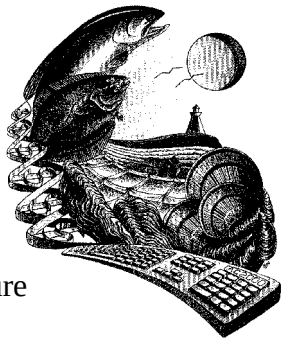
Unit 3 : Aquaculture

A Look at Fish Farming

What is Aquaculture?



The word Aquaculture comes from the Latin words Aqua (water) + Cultura (to grow). It is defined as the growing and cultivation of fish, shellfish and plants in any water environment whether that environment be natural, such as the seashore, or in human-made containers of tanks or raceways. In biological terms, this means improving the yield of aquatic organisms by skillfully handling of their rates of growth, mortality, and reproduction. The ultimate objective of aquaculture is to harvest a product that has commercial value. It is the aquatic equivalent of agriculture and it is often referred to as "fish farming."

Another word often used is Mariculture (Mare (sea) + Cultura (to grow)). This term specifically refers to the culture of animals or plants in the sea or marine environment.

Aquaculture is not a new activity. In fact, aquaculture stretches back to early civilizations. It is believed that China cultured carp some 4000 years ago. The Japanese farmed oysters in tidal waters about 2000 B.C., while the Romans cultured oysters in 100 B.C. In Nova Scotia, oysters were being cultivated 100 years ago.

Aquatic farming has been increasing around the world as countries strive to meet growing demands for protein foods. Aquaculture facilities exist in every Canadian province and territory. The Canadian aquaculture industry generates hundreds of millions of dollars annually in revenue and employs thousadnds in aquaculture and in supplies and services.

Is Aquaculture Important for Nova Scotia?

Nova Scotia is closely identified with the sea. The vast majority of Nova Scotians live near or on the coast, and many make their living from the sea through traditional fishing activities and more recently aquaculture. With over 7000 kilometers of varied coastline, Nova Scotia provides many areas suitable for culturing a variety of marine and freshwater species.

Nova Scotia has an important fishing industry. In fact, Nova Scotian companies export hundreds of millions dollars worth of seafood products each year to countries around the world. Aquaculture is helping many fishing communities diversify industrial activities and create employment opportunities.

In addition to jobs directly associated with aquaculture operations, there are significant spin-off benefits for businesses that manufacture fish feed, netting, boats and other equipment. Fish plants, which often drive the economy of coastal communities, also reap the benefits of processing aquaculture products.

How Is Nova Scotia Developing Aquaculture?

The Nova Scotia Department of Agriculture and Fisheries is the lead agency for aquaculture development in the province. The department issues leases and licences for aquaculture sites. Currently, there are a few hundred licenced sites in the province.

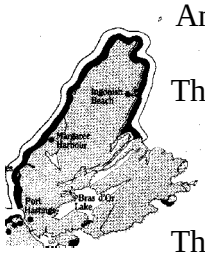
The Aquaculture Division of the department provides information, technical expertise and technology transfer to aquaculturists. Field staff work with finfish and shellfish farmers to solve problems and improve production. The department also carries out applied research and development projects that support aquaculture development for species currently cultivated and for species that show a potential for farming such as halibut and cod.

The government is committed to developing aquaculture in partnership with industry and coastal communities.

Where is Aquaculture Happening?

Currently, there are a few hundred issued aquaculture sites in Nova Scotia. What makes Nova Scotia different from other provinces is the range of different types of species and places where aquaculture is practiced. Check out the aquaculture mapping site at: www.gov.ns.ca/nsaf/aquaculture/aquamap.htm.

The Gulf of St. Lawrence/Northumberland Straight area has traditionally been an excellent place to grow American Oysters and this activity continues today.



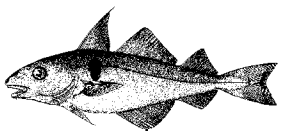
The Bras d'Or Lakes in Cape Breton has the largest concentration of American Oysters in the province. Ideal habitat combined with warm waters of 22°C (72°F) provides excellent growth rates and natural seed regeneration to give this area great potential for oyster culture. Rainbow Trout leases also exist in areas of the lakes and have for many years. This is due in part to the existence of two hatcheries that have supplied farms with young fish to grow out on their sites. Today there are several private hatcheries throughout the province that supply fish farms with fingerlings (young trout) and smolt (young smolt). Coastal areas of Cape Breton have several areas that have sheltered coves and harbours where mussels and scallop farms exist.

The Eastern Shore area from the Strait of Canso to Halifax has clean, cold water that currently supports Blue Mussel and Sea Scallop culture and is predicted to be a promising area for Steelhead Salmon in the future.

The South Shore area from Halifax to Yarmouth is characterized by good currents and warm water temperatures, both excellent conditions for Blue Mussels, European Oysters, Steelhead Salmon and Sea Scallops. There is also a lot of activity related to Steelhead Salmon in the Lobster Bay area.

Atlantic Salmon require relatively warm water throughout the winter. For this reason, areas acceptable for year-round farming are limited. Areas include the Annapolis Basin, Shelburne Harbour and parts of St. Margaret's Bay.

Nova Scotia also has great potential for growing many other types of species such as sea urchins, Atlantic Halibut, haddock, flatfish and sea plants in areas where water conditions are suitable.



How Do Communities Get Involved in Aquaculture?

The department works with communities through Regional Aquaculture Development Advisory Committees (RADACs) to establish sites and resolve potential conflicts among users of coastal resources. The RADAC's exist currently in several coastal areas within the province and consist of 15 - 25 people who represent the interests of the area. These may include local MLA's, marine users such as fishermen, boaters and waterfront landowners as well as other interested individuals.

These community-based organizations provide an important forum for interest groups to voice opinions and concerns about aquaculture projects proposed for their area. RADACS are an important source of information and feedback from communities to the provincial Agriculture and Fisheries Minister.

The RADAC reviews aquaculture applications to determine if they are suitable for the proposed site and if there are any conflicts with other user groups. The organization then passes its recommendations to the minister, who makes the final decision on issuing a lease and license.

This approach has been highly successful in introducing aquaculture into new areas and in resolving user conflicts. It gives residents an opportunity to take control of aquaculture development in their area and it provides the department with much-needed local input.

How Does Aquaculture Work With Nova Scotia's Traditional Fishery?

