THE NEWFOUNDLAND AND LABRADOR COD TRAP FISHERY: THE BASIS FOR A FUTURE COD GROW OUT INDUSTRY

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ABSTRACT

Atlantic cod (Gadus morhua) has been the economic foundation for the settlement and maintenance of communities along the coastline of Newfoundland and Labrador. Although there has been some economic diversification throughout the past century, today the vast majority of coastal communities continue to be dependent on the fishery for their continued existence. Cod will play a major role in their future survival.

Historically, the fishery with the greatest impact on coastal communities was the inshore cod trap fishery. This has proved to be the most efficient method of taking large quantities of cod in a short period of time. The cod trap season is a relatively short one, based on the annual feeding migration of cod to inshore waters. This feeding migration coincides with the spawning of capelin (Mallotus villosus).

Cod trap catches have a spatial and temporal variability in landings. In the NAFO area 2J3KL (Northern Cod), trap landings have fluctuated between 15,000 to 50,000 metric tonnes (Harris, 1990). While the cod trap was used throughout Newfoundland and Labrador, the majority of the catch occurred in 2J3KL.

In general the cod trap fishery has failed to generate the economic returns that it is capable of producing. If rural Newfoundland and Labrador is to survive, then the fishery and in particular the inshore cod fishery must continue to play an integral role. Even as the cod fishery rebounds around the province, limited Total Allowable Catches (TAC's) will not ensure sufficient returns for everyone involved. Low quotas will mean that fishers will be forced to do more with less and the emphasis will shift away from volume and towards maximizing the value.

A unique concept for increasing revenues from the Newfoundland and Labrador cod trap fishery is the idea of cod grow out. Fishers have the opportunity to double the weight of their fish in a three to four month period by holding them in cages and feeding male capelin and other baitfish such as herring and squid. Flesh yields and overall fish quality can be improved so that the fish can achieve a higher market value. As well, these same fish that would normally be sold in June - August when market conditions are less than favorable, can now be sold in November - January when higher returns are experienced in markets. From a processor's point of view, cod grow out is a potential solution to many of the processing and marketing problems associated with the purchase of trap cod. It also allows for a controlled supply of cod which can lead to stability and higher prices in the marketplace.

From the perspective of fisheries resource managers, the concept of cod "grow out" cannot be overlooked since it maximizes the value from a limited resource. There are also significant economic benefits to both harvesters and processors. The idea of a partnership between the two should not be ruled out. Cod growout has the potential to be an industry of its own that may compare or even surpass the economic returns generated from the wild cod fishery. It is not unrealistic to forecast a cod growers association that will have

the potential to produce somewhere in the vicinity of 20,000 MT of farm raised cod within the next five years. In terms of additional revenue generated into the economy of the Province, potential economic benefits are significant. 20,000 MT of farm raised cod sold for $1 a pound on average will yield $44 million as compared to $5.1 million for the starting stock at an average of $0 33 a pound. Government has to promote this industry so that experienced fishers can become fish farmers. For this to happen, fishers have to be able to access a relatively cheap starting stock with a cheap source of feed.

Research has indicated that the grow out of cod is biologically possible if the logistics of collection near cage sites, and food supply can be achieved. More research is also needed into the processing and marketing of this fish product to address factors such as the rigor mortis process, and gaping of the fillets. High growth rates obtainable in net cage culture in combination with better quality and higher market prices from the period of late November to March suggests that an economically feasible cod grow out operation is possible and foreseeable. As the commercial cod fishery of the province reopens, it is obvious that an opportunity exists to increase the value of the inshore cod trap fishery.

A study conducted in 1997 showed that such a concept is biologically viable. Growth rates and market reaction to the products produced were more than favorable. If the success of the 1997 pilot project can be duplicated in the future on a larger scale, then the foundation will be laid for what promises to be a viable commercial undertaking.

