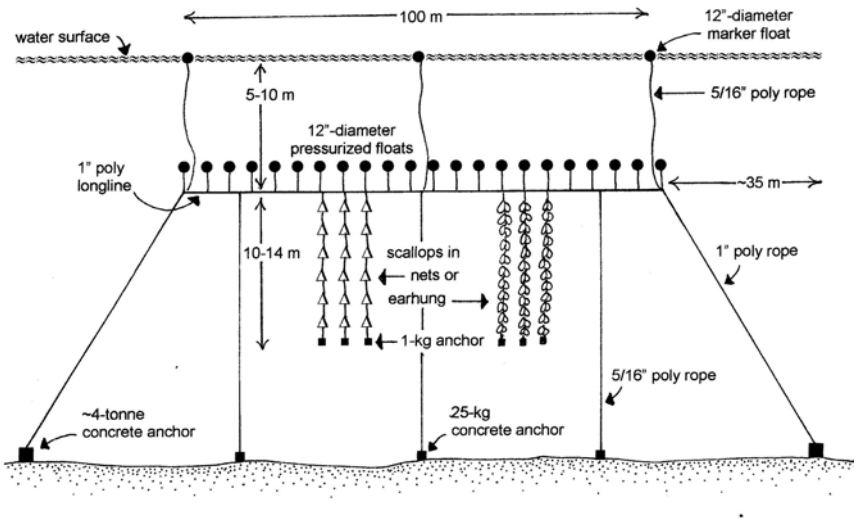


Figure 92. Submerged long lines with drops of pearl nets and strings of ear hung scallops.

All the equipment on the 40 ft culture boats (Figure 93a) is hydraulically powered. Two starwheels are powered on a single valve (Figure 93b). Since the long lines are submerged, a grapple hook (Figure 93c) is used to retrieve the long lines. They are then placed on the starwheel allowing workers to travel along the long line to work on the culture gear.

a) b) c)

Figure 93. a) Culture boat; b) Starwheel; and c) Grapple hook.

Pearl nets are used to grow-out scallops at sea (Figure 94a). Spawning starts at the hatchery in February and finishes by late May or early June. Scallop spat that have a shell height of 2mm are placed in pearl nets between May and August. By September the

early sets have reached 20mm. A lot of equipment is purchased from Japan such as the pearl net washing machine (Figure 94b). The grapple hook is used to retrieve the submerged long lines.

a)

b)

Figure 94. a) Pearl nets and b) Pearl net cleaning machine.

Initially, the 2mm scallops are placed in pearl nets at the high density of 3000/ tier and the density is reduced to 50/ tier in September (Figure 95a). Scallops often need to be sorted before they are transferred to keep the same sizes together. A Japanese sorting machine is used for this purpose (Figure 95b). Last year, over 7 million scallops were handled.

a)

b)

Figure 95. a) Scallop spat (20mm) in pearl net, and b) Scallop sorting machine in use.

The ear hanging technique is presently being explored. A Japanese pinning machine is used to insert pins through ropes (Figure 96a). Scallops are taken out of the pearl nets (Figure 96b) and a hole is drilled through each scallop shell at a specific location (Figure 97a). Water is used to keep the drill cool. Machines are set-up for two different sizes of scallop. Each scallop is then attached to the rope by inserting the pin through the drilled hole (Figure 97b).

a) b)

Figure 96. a) Machine to insert pins in rope; and b) Scallops that are ready to be drilled.

a) b)

Figure 97. a) Machine to drill hole in scallop shell; and b) Scallop being manually attached to rope.

In one day, with personnel of 15 people, about 40,000 scallops can be placed on ear hanging ropes (Figure 98a). Each rope is attached to the long lines at sea and the scallops are harvested when they reach an average shell height of 11cm (Figure98b). They are sold live in the shell. Presently, the scallops are being sold for $3.00/lb and there could be anywhere from 3 to 5 scallops/lb.

a)

b)

Figure 98. a) Placing freshly ear hung scallops at sea; and b) Harvesting 11cm ear hung scallops.

In recent years, Island Scallops Ltd has been conducting some genetic research to select for disease resistance stock.

Island Scallops Ltd.

Foot note:
Since the workshop, Island Scallops Ltd has suspended the use of earhanging. The technique is OK in certain situations. Because of the amount of biofouling and also a higher mortality rate, ISL is using lantern nets now. This is a method that allows us to keep close to the same amount of production over a unit length of longline.

Questions and comments:

Participant: You say the harvested scallops are 20 months old. That would mean they grow much faster than they do here?
Bruce Evans: Yes. Growing off the bottom shaves a whole year off the regular harvesting time.