The traditional fishery is a major industry in Nova Scotia with an annual market value approaching one billion dollars.

Aquaculture works with the traditional fishery, and offers coastal communities new opportunities for diversifying their economy and creating jobs. Many coastal communities, particularly those with a history of traditional fishing, have wharves, slipways, gear sheds and other fishing infrastructure that can be used by aquaculturists as well. People, particularly fishers, living in these communities possess good knowledge and the experience of working on the ocean and can extend that expertise to aquaculture activity.

Sites that are chosen for aquaculture along the coast of Nova Scotia are screened to ensure they are not traditional fishing areas that would conflict with the fishing industry.

In fact, traditional fishermen are taking advantage of the new opportunities in aquaculture. Some are going into aquaculture as a full-time business while others see aquaculture as a way to diversify their fishing activity.

How Do I Start an Aquaculture Site?

If you are interested in starting your own aquaculture site contact the Fisheries Representative at the nearest Nova Scotia Department of Agriculture and Fisheries office to request an application package. The Fisheries Representative will check the hydrographic chart for possible conflicts and the classification (shellfish only) of the area. The applicant should consult with the department's Fisheries Representative and Aquaculture Division in preparing the proposal and application.

The application package must be completed and returned to the local Fisheries Representative. And must include:

- Application fee (cheque or money order made payable to Minister of Finance)
- Completed application form and development/business plan;
- A 1:10,000 digital planimetric plot or orthophoto with the site drawn to scale.

All relevant information regarding the operation is included in the application to ensure prompt and proper review by the various government agencies. Incomplete applications will not be accepted.

Once the completed application is given to the Fisheries Representative they forward the completed application package and application fee to the Nova Scotia Department of Agriculture and Fisheries office in Halifax for review by staff. If it meets basic criteria it will be given a site number and submitted to the full review process.

All applications will be reviewed by:

- A technical/financial committee made up of Nova Scotia Department of Agriculture and Fisheries staff,
- A network of federal and provincial review agencies and,
- A Regional Aquaculture Development Advisory Committee (if RADAC is established). If there is no RADAC, a public hearing may be held to allow for public consultation.

Approval or rejection of the application by the Minister of Agriculture and Fisheries is based on information and recommendations received during the review process.

All site coordinates are verified by the Fisheries Representative with the applicant present at the site.

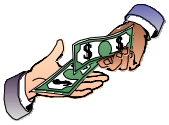
Documents are only issued when site coordinates are verified. The lease/licence will not be considered issued until all copies of lease/licence documents and fees are returned and signed by the Minister of Agriculture and Fisheries.

The licence plate will be mailed out when the documents have been issued for the applicant to display at the aquaculture site.

Aquaculture lease/licence fees vary according to the type of fee requested such as application fee, yearly license fee (U-Fish, all others), yearly lease fee, lease/licence assignment/ amendment/ renewal fee, etc.

Apply for Funding

Loans are available through the Nova Scotia Fisheries and Aquaculture Loan Board to develop and sustain aquaculture for finfish, shellfish and seaplants. Note: Motor vehicles, real estate and feed are not eligible.



To apply for a loan the applicant must be a Canadian citizen and a resident of Nova Scotia and show evidence of competency in aquaculture. Financing is available for salmonid seed stock; shellfish seed/spat; collection materials, grow-out equipment and materials; and rafts, buoys, floatation devices, anchors, nets, cages for finfish grow-out, small boats, outboard motors and onboard gear handling devices

Aquaculture working capital loan guarantees for feed or operating costs are available through the chartered banks. The amounts are flexible, bank rules apply, and the line of credit must revolve through each growing cycle. For more information on loans, contact:

Fisheries and Aquaculture Loan Board
Nova Scotia Department of Agriculture and Fisheries, Box 2223, Bank of Montreal Tower, 6th Floor, 5151 George St., Halifax, Nova Scotia, B3J 3C4 ..... Phone: (902) 424-4560
Other financing options for both start up and existing aquaculture businesses are found on the Nova Scotia government website at: www.gov.ns.ca/nsaf/aquaculture/application/funding.htm#1

Career Opportunities

Should I Consider Aquaculture?

If you enjoy working with animals, particularly fish, are willing to work outside in any kind of weather, love being around the water, have a love of nature and enjoy trying new things, aquaculture may be the field for you. With the world population destined to double by 2025 A.D., the demand for fish is expected to increase to an estimated 162 million metric tons (178.2 imperial tons) per year, far exceeding the available supply of 85-95 million metric tons (93.5 - 104.5 imperial tons) from the wild fishery. Huge opportunities for the farming, marketing and processing of many varieties of fish are opening up throughout North America.

Where Will It Take Me?

Career paths in aquaculture are still evolving as this relatively new industry grows. Converting from a harvest to a husbandry approach to fish production will demand not only greater technical knowledge but also specialized business skills in accounting, farm business management, marketing, distribution and international policy. At present, opportunities exist for entrepreneurs to take advantage of the growing demand for fish. As the aquaculture industry expands, more career opportunities will open up in the areas of research, teaching, consulting, processing and sales.

Can I Make a Good Living At It?

With steady growth and good record keeping, your farm can grow to provide a solid, sustainable business. It's not a get-rich-quick scheme. Some farms take a few years before species are ready for harvest, but like the family farm of generations ago, aquaculture operations can become a family-run business that grows with them. Other areas besides fish farming can offer many career opportunities. Employment in this industry is, at times, strenuous, and involves both indoor and outdoor work. In Atlantic Canada the work is largely related to trout, salmon, mussels and oysters, although other species are cultured on a smaller scale.

Where Can I Learn More?

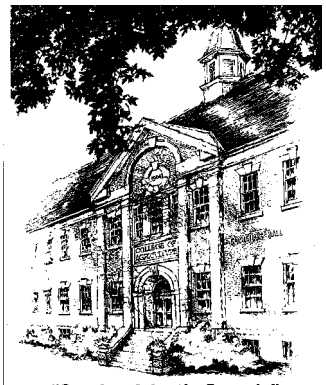
The Nova Scotia Agriculture College

The Nova Scotia Agricultural College offers a comprehensive four year undergraduate program in aquaculture with some examples of career opportunities being an aquaculture farmer, hatchery manager, nutritionist, researcher, instructor or consultant.