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Chapter 1: Introduction

Atlantic cod (Gadus morhua) has been the economic foundation for the growth of a settled community along coastline Newfoundland and Labrador. Although there has been some economic diversification throughout the past century, it is true even today that a vast majority of the Newfoundland coastal communities that were built upon a foundation of cod are still largely dependent upon that resource for their continued existence. This has become abruptly apparent with the continuation of the moratorium in 2J3KL in the absence of a compensation program.

If rural Newfoundland is to have any economic basis for survival, then the fishery, and in particular, the cod fishery must play an integral role. The consequences of this dependency have been very dramatic in the last few years of moratoria on Northern cod and since the limited reopening of stocks at low Total Allowable Catch (TAC) levels will not provide enough resource to economically support the industry. Fishers will be forced to do more with less of the resource and must shift from a volume driven fishery to a fishery which maximizes the value from the catch.

For years the cod trap has dominated as the most popular harvesting method for Atlantic cod. A problem which has been associated with this harvesting technique is that it catches a high amount of small fish during a relatively short season. This has historically generated lower returns per pound to the fish harvester in comparison to other harvesting

methods. Most of this raw material ends up as frozen block, due in part because of the small size of the fish, and the nature of this fishery (ie. high landings in a short time frame, summer weather conditions, deteriorating flesh texture, etc.). The end result is that both fish harvester and fish processor do not receive the full potential economic benefits from this resource.

The challenge for fisheries resource managers is to overcome these harvesting and processing problems, and ensure the maximum economic returns from the limited resource. The majority of fishers in Newfoundland and Labrador fish the inshore area in vessels less than 35 feet, and many of these use cod traps (particularly in NAFO area 2J3KL - see Figure 1.1). As the fishery of this province rebuilds, attention has to be paid to the cod trap fishery to ensure the past problems are overcome.

A unique way to address some of the problems of the inshore cod trap fishery, is to develop a cod grow out industry. Small fish caught in the summer months can be held in cages for a two to three month period, whereby they can double their weight, and be harvested as a top quality product when market conditions are more favorable. The benefits of cod grow out address many of the fundamental problems associated with the cod trap fishery, and can be a means to maximize the value of this resource.