Participant: When you hang scallops to the lines, how old are they?
Bruce Evans: They would be 12 months old.

Participant: What species do you work with? Would they freeze here?
Bruce Evans: They are "Pacific" scallops, a hybrid we created with the Japanese scallop and the local weathervane scallop. They are very similar to yours.

Participant: Have you ever considered using collectors next to your lines?
Bruce Evans: No, because we rely on the hatchery for our spats. Also, it is not a good growing bottom- it's too silty.

Participant: In the hatchery, what is your survival rate?
Bruce Evans: Of an initial 300 millions larvae, we sell 40 millions, so it would be around 13%.

Participant: From your pictures, the lines seem close to shore…
Bruce Evans: Yes, they are 500 meters off shore, in about 100 feet of water.

Participant: What is the final price for your production?
Bruce Evans: We sell our scallops live in the shell, so there's a limited market for this product. It's mainly an oriental specialty, sold in restaurants. On average the price hovers around $3/lb. For the 10cm scallop, one gets 5 to a pound, and for the 11-12cm, it's 3 to a pound.

Participant: Is there any other commercial fishery around your area?
Bruce Evans: Yes, but it is a very small fishery. Besides, this variety is not caught wild, so we are not really competing with the wild fishery.

Participant: What are your production costs?
Bruce Evans: For the hatchery, where we have a potential of 100 million spats and a budget of $500,000, the cost varies on the output.

Participant: Have you done any genetic work?

Bruce Evans: Yes. We had an early problem with disease and exotic species. In our third year, we lost 80% of our production to disease. We are working on traits on our brood stock, and with natural selection we'll get better resistance to disease.

Participant: Is there a potential for contamination because the scallops are not shucked?
Bruce Evans: Our long line site in only 20 minutes from our site. In the heat of the summer, we work with insulated totes to try to keep the temperature down. We transfer them to clean water, hold them overnight in cold water and they are processed the next day.

Participant: What is the cost of the equipment?
Bruce Evans: The automated drill can go from $1,000 to $30,000-$40,000 or even $80,000. It is made in Japan. The pinning machine showed is $12,000 US. You need high speed, water and bits changed twice a day.

Participant: How do you handle problems with invasive species that cause fouling?
Bruce Evans: Each site is different (the number of barnacle sets varies) and each year is different.

Participant: With your sorting machine, what is the rate of mortality?
Bruce Evans: It's pretty good (a very slight number). You need to handle the thin edge outside the shell to cause minimal damage.

Participant: What do you do for net cleaning and waste disposal?
Bruce Evans: We have not been successful in dealing with this yet! The only way we have found is to put a tarp over the pile, and have a sprinkler on to keep it cool. It works better if nets have had "biological activation" – they clean better. Our dream is to have a big enough boat so we could clean with a high pressure system on a conveyor belt directly on board. Of course we would need approval from DFO to do this.

Participant: Is the company actually making a net profit?
Bruce Evans: Yes. In fact, we have just gone public. It was the only way to source financing to expand. We went from a production of 1 million scallops three years ago to 7 million in 2005.

Appendix 1

Letter of Invitation

Gulf Region P. O. Box 5030 Moncton, NB E1C 9B6 March 3, 2006 Dear Sir / Madam, The Department of Fisheries and Oceans – Gulf Region would like to extend to you an invitation to attend a Workshop on the Future of the Southern Gulf Scallop Fishery scheduled to convene in Moncton, New Brunswick, on March 30th - 31st, 2006 involving fisher associations, industry, aboriginal, academia, provincial and federal government. The workshop will be directed towards identifying progressive management methods for the traditional scallop fishery, while also exploring new harvesting methods. Lately the scallop fishery, like most other mobile gear fisheries, has been receiving increased media attention concerning its alleged effects on the habitat and ecosystem. Two key discussion themes have therefore been identified as the focus of this workshop: • The Evolution of the Traditional Scallop Fishery • New Scallop Harvesting Methods	Région du Golfe C. P. 5030 Moncton (N.-B.) E1C 9B6 Le 3 mars 2006 Monsieur / Madame, Le Ministère des Pêches et Océans - Région du Golfe vous invite à un Atelier sur le futur de la pêche aux pétoncles dans le sud du Golfe qui se tiendra à Moncton, Nouveau-Brunswick, le 30 et 31 mars, 2006 qui comptera aussi sur la participation d'associations de pêcheurs, de l'industrie, de regroupements autochtones, d'académiques, des gouvernements provinciaux et fédéral. L'atelier se concentrera sur l'identification de méthodes progressives de gestion pour la pêche traditionnelle de pétoncles, tout en explorant de nouvelles méthodes de récolte. La pêche de pétoncles, comme la plupart des autres pêches à engin mobile, a suscité l'intérêt des médias dernièrement en raison des effets présumés sur l'habitat et l'écosystème. Deux thèmes principaux de discussion ont donc été identifiés comme noyau pour cet atelier : • Évolution de la pêche traditionnelle du pétoncle • Nouvelles méthodes de récolte du pétoncle Nous prévoyons que la participation de