Contact the

Office of the Registrar
Nova Scotia Agricultural College
P.O. Box 550
Truro, Nova Scotia, Canada
B2N 5E3

Phone: (902) 893-6722, 893-6723
Fax: (902) 895-5529
Email: reg_info@www.nsac.ns.ca
Website: http://www.nsac.ns.ca


"Serving Atlantic Canada"

The Nova Scotia School of Fisheries

In this one year program, students learn all the basic skills of husbandry of freshwater and marine organisms being farmed commercially or for enhancement programs in eastern Canada. Technical aspects such as water quality analysis, animal nutrition, farm management and disease diagnosis and treatment are emphasized. Designing and maintaining nets and enclosures for marine farms are also covered. In addition, students gain knowledge in managing the day-to-day business records of an aquatic farm.

Graduates may seek employment with private aquaculture operations, government operations and with experimental aquatic farms. You may also become self-employed, owning and operating your own aquaculture operation.

Nova Scotia School of Fisheries
P.O. Box 700
Pictou, Nova Scotia
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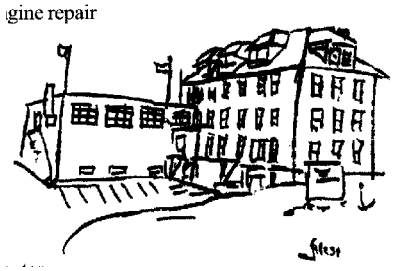
Fax: (902) 485-7065
E-mail: nssf@gov.ns.ca
Website: http://www.nscc.ns.ca



Nova Scotia Aquaculture Species Information

There are three groups of species currently under culture in Nova Scotia - Finfish, Shellfish, and Other.

Finfish

Some of the most common finfish farmed in Nova Scotia are :

Atlantic Salmon

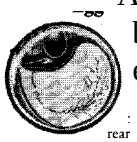
"The leaper" or *Salmo salar* is well known for it's beauty of form and it's spirit. The Atlantic Salmon has an elongate, somewhat laterally compressed body, a large mouth, fairly large scales, and a fleshy adipose fin on the back just in front of the tail fin. An average adult weighs anywhere from 2 - 10 kg (4.4 - 22 lbs), although some grow to much greater sizes.

The average length of the salmon is 50 - 100 cm (20 - 40 inches). From parr (small juvenile) to adult, the Atlantic Salmon changes color several times, ranging from black to silver. The first Atlantic Salmon fish farm opened in Norway in the 1960's. Since it's humble beginnings, Atlantic Salmon aquaculture has expanded to meet the growing world demand now facing the salmon market.

Salmon are anadromous, meaning they spend most of their adult lives in salt water, but must return to fresh water to spawn. Fish farmers have mimicked this natural life cycle when developing the techniques for culture.

Production Life Cycle:

➤ Freshwater



Atlantic Salmon spawn two or three times in their life. Eggs and milt are extracted from the fish by anesthetizing the fish and running the hand down the belly of the fish to squeeze out the eggs and sperm. Freshwater hatcheries collect eggs and milt (sperm) from their broodstock (mature fish) in November and the eggs are fertilized. The are incubated at varying water temperatures.

In late winter or early spring they hatch as sac fry. They begin to feed on special starter diets and are kept in tanks designed for feeding. Once they reach a sufficient size, the salmon are graded for uniformity and size and transferred to rearing tanks in May or June. They are now at the parr stage and feed throughout the summer, until fall, when they are graded again to select potential smolt (or fish that adapt to a saltwater environment). It can take up to a full year for this to happen for Atlantic Salmon.

➤ Saltwater

Smolts are transferred to saltwater pens in the spring when they have reached a weight of about 80 grams (3 oz.). The smolts are then placed in sea cages (net enclosures supported by floating frames made of plastic, steel, aluminum and wood). They are fed a special protein rich diet of fish meal and fish oil until they reach market size, between 4 - 4.5 kg (8 - 10 lbs). This is usually 14 - 18 months later.

➤ Feeding Habits

In the wild, Atlantic Salmon feed on a wide variety of fish and crustaceans. But in the hatchery, their feed is mostly made up of fish meal and fish oil. This is formulated to provide proper nutrition for each stage of development.

➤ Growing Techniques

Atlantic Salmon are reared to smolt size in shore-based fresh water hatcheries and then transferred to floating sea cages. They remain in the cages for about 18 months, until they are ready for market. At this time they weigh between 2 - 5 kg (4.5 - 11 lbs).

➤ Farming Areas

The Atlantic Salmon is farmed mainly in Norway, Chile, Scotland, Canada and the United States. The industry continues to grow in Nova Scotia with potential for the farming of species other than salmon and trout. Since Atlantic Salmon require relatively warm water throughout the winter, only selected areas in Nova Scotia are suitable for year round production. They are grown primarily in the Bras d'Or Lakes, the Annapolis Basin, Shelburne Harbour and parts of St. Margaret's Bay.

Steelhead Salmon

Steelhead Salmon are actually rainbow trout that are raised in saltwater. The Latin name is *Oncorhynchus mykiss*. Steelheads have a long body and their coloring ranges from bluish to yellow-green, brown or black. They are characterized by a silvery sheen. These finfish are natives to the west coast and are a relative of the west coast salmon. In the wild, Rainbow Trout migrate to saltwater from freshwater streams and return to freshwater to spawn when they are mature. Steelheads were first cultured in Nova Scotia in the 1970's, Cape Breton being the first aquaculture site.

Life Cycle:

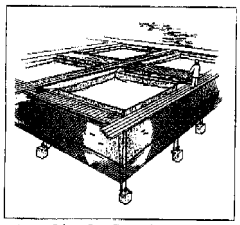
➤ Freshwater

Steelhead start their lives in freshwater and are reared similarly to Rainbow Trout. When steelheads reach 100 grams (3.5 oz.) they are ready to be transferred to saltwater. Some steelheads are grown to 450 grams (16 oz.) before they are moved to saltwater cages. The fish are transferred in May and go through the final grow-out over the summer and fall.

➤ Saltwater

The fish are grown in net-pens in saltwater. They are placed in the pens in spring (April-May) and grow to market size, which takes between six and nine months. Harvesting is between September and December at which time the fish are between 1 - 3 kg (2.2 - 7 lbs).

➤ Feeding Habits


Salmon Farm Float and Netpen

Steelheads are fed a similar diet to the Rainbow Trout. This may be either dry or moist food pellets. These contain 80 per cent fish meal and fish oil with added minerals and vitamins. The diet provides a proper nutritional balance that promotes growth and quality.