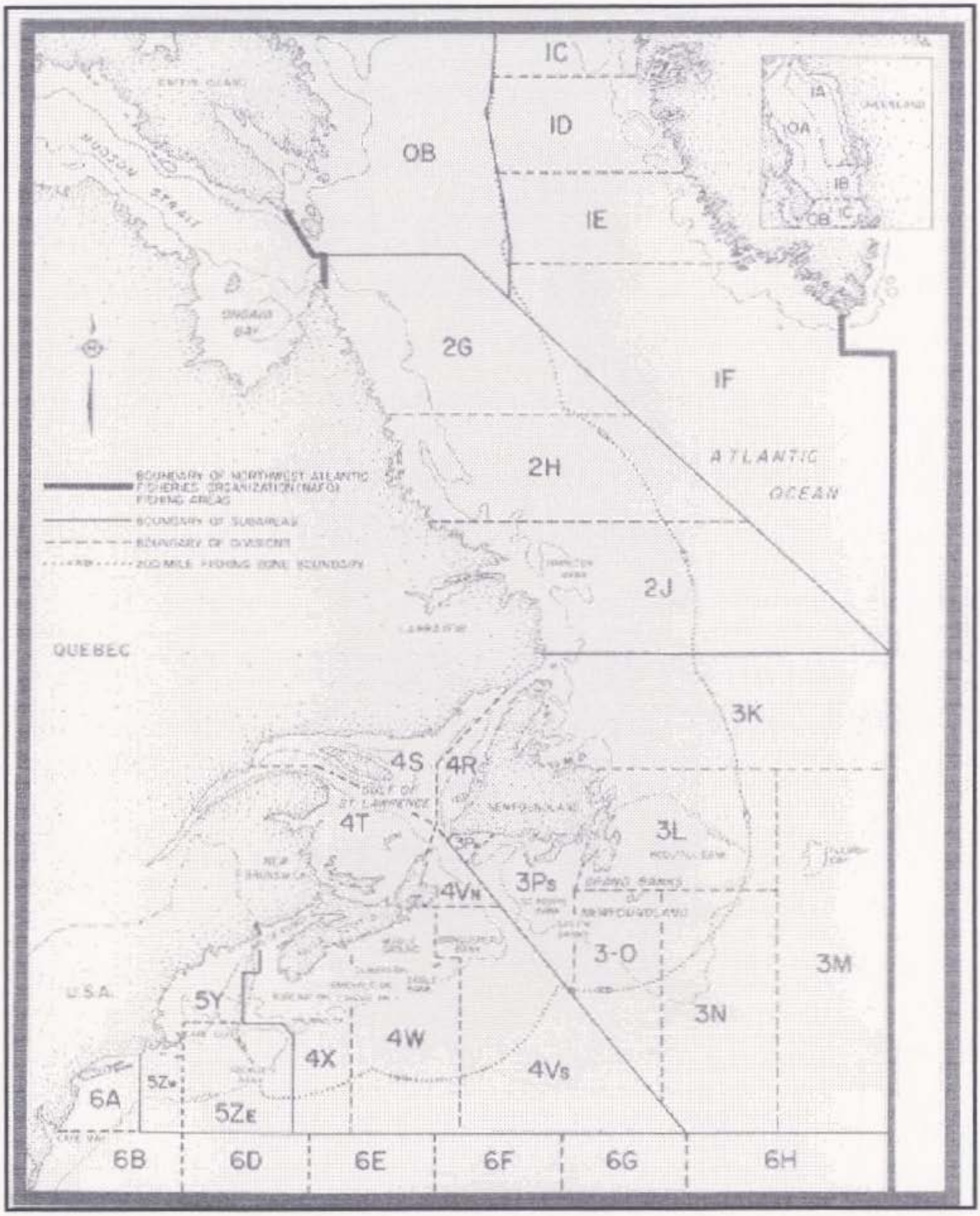


Figure 1.1: Northwest Atlantic Fisheries Organization Area Map.

1.1 Purpose and Scope of the Study

The purpose of this study is to examine the concept of cod grow out as a means to increase the economic value of the cod trap fishery of Newfoundland and Labrador. The study will address past problems with the cod trap fishery such as gluts, quality, low prices, and seasonality. Furthermore, it will examine cod grow out from a biological, economic, and technological perspective.

Cod grow out will be presented as a potential solution to these problems. In this regard, the paper will examine the history of cod grow out in Newfoundland and Labrador and its developmental limitations over the past few years. While keeping the biological aspects of the species in mind, this study will focus on the economic, and technological aspects of such a venture. This will include a review of cod grow out operations in 1997. Future considerations of cod grow out will be discussed further in the context of a reopened cod fishery with limited quotas, as well as business structure.

1.2 Justification for Research

The fishery of Newfoundland and Labrador is in a process of restructuring. While the development of shellfish fisheries in the offshore area has thrived in recent years, the inshore (less than 35 feet) sector has virtually been waiting for Northern Cod stocks to recover. The cod trap fishery is the major source of income for most inshore fishers in the

less than 35 feet vessel class. It is critical that the past problems of high volume and low value be addressed before the cod fishery reopens.

> "One of the major recurring problems associated with the province's inshore fishery relates to the inability of inshore cod trap fishers to dispose of all landings during the peak of the cod trap fishery".

This was a statement taken from a study done in 1977 titled, "Seasonal Inshore Cod Trap Fishery Glut" by the Department of Fisheries and Oceans, St. John's, Newfoundland. During the 1980's the solution to the glut was to increase processing capacity. Now the processing sector is downsizing. As recent as 1997, cod fish was dumped in NAFO area 3Ps because the short fishing season permitted the harvesting capacity to over whelm the processing capacity of the area. Should this be allowed to continue and what can be done to prevent it?