It is anticipated that the participation of federal researchers, industry interests including fishers, processors, as well as federal and provincial government representatives should provide sufficient collaborative counsel to guide the future management of this fishery. Formal proceedings of the presentations, discussions and conclusions associated with this workshop will be published The attached brochure, which includes your registration form, will also provide you with details of location and lodging. Please complete the included form and submit it to us by fax at (506) 851-2607 no later than March 20th, 2006. We look forward to your valuable participation at this workshop. Sincerest regards,	chercheurs fédéraux, de membres de l'industrie comprenant les pêcheurs, les transformateurs, ainsi que les représentants fédéraux et provinciaux de gouvernement devraient fournir suffisamment de conseil pour diriger la future gestion de cette pêche. Les présentations, les discussions et les conclusions liées à cet atelier seront publiées sous format d'un acte de conférence. Vous trouverez une fiche d'inscription inclut dans le livret ci-joint, qui vous fournira également des détails concernant l'endroit et le logement. S.V.P. compléter cette fiche et nous la faire parvenir par télécopieur au (506) 851 2607 au plus tard le 20 mars, 2006. Nous espérons pouvoir compter sur votre présence à cet atelier. Salutations distinguées,

Rhéal Vienneau

Director | Directeur
Resource Management | Gestion des Ressources
Fisheries and Oceans | Pêches et Océans
Gulf Region | Région du Golfe

Appendix 2

Workshop Agenda

March 30, 2006		
10:00AM:	**Welcome** ▪ Opening Remarks	Laurent Paulin (Chair) – Department of Fisheries and Ocieans (DFO)Resource Management
10:15AM	**Presentation:** ▪ Habitat Management Program	Roland Cormier – DFO Habitat
10:45AM	**Presentation:** ▪ Lobster Habitat and Ecology	Michel Comeau – DFO Science
11:15AM	**Questions**	
11:30AM	**Presentation:** ▪ Overview of the Scallop Fishery	Luc Légère – DFO Resource Management
11:50AM	**Questions**	
12:00PM	**Lunch Break**	
01:00PM	**Presentation:** ▪ Biological Overview ▪ Stock characteristics	Leslie-Anne Davidson – DFO Science Monique Niles – DFO Science
01:30PM	**Questions / Discussion**	
02:00PM	**Presentation:** ▪ Pétoncle 2000 Scallop Enhancement Program	Madeleine Nadeau – Le ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ)
02:30PM	**Questions / Discussion**	
03:00PM	**Presentation:** ▪ PECTEN I Scallop Enhancement Project ▪ HADD – potential projects ▪ Enhanced bed evaluation / Rotational fishery	Bruno Frenette – Maritime Fishermen's Union (MFU) Bruno Frenette – MFU Leslie-Anne Davidson – DFO Science
03:45PM	**Questions / Discussion**	
04:15PM	**Health Break**	
04:30PM	**Presentation:** ▪ Commercial Scallop Diving in Maine	George Freeman – Maine Fisherman
05:00PM	**Questions / Discussion**	
05:30PM	**Social Break**	

March 31, 2006

09:00AM	**Welcome**	Laurent Paulin (Chair) DFO Resource Management
09:15AM	**Presentation:** ▪ PECTEN II – Scallop Aquaculture Project	Bruno Frenette – MFU
09:30AM	**Questions / Discussion**	
09:45AM	**Presentation:** ▪ Scallop Cage Culture Pilot Project: 2001-2004	Donna Murray – Botsford Professional Fishermen's Association (BPFA)
10:00AM	**Questions / Discussion**	
10:15AM	**Health Break**	
10:30AM	**Presentation:** ▪ Commercial Scallop Aquaculture and Hatchery ▪ Japanese Scallop Programs	Bruce Evans – Island Scallops / Edgewater Foods, BC
11:00AM	**Questions / Discussion**	
11:30PM	**Next Steps**	Luc Légère – DFO Resource Management