➤ Growing Techniques

The saltwater growth takes place in sea cages. These consist of a nylon mesh cage suspended from a floating collar. This can be made from steel, wood, plastic or aluminum. The nets must be periodically changed or cleaned of fouling organisms (seaweeds, mussels) which block the flow of water through the cage.

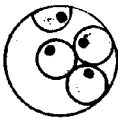
➤ Farming Areas

There is currently a lot of activity related to Steelhead Salmon in Nova Scotia. Farms are located in the Pubnico and Lobster Bay areas and the Bras d'Or Lakes in Cape Breton. The Eastern Shore area of Nova Scotia has clean, cold water that also supports a number of sites. See also Rainbow Trout.

Rainbow Trout

Onorhynchus mykiss is well known for its ability to adapt to different conditions. It is a member of the Salmonidae family and native to the Eastern Pacific where it is found from Alaska to Mexico. It is now in every Canadian province and was first introduced to Nova Scotian waters in 1899. The size of the Rainbow Trout varies, but in Atlantic Canada, the average weight is 0.5 - 1 kg (1 - 2.2 lbs). It has a long, slender body, with an iridescent band running along each side from head to tail. The overall body color can range from bluish to yellow-green, brown or black.

➤ Farming Life Cycle



The cycle begins with harvesting eggs from selectively bred spawners. Once the eggs are fertilized, they are placed in tanks for hatching. After they hatch, they are called sac-fry and remain in the tanks, living off the energy reserves in the yolk sac, which is attached to the belly. After four to six weeks, the fish are fed commercial food. Soon the fry grow and reach the fingerling stage. They are fed a special diet and grow until they are big enough to be harvested. It usually takes the trout between 12 and 18 months to reach market size. The harvest size is generally 284 - 397 grams (10 - 14 oz.), commonly referred to as "pan-sized." Rainbow Trout products are sold fresh whole, as fillets and smoked.

➤ Feeding Habits

In fish farms, Rainbow Trout are fed food pellets. The pellets contain 80 per cent fish meal and fish oil with minerals and vitamins added. Their diet is similar to the salmon diet. This provides proper nutritional balance geared toward growth and product quality.

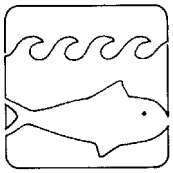
➤ Growing Techniques

First, eggs are placed in incubators where the rate of growth is controlled mainly by water temperature. There are a number of incubator units, including troughs, combi-tanks, stacked tray units, jars and baskets. After hatching, the fry are fed in troughs or small, circular units where they are reared to a 1 - 5 gram (.04 - .2 ounce) size. Next, they are transferred to rearing units. A number of methods are then used for final grow-out. The facilities may include earthen ponds, cages in ponds, rectangular or circular tanks or concrete raceways.

➤ Farming Areas

There are numerous hatcheries and grow-out ponds in Nova Scotia. Hatcheries and grow-out sites must have adequate water supplies to be successful. These operations supply rainbow trout for U-fish or retail markets, as well as seed stock for marine grow-out sites. See also Steelhead Salmon.

What Challenges Does the Producer Face?



Salmon are raised in the same environment as their wild cousins, with only a net keeping them 'inside". Accidents, storms and predators have to be constantly protected against to prevent escape of the farmed fish into the wild and the loss of profits for the company. Good husbandry practices must be constantly maintained to reduce the incidence of disease on the farm. Other challenges are competition from other countries producing the same type of fish. Many countries do not have the same strict regulations that we do here in Canada and they are able to flood the market with their product driving the price down. Also, monitoring the water temperature and the effects of the farm on the surrounding environment is important and another challenge to face.

What Happens After the Fish Leave the Farm?

Fish from farms are available to the consumer in under 24 hours. When the fish leave the farm they are shipped live to processing plants, cleaned, packed in ice and sent to market. Fish are sold whole, in steaks or as fillets, which requires removing the spine and skin. Fish must be refrigerated immediately after harvest. Much of the farmed salmon and trout is sold on the domestic market to restaurants and seafood markets. The rest is sold nationally and internationally.

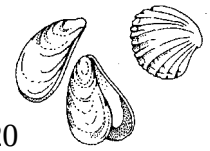
Salmon can be eaten fresh as whole baked fish, grilled as steaks or barbecued fillets or it can be smoked and served as an appetizer. Trout is popular as a pan fried dish. The demand for fish has increased rapidly in the last few years. Fish contains many vitamins and minerals and is an excellent source of protein and Omega-3 fatty acids.

Who's Involved in Producing the FinFish?

- Fish farmer
- Fish Processors
- Wholesalers, brokers, retailers
- Government licensing agencies

What Are Shellfish?

Shellfish are sea animals whose skeletons are on the outside of their bodies. The only shellfish grown commercially are bivalves such as oysters, mussels and scallops, These shellfish have two halves to their shells, connected by a hinge. A shellfish can open its shell to filter water for its food or close up the shell tight for protection. All bivalves feed by filtering water through siphons and collecting plankton in the gills. An oyster can filter 20 - 30L (4.3 - 6.5 gal) of water a day.

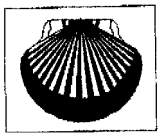


All bivalves spawn at specific water temperatures and the eggs takes five to six hours to hatch into larvae. This larvae is mobile for about two weeks. During this time it will find a place to settle and grow. Shellfish then are allowed to attach themselves to a cultch, then are transferred to growing areas and harvested when they reach the right size.

Shellfish are grown in salt water. When the larvae of bivalves (e.g.,oysters and mussels) firmly attach themselves to some sort of substrate they don't generally move from that location. Scallops are free to move along the bottom of the ocean in the wild. Some of the most common shellfish produced in Nova Scotia are as follows.

Sea Scallops

Sea Scallops are called giant scallops in some areas, where they are known as the King of Scallops. Their Latin name is *Placopecten magellanicus* and they can be found in the eastern North Atlantic from northern Gulf of St. Lawrence and northern Newfoundland to Cape Hatteras, North Carolina. The Sea Scallop is a bivalve, it has two valves or shells. Both are round, almost equal in diameter, and held together by a small, straight hinge and the adductor muscle. The lower valve is white or cream in color and the upper is usually reddish. Inside these shells is the "meat" (the adductor muscle), which is the part of the scallop commonly eaten in North America.