Cod grow out is one possible way to ensure a top quality product that guarantees the maximum economic return. It is fair to assume that the inshore fishery of this province will never be the same again. High volume landings will likely be replaced by low TAC's and consequently small individual boat quotas. Fishers will be forced to maximize their returns from a limited amount of resource. It is possible to place the catch in a cage, double its overall weight in a three month period by feeding the fish with natural prey, and then sell these fish for double their initial price?

1.3 Approach

This study will review all existing literature as it relates to cod grow out. In particular it will review those studies which have focused on this concept for Newfoundland and Labrador. Other sources of literature relating to the cod trap fishery of this province will be examined as well. These will be used to illustrate the history of cod trap landings, and the problems associated with such a fishery. The information for this report was gathered from a series of library searches, both at Memorial University and the Department of Fisheries and Oceans, as well as contacts made with key industry personnel.

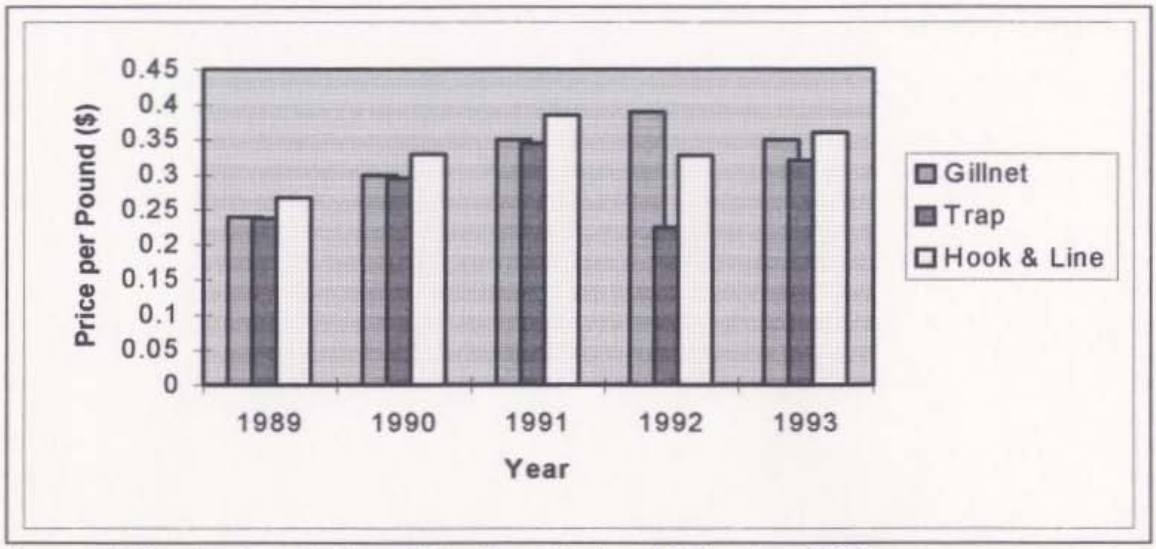
Chapter 2: Background

The cod trap was developed in the late 1860s by Captain William H. Whitely, a Newfoundland fishing captain operating off the coast of Labrador (Department of Fisheries and Oceans, 1983a). The traps are set in places where the cod are known to migrate to shore in large numbers year after year, and where water depth and bottom conditions are suitable for mooring. This stationary, untended trap was devised as an alternative to the traditional cod seine, which had to be continuously fished by a crew of men. Probably the greatest attraction of the cod trap is the enormous amount of fish that can be taken in such a short time (Department of Fisheries and Oceans, 1983a).