➤ Reproduction

Sea Scallops usually spawn in late summer or early fall. Eggs and sperm are released in what looks like a white or orange cloud in the water. Fertilization of the eggs is external.

➤ Life Cycle

A few hours after fertilization, the embryo develops a small cilia, fine hairs, and starts to swim. Within 48 hours, it develops into a trochophore larva. It feeds on small phytoplankton cells and soon develops a larval shell with a distinct "D" shape. At this stage the scallop is called veliger larvae and it swims, feed and grows. In four to five weeks it reaches the pediveligar stage and is 0.4 mm (1/32 inch) long. It finds a place to settle, anchors itself securely and grows into a mature scallop.

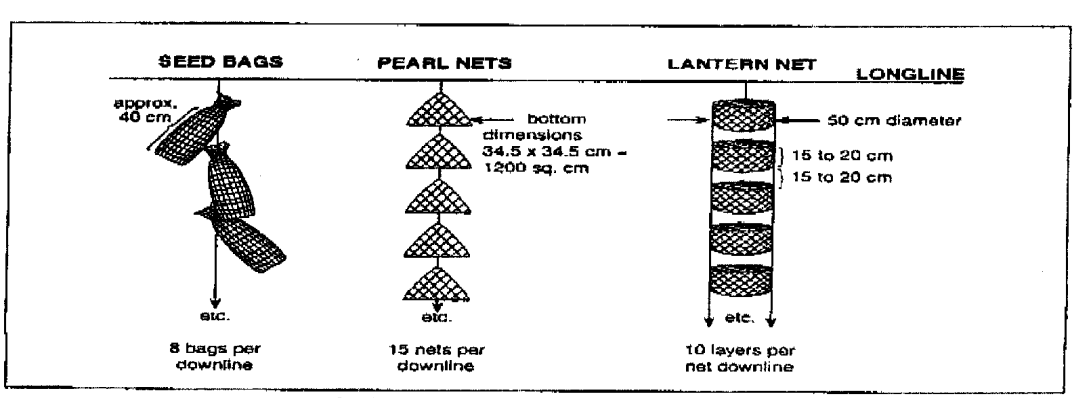
➤ Feeding Habits

In shellfish farms, Sea Scallops feed on phytoplankton and other particles. The food is captured by the gills and transferred to the labial palp (located at the forward end of the gills) where it is sorted for digestion.

➤ Growing Techniques

Sea Scallop farming is a process that goes through certain steps. First spat are collected from the wild or from hatcheries. Scallops are set in tanks on a filamentous material, or cultch. Once they reach about 5 cm (2 inches) in diameter, the cultch is bagged. When the scallops are bigger, they are removed from the cultch and placed in trays or lantern nets which are suspended from rafts for grow-out to harvest in the ocean. The juvenile scallops are then grown in hatcheries and suspended on long lines using fine mesh lantern nets or pearl nets.

The final step is to grow them out in the ocean. A number of methods can be used. One is Chinese lantern nets. Another technique involves passing loops through small holes drilled in the outer edge of the scallop shell and hanging them from the long line. Waterproof adhesives are a third option and growing scallops on the sea floor (bottom culture) is the fourth. Growth varies from site to site, but with suspended culture, scallops usually take 18 months to two years to grow to market size.



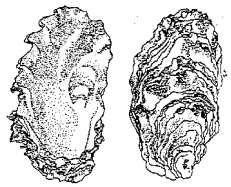
Scallop Farm Diagram — Longline Culture

➤ Farming Areas

The eastern shore of Nova Scotia from the Strait of Canso to Halifax has clean, cold water that currently supports sea scallop culture. The South Shore area from Halifax to Yarmouth is known for its good currents and warm water temperatures, factors that also support sea scallop farming. Additionally, coastal areas of Cape Breton hold promise for farming the sea scallop in the future.

American Oyster

Depending on where it is grown, the American oyster may also be known as an Atlantic or Eastern Oyster. Its Latin name is *Crassostrea virginica* and it is native to the North American coast. A hardy species, this oyster can live in a range of temperatures from -2˚C to 32˚C (28 to 90°F). It has a thick shell with a rough, sculptured appearance and varies in color. Usually it is a mixture of brown, gray, green and white shades. Most American Oysters take between four and seven years to reach market size, and there are records of 100 year old oysters found in the waters of the Bras d'Or Lakes.



➤ Reproduction

American Oysters spawn in summer when the water warms up to above 20˚C (68°F). The oysters release eggs and sperm into the water at intervals over a period of four to six weeks. Fertilization takes place in the open water and cell division begins.

➤ Life Cycle

The fertilized eggs of the oyster first develop into microscopic larva. Within 24 hours, they form a shell and develop organs to help them swim and feed. This consists of a disc covered with vibrating hairs. For the next three weeks, the larva swims and feeds on microscopic plants in the plankton community. Soon the oyster reaches the size of a grain of pepper and it searches for a place to settle. It then attaches itself and remains there to grow into a mature oyster.

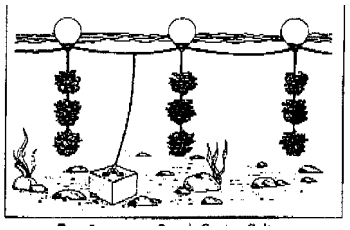
➤ Feeding Habits

American Oysters feed primarily on plankton, microscopic plants and animals in the water. When water conditions are favorable, the oysters feed almost continuously.

➤ Growing Techniques

Off-bottom culture is commonly used in the Maritimes. This technique uses rafts, floating longlines and fences.

Cultch (a substance used to attach spat) is strung like beads on wire or nylon rope. This is then suspended above the bottom to collect the setting larvae. The collected spat are grown in suspension until they reach the desired length. Finally, they are separated from the cultch and either planted on the bottom or placed on trays that are suspended in the water. Held in suspension, the oysters grow quickly and develop plumper meats than those bottom grown.



➤ Farming Areas

The Northumberland Strait shore area of Nova Scotia has traditionally been an excellent place to grow American Oysters and this activity continues today. The Bras d'Or Lakes in Cape Breton have also been a popular place for farming American Oysters for many years.

European Oyster

The European Oyster goes by the Latin name *Ostrea edulis.* It has a great reputation and is served in fine restaurants all over the world. Although native to northern Europe and the Moroccan coast of North Africa since Roman times, the European Oyster was only introduced to Nova Scotia in 1973.