The cod trap season is relatively short compared to the fishing season in general. It usually starts with a slow period of quite small catches in May or early June, peaking rapidly in June or July, and tapers off just as rapidly to another low catch period in August. The trap season occurs in early June during the annual inshore migration of cod which is linked to a similar inshore migration of smelt-like pelagic fish called capelin (Mallotus villosus). The history of cod trap catches is one of variability (Chen, 1993). The nature of the cod trap itself is one of the reasons for these fluctuations in catch. It is a stationary gear set in a specific location and must wait for the fish to come to it. While the trap is used throughout Newfoundland and Labrador, the majority of the catch has historically occurred in NAFO area 2J3KL (Northern Cod) where past landings range from 15,000 to 50,000 metric tonnes (Harris, 1990). One of the major problems that has faced the cod

trap fishery in the past four decades is the fact that these traps catch mostly small fish (DFO, 1983b).

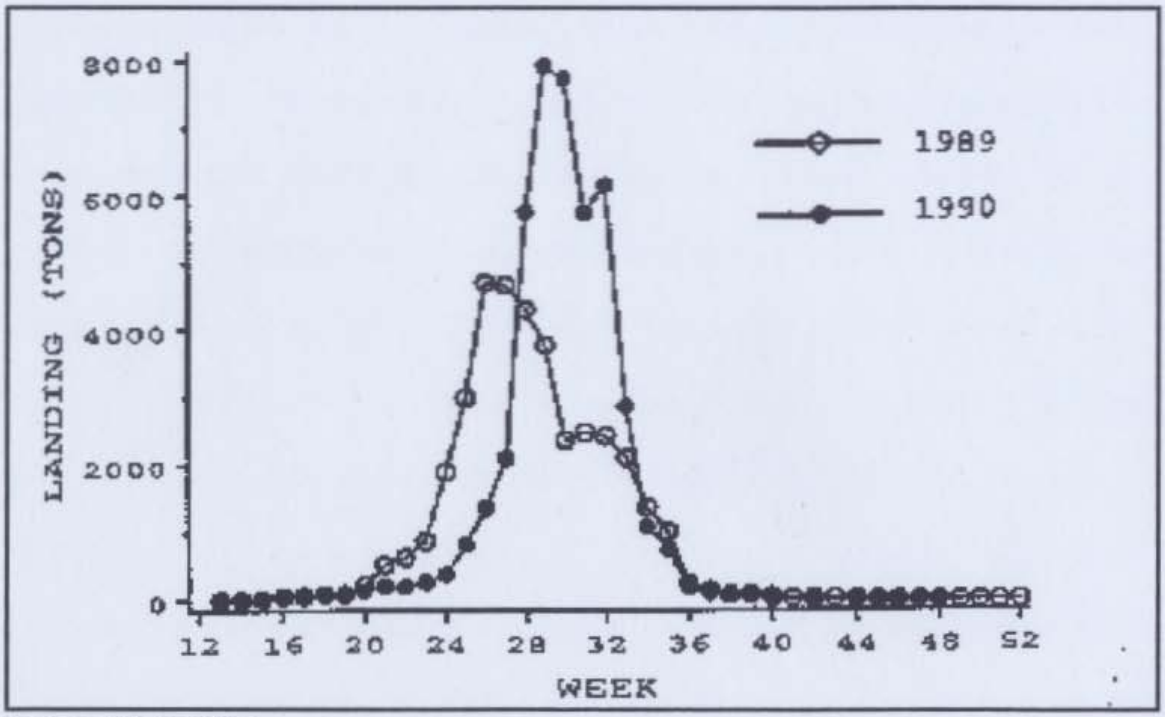
Compounding the small size problem, trap cod are usually filled with capelin which leads to rapid deterioration in the quality of the flesh. Inferior size and quality mean that trap cod are usually processed into frozen block form which traditionally receives a much lower price in the market place when compared to fresh/frozen fillets. This was reflected in the price paid to fishers for their fish (see Figure 2.1). As well, small fish are most prevalent during the trap season when most plants are "glutted". Fish texture already softened by the warmer temperatures of shoal water and summer weather may be further softened by extended holding times at the plant. During times of high landings, fishers often dumped fish which they couldn't sell because landings exceed processing capacity. Likewise, processors, in an effort to handle as much of the catch as possible, have oftentimes been forced to process all of the trap catch into block product (DFO, 1983b).