The shell is similar to the American Oyster, but flakier in texture and more evenly rounded with a wavy edge. The European Oyster is pinkish white in color, sometimes with purplish pink margins.

➤ Reproduction

European Oysters are usually ready to spawn when they are two years old. Spawning is seasonally controlled and gonad (reproductive gland) development occurs in late spring. A unique feature of this species is its ability to develop both male and female gonads in the same spawning season. If food remains available and temperature is adequate an oyster may develop eggs after having spawned as a male, or vice versa. When spawning occurs, females retain the eggs within their shells. Males release sperm into the water which is drawn in by the female and fertilization occurs.

➤ Life Cycle

After fertilization the eggs remain in the female's shell for one or two weeks living off food stored in the egg. When they are about 0.18 mm (3/4 inch) in size the female releases the larvae and they begin feeding. They continue to feed and develop until they are approximately 0.32 mm (1/32 inch) in size and ready to set on a suitable surface. The larvae are now called spat and undergo metamorphosis. During metamorphosis they lose some of their larval organs and develop adult organs such as gills. After this change, the juvenile oysters resemble adults and grow according to food availability and temperature.

➤ Feeding Habits

European Oysters are filter feeders. As water passes over their gills, particles in the water (such as phytoplankton) are trapped on the gill surfaces. This is transferred to the labial palps where it is sorted for digestion.

➤ Growing Techniques

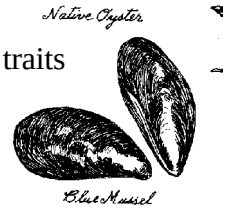
European Oyster culture begins in a hatchery. Fertilization takes place in tanks and plastic discs are provided for the larval oysters to set on. About 12 hours after setting on the discs, the oysters are scraped off. These juvenile oysters are now about 0.32 mm (1/32 inch) in size and they are moved to upweller tanks where they feed on algae. They usually remain here for two or three weeks until they reach 5-15 mm (1/4 - ½ inch).

In June the oysters are placed in seed trays in the ocean. They spend 1-2 months growing in these wooden trays until they are 2-5 cm (.8 - 2 inches) in size. For final grow-out they are placed in lantern nets or mesh bags. It usually takes between 36 and 48 months for oysters to grow from hatchery to market size.

➤ Farming Areas

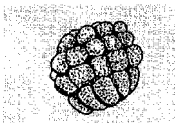
In Nova Scotia, European Oysters are farmed in the area from Halifax to Yarmouth. This is an area known for its good currents and warm water temperatures, conditions that make it suitable for growing this species. Select areas on the eastern shore may also be suitable for European Oyster farming, where environmental conditions are optimum.

Blue Mussels



Coastal dwellers have feasted on *Mytilus edulis,* a member of the Mytilidae family, since before recorded time. Mussels are bivalve shellfish that grow quickly and profusely, two traits that make them ideal for aquaculture. They have two identical, convex shells. These shells are elongate, triangular and joined by a rubbery hinge ligament on the upper side. A commercial sized mussel takes 18-24 months to grow to about 50 mm (2 inches) and at this size can pump 4 litres (1 gallon) of water an hour.

➤ Reproduction



Mussels usually become sexually mature in late spring or early summer. Following some spawning stimulus, most mussels release some or all of their eggs and sperm in what looks like whitish or orange clouds in the water. Fertilization is external and in a very short time all the eggs are fertilized. The fertilized egg divides rapidly into a microscopic mass of cells. The average mollusc produces several million eggs.

➤ Life Cycle

Once fertilized, it only takes five hours for the embryo to develop a small cilia and begin to swim. After 48 hours, it develops into a trochophore larva. It feeds on small phytoplankton cells and begins to develop the larval shell which has a distinct D shape.

The next stage is the veliger larvae. In 3 to 4 weeks, the mussel grows to 1/4 mm in size. The larva develops a foot and gills and is ready to change into a juvenile mussel. It settles on a suitable hard substrate, such as a rock, wharf or boat, extends the foot and withdraws the velum.

Finally, it secretes byssus threads and anchors itself to the surface where it will grow into a mature mussel.

➤ Feeding Habits

Mussels are suspension feeders, they feed by actively filtering particles from the water. Phytoplankton cells are the main source of food and decomposed macrophytes or resuspended detritus may also supplement their diet.

➤ Growing Techniques

In eastern Canada, mussels are usually cultured on long lines. These are typically 182 m (600 foot) ropes, anchored securely at both ends, and supported by floats tied at intervals along their length. Growers generally use concrete or salvaged railroad rails for anchors and lobster trap buoys for floats. Mussel farmers need lots of seed for a satisfactory harvest. Hundreds of plastic mesh or rope collectors are hung on the long lines just before the spat are expected to settle in the early summer.

By fall, most settled spat have grown to about 15 mm (½ inch). They are then stripped off the collectors

and loaded into lengths of mesh tubing called socks. The socks are then taken to the farm and tied at intervals onto another long line where they will grow to market size. This takes 18 months to 3 years, depending on location, water temperature, and the availability of plankton.

➤ Farming Areas

The Eastern Shore of Nova Scotia from the Strait of Canso to Halifax has clean, cold water that supports Blue Mussel farming. The south shore area from Halifax to Yarmouth is characterized by good currents and warm water temperatures, which are also excellent for growing mussels. Coastal areas of Cape Breton also hold promise for mussel farming.

What Challenges Does The Producer Face?

Major constraints to the development of shellfish aquaculture includes the harmful algae outbreaks, environmental concerns, development of new markets, maintaining water quality and finding sites that are not competing with recreation or urban consumers.

What Happens When The Shellfish Leave the Farm?

Shellfish are marketed to restaurants and through seafood outlets. Many of the of the oysters grown in the province are exported others are sold locally in shell and served on the "half shell'. Scallops are mostly exported and sold shelled as only the adductor muscle, the muscle that moves the shell open and closed, is generally eaten. Most of the mussels are sold within the province and distributed in the shell, cooked that way and then shelled when ready to eat.

Who's Involved in Producing Shellfish?

- ➤ Shellfish Farmer
- ➤ Processor
- ➤ Wholesalers, brokers, retailers
- ➤ Equipment manufacturers and suppliers
- ➤ Government licensing agencies

New and Other Species

Researchers have been testing the following species and research indicates that they hold promise and profits for fish farming in Nova Scotia.

- ▸ Arctic Char
- • Sea Urchin
- • Halibut
- • Haddock
- • Cod
- • Tilapia

Aquaculture Terms

Aquaculture: The farming of aquatic plants in fresh or marine waters. It is the aquatic equivalent of agriculture and often called 'fish farming'.

Bedding Size: The size of a mollusc which is normally distributed to bottom areas for further growth.

Bivalve Mollusc: An aquatic invertebrate animal with a shell. Common species grown in Nova Scotia include American oysters, bay scallops, Blue Mussels, European Oysters and giant scallops.

Brood Stock: Adult organisms kept for breeding purposes.

Byssus Threads: Tuft f strong filaments by which e.g., a mussel makes itself fast to a fixed surface.

Cilia: Small hairlike projections extending from certain plants and forming a fringe.

Collector (Cultch): A medium used to collect free swimming mollusc larvae by allowing them to settle and attach themselves.

Detritus: Rock fragments, etc., from disintegration.

Feed Stock: Any form of flora or fauna used as food for aquacultural produce.

Flagella: A long whip like strand or extension that enables organisms to move.

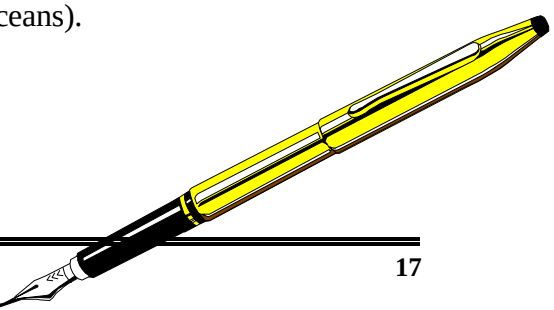
Invertebrate: An organism without a backbone.

Larva: The early form of an animal that is unlike its parent at birth or hatching and gradually changes and adopts adult characteristics.

Macrophytes: Large multi-cellular aquatic plants, e.g., kelp.

Mature Oyster: An oyster which had reached the reproductive age and it large enough for the food market.

Moult: The shedding of an shell (in crustaceans).



Phytoplankton: Photosynthetic or plant constituent of plankton, mainly unicellular algae.

Rope Culture: Growing molluscs on ropes suspended from rafts or anchored float-lines.

Seed Stock: The early life stage of aquatic flora and fauna. It is collected or bought by the farmer to use as the primary source of the aquaculture produce.

Setting: The process by which mollusc larvae settle and attach themselves to a substrate to begin their immobile stages of development.

Sock (Stocking): A type of fish-net tubing sometimes used to contain certain molluscs (articularly mussels) in suspended culture.

Spat: The stage of development when the shellfish attaches itself to a substrate (immediately following the free-swimming larval stage).

Substrate: The base on which an organism lives.

Suspended culture: Refers to techniques for growing molluscs using ropes, poles, socks, or trays suspended from rafts, ropes or floats. Rope and long line culture are commonly used in Nova Scotia.

Veliger Larvae: Larval stage of many shellfish including oysters and mussels in which the larvae develops a "velum" or foot -like structure which is used for both swimming and feeding.

Water quality: The chemical and physical characteristics of water that determine if it is suitable for use. Flow, volume, pH, temperature, hardness, and ionic composition for waters suited to fish farming.

Activity Ideas

1. Visit a shellfish or finfish aquaculture site.

2. Visit the Nova Scotia Agriculture College or the Fisheries School at Pictou Campus of the Nova Scotia Community College.

3. Study the aquatic environment assessing factors that affect the maintenance of the environment. Some topics to include are:

    - Healthy water - what is it, it's quality, how to restore it, basic needs of fish for growth in the wild.
    - Life in the aquatic environment
    - Fresh or salt water environments

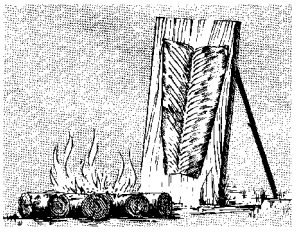
7. Cook planked salmon. Planking is an ancient Indian method of cooking which originally involved grilling a fish on wooden plank propped up beside a bed of hot coals. Today it means baking the fish, surrounded by vegetables, on an 2.5 cm (1 inch) thick plank of kiln-dried oak, ash or maple with a design cut in the surface to catch the juices. During the process, the hot wood imparts a delicious flavour to the fish. Planking is undoubtedly one of the most spectacular ways to present a whole salmon for a special occasion. As a general rule of thumb, allow at least 225 g (½ lb) of fish per person. Thus a 3 kg (6.6 lb) salmon with head and tail left on should serve eight people generously.

    You will need:

    1 salmon, cleaned
    Cooking oil
    Lemon juice
    Soya sauce
    1 onion, sliced
    Freshly ground pepper
    Cherry tomatoes
    Fresh, hot mashed potatoes
    Carrot sticks, parboiled until tender

    Method:

    - Place a cold plank in a cold oven and preheat for 10 minutes.
    - Remove plank and oil it well to protect from charring while continuing to preheat oven to 218 °C (425°F).
    - Mix lemon juice, soya sauce and an equal quantity of oil and brush well on both inside and outside of salmon.
    - Arrange onions slices and freshly ground pepper in cavity of fish and lay it on the centre of the plank.
    - Place fish in the oven and bake for about 10 minutes for every inch of thickness of the fish, basting occasionally with the oil, lemon and soya sauce mixture.
    - When flesh flakes easily, remove fish from the oven, arrange parboiled vegetables, mashed potatoes, and whole cherry tomatoes around it on the plank.
    - Return to oven under hot broiler fro a few minutes until the potatoes start to turn golden brown.
    - Bring the fish and potatoes to the table on the plank and serve.



Project Ideas

1. Make a model of a fish cage.

2. Raise salmon fry in an aquarium with assistance from Nova Scotia Department of Agriculture and Fisheries and the Nova Scotia Salmon Association's *Fish Friends* program. Check out their website at www.novascotiasalmon.ns.ca/projectsandprograms/fishfriends.htm.

3. If possible, 4-H members should visit a provincially run aquaculture facility such as Fraser's Mills Hatchery in Antigonish County or McGowan Lake Hatchery in Queens County. 4-H members should have a list of questions to answer to use to write up a report or do a display. This will help them understand a lot more about how the facility is run and why they have chosen to use certain practices over others.

Example questions:

1. What species are raised and why? What were the factors in choosing that species? (i.e., water type, flow rates, water temperatures).