Source: Fisheries Association of Newfoundland and Labrador, 1998.

Figure 2.1: Prices Paid For Head-On Gutted Cod Per Harvesting Method (1989-93).

The inshore cod trap fishery of Newfoundland and Labrador has been associated with a spatial and temporal variability in landings (see Figure 2.2). It is not unusual that some areas report very good harvests while other areas have a bad year (Chen, 1993). The current resource crisis and moratorium on fishing has led to a great deal of uncertainty with respect to future fisheries. While all industry players have to accept the fact that drastic action was required in the area of resource management, they also believe that new initiatives are necessary for the long term economic survival of the industry. One such initiative is the idea of cod grow out in Newfoundland using the four to five year old wild fish from the cod trap as the basis for a new aquaculture industry.



Source: Chen, 1993.

Figure 2.2: Trap Landings By Week in 1989 and 1990.

Due to the biological limitations on the cod resource, the fishery of the future will no longer be volume driven and fishers will likely be held to low quotas as the cod fishery reopens around the province. These same fishers will be forced to do more with less fish in order to increase their economic returns. The ability of the inshore sector to employ large numbers of people accomplishes government's employment objectives from a social and economic perspective (Blackwood, 1996), and therefore cod grow out should be a means to maximize the value of the resource. The benefits of cod grow out also address many of the fundamental harvesting, processing, and marketing problems experienced in the industry today.

History suggests that the cod trap fishery of Newfoundland and Labrador which has landed 32,000 MT on average in the 1980s has had severe problems (Harris, 1990). Fishers traditionally catch high volumes of small fish which not only yield very poor quality, but also combine with unfavorable market conditions during this given time. These factors will generally dictate a very low price - New England market price for fresh fillets in June 1997 was $2.95 US a pound (Seafood Price-Current, 1997) compared to a price of $4.30 US a pound in January 1998 (Seafood Price-Current, 1998).

Given the past problems associated with large quantities of low valued trap cod generally available in Newfoundland and Labrador in June, July, and August, it is obvious that an opportunity exists to increase the value of this fishery. The high growth rates obtainable in net cage culture in combination with better quality and higher market prices from the period of late November to March suggests that an economically feasible cod grow out operation is possible (Vardy, 1986).

2.1 History of Cod Farming in Newfoundland and Labrador

Cod farming was pioneered in Newfoundland by Seaforest Plantation Limited in 1985 (Vardy, 1986). The basic concept for this business involves harvesting low value trap cod in summer and transferring the fish to sea cages for grow out. This approach offers several benefits over the traditional wild fishery. First of all, the fish weight can be doubled in a three month period as compared to three years of feeding in the wild

(Kearley, 1994). Second of all, because the fish are being held in an enclosure, their diets can be controlled. This can improve flesh yields and maximize overall fish quality to achieve a higher market value. The objective was (is) to sell the fish for better prices when there is a shortage in the New England markets (Department of Fisheries and Aquaculture, 1998b).

This concept for increasing revenues from the Newfoundland and Labrador cod trap fishery was tested by Seaforest Plantation Limited in 1986-87. Live Atlantic cod ranging in length from 30 cm to 60 cm were collected from cod traps operated by commercial fishers. These fish were purchased at the trap site and transferred to tanks on collector boats and transported to sea cages for maintenance and grow out. This research concluded that given the varying nature of the inshore cod trap fishery, cod grow out offered the possibility of considerably augmenting the earning potential of the fishery while in no way interfering with its traditional conduct (Fisher, 1988).