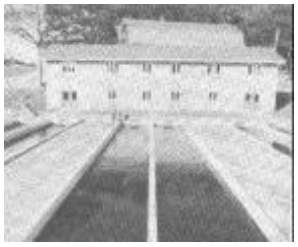
2. What numbers of species are raised? Why that number? i.e. space limitations, water limitations, temperature limitations (e.g,. in a pond summer temperatures severely limit oxygen availability of the water thereby limiting the number of animals it can support)

3. What water systems are used? Ground water or surface water? What are the extreme winter and summer temperatures? Is the water heated or filtered at any time and for what reason? Do they use pumps or is the water gravity fed through the system? Is oxygen added to the water? How ? Is any of the water re-used? Are any gases (nitrogen or carbon dioxide) removed from the water? How?

4. How do they maintain fish health? Do they add anything to the water to keep parasites low - e.g., a low amount of salt? What are their most common parasites or disease problems? What are the symptoms? How do they treat them?

5. What is the production cycle in their facility: (e.g., in a finfish operation it may be - Import eggs - sac-fry - feeding fry - fingerlings - smolts - shipped to saltwater cages for grow out - harves). What size are the species at the major stages (i.e., smolt, saltwater transfer, harvest)? When do they sell or ship them - at what time of the year? How do they ship them? If they are transported to saltwater how do they ship them live?

   Produce a rough diagram of the facility. Include all key areas: (i.e., hatchery, fry tanks, grow-out tanks etc.)



Do A Display -

6. Fish health plays a large role in the profitability of an aquaculture operation. Choose a disease or fish health problem and create a display to inform the public on it.

   Do a display using the following ideas (or use your own ideas): How is the disease transmitted, stages of diseases, symptoms of the disease, how it is treated, limitations of the disease/ parasite (e.g., sea lice are only found in salt water). Things that could prompt a disease outbreak (stress)- (i.e., temperature fluctuations, overcrowding, low oxygen levels, over/underfeeding etc.). Common diseases: ISA, Vibrio, etc. Internet research, talking to a veterinarian or contacting the Nova Scotia Department of Agriculture and Fisheries - Aquaculture Division at (902) 424-3735 would be helpful here.

7. Do a display illustrating different methods of rearing shellfish - i.e., Compare two methods for rearing mussels or compare a common method of raising mussels to a common method of raising oysters etc. What are the advantages/ disadvantages of each (space required, stocking densities, site layout showing anchoring system for longline culture, cages, lanterns, etc.,

8. Do a display on a specific species and how it is commonly raised. Include the water depth, salinity, seasonal temperature range, production lifecycle, predators, (e.g., European Green Cab, Starfish, Rock Crab, etc, fouling organisms, and harvesting methods). Include drawings or pictures.

9. Do a display on the different methods of cooking and storing fish. Include recipes, pictures of dishes made, food safety tips and a sample food item.

Beginning Trout Farmer

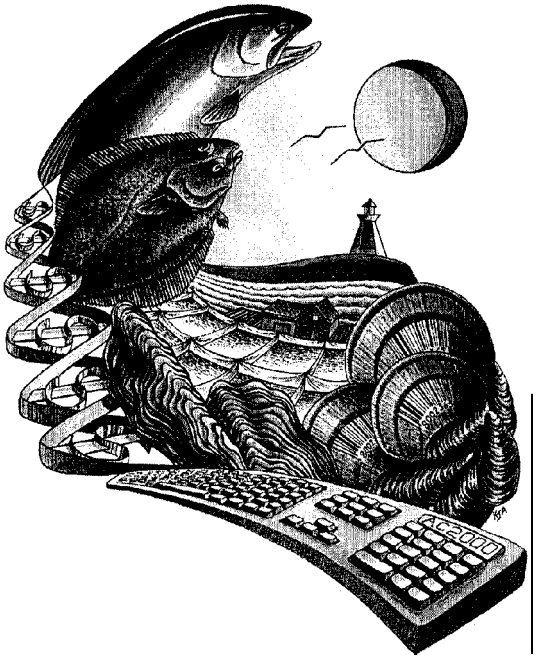
10. 4-H Members can rear quality fingerlings (5 to 10 g/ 2.5 cm + in size) to early market size (40 - 60 g/ 15 + cm). The number of fingerlings will be limited to the size of the pond, tank or horse trough with the minimum size being one cubic meter with a maximum amount of fingerlings in 90 in three cubic meters. The member will learn basic fish feeding, husbandry, basic physiology, handling, and water quality. Exhibit either fish or photos of your experience at Achievement Day.

Where To Go For More Information

Nova Scotia Department of Agriculture and Fisheries

4-H & Rural Organizations Section	
Phone: (902) 893 - 6585	Fax #: (902) 893-2757
DeWolfe House 157 College Road, Truro, Nova Scotia B2N 2P2	P.O. Box 550 Truro, Nova Scotia B2N 5E3
Aquaculture Division	
Phone: (902) 424-3735	Fax #: (902) 424-1766
Bank of Montreal Building 5151 George Street, 7th Floor Halifax, Nova Scotia B3J 3C4	P.O. Box 2223 Halifax, Nova Scotia B3J 3C4
Fisheries and Aquaculture Services Branch	
Phone: (902) 424-4560	Fax #: (902) 424-1766
Bank of Montreal Building 5151 George Street, 6th Floor Halifax, Nova Scotia B3J 3C4	P.O. Box 2223 Halifax, Nova Scotia B3J 3C4
Inland Fisheries Division	
Phone: (902) 485-5056	Fax #: (902) 485-4014
91 Beeches Rd, Pictou, Nova Scotia B0K 1H0	P.O. Box 700 Pictou, Nova Scotia B0K 1H0
Marine Fisheries Division	
Phone: (902) 424-4560	Fax #: (902) 424-1766
Bank of Montreal Building 5151 George Street, 6th Floor Halifax, Nova Scotia B3J 3C4	P.O. Box 2223 Halifax, Nova Scotia B3J 3C4

Nova Scotia Agricultural College	
Phone: (902) 893-6600	
P.O. Box 550, Truro, Nova Scotia B2N 5E3	For NSAC department information see: http://www.nsac.ns.ca/contacts/
Nova Scotia School of Fisheries	
Phone: (902) 485-8031	Fax: (902) 485-7065
P.O. Box 700 Pictou, Nova Scotia B0K 1H0	http://www.nscc.ns.ca



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