Sea Forest Plantation Ltd. was founded on an idea of Mr. Cabot Martin. In the early 1980s, he noticed an increase in catches of unsaleable small cod fish. He knew that male capelin caught commercially were discarded and wondered what would happen if you fed these waste capelin to the undersized cod (Kearley, 1994). His idea worked, but it did not become commercial because of the moratorium announced in July 1992. Despite this, in 1993, 153 people graduated from 12 cod farming courses held across Newfoundland. To date, over 200 people have received such training (Kearley, 1994). The course, offered

jointly by Sea Forest Plantation and the Aquaculture Unit of the Marine Institute, was for six weeks in duration and gave participants the skills needed to farm cod. Training emphasized "hands-on" experience. A sea cage site was set up wherever courses were offered (Kearley, 1994).

In 1986 Sea Forest Plantation Limited was developed as a capital intense, vertically integrated corporation which collected juvenile cod from the trap fishery, grew them, and ultimately marketed its own product. The weakness of this approach became apparent when the fishery failed at the sites where the farms were located. These failures were the result of a rapid decline in the inshore fishery after the late 1980s. This forced Sea Forest Plantation to revise its corporate plan in 1990 to reflect the benefits gained through an association of farms. This new plan minimized fishery failure impacts by having a large number of low cost production units spread throughout the major cod fishing regions of Newfoundland. A large number of small farms would produce sufficient product volume to enable access to high value markets (Moir, 1994).

A 1992 moratorium on Northern Cod prevented Sea Forest Plantation from further development along that model. The company did however see the moratorium as an opportunity to spread the cod farming concept and, at the same time, train fishers in an occupation which complemented their fishing income. In October 1992, under the Northern Cod Adjustment and Recovery Program (NCARP), the company planned the establishment of 20 sites with 20 students each as a training ground for cod farming. It

was intended to develop these training sites as commercial entities in 1994 once the moratorium was over and fishers were back fishing. The equipment provided in the program was to be used as capital assets for the fishers/partners during the commercialization phase. However, revised forecasts on the status of the Northern Cod stock and the rapidly worsened condition of all other stocks in Newfoundland waters caused a moratorium in all areas in which Sea Forest Plantation operated (Moir, 1994). Faced with a lack of fish from the wild fishery, Sea Forest Plantation invested a considerable amount of time and money in the development of a cod hatchery (Moir, 1994). The plans for cod grow out operations were postponed until the summer of 1997.

The reopening of the cod fishery in NAFO areas 4RS, 3Pn, and 3Ps in 1997 meant that cod would potentially be available for cod farming. Through the cooperation of the Fishermen Food and Allied Workers Union (FFAW), the Newfoundland Aquaculture Industry Association (NAIA), the Canadian Department of Fisheries and Oceans (DFO), and the Newfoundland and Labrador Department of Fisheries and Aquaculture (DFA) eight sites were selected (see Figure 2.3) to establish small scale cod farms using a total of 67,000 pounds of cod. Despite the failure of some sites, this starting stock produced a total of 93,447 pounds of harvested cod in late fall (DFA, 1998b). The growth rates and market response to the fish produced from these efforts in the 1997 project, confirmed that cod grow out could be profitable on a small scale, low technology level. These results in combination with the reopening of other commercial cod fisheries of the province should enhance a cod grow out industry of the future.

- cod farm site in 1997

Figure 2.3: Selected Cod Farm Sites for 1997 (DFA, 1998).

2.2 Developmental Limitations

Initially, fishers did not recognize the incentive for farming cod when one could catch high volumes anyway. When Sea Forest Plantation Ltd. revised its corporate plan in 1990, the idea was to have a large number of low cost production units spread throughout the major cod fishing regions of Newfoundland that would produce sufficient product volume so that the company could gain access to high value markets. All product would be channeled through Sea Forest Plantation to be processed and marketed. Fishers didn't favor this idea of being controlled by a company and as a result, the interest in cod farming was not generated as anticipated, in fact there was resistance to the idea. There was also

some skepticism by fishers regarding whether or not this could actually work. While the imposition of a cod moratorium in 1992 convinced many fishers to take a second look at cod farming, the continued closure eliminated all access to trap cod and prevented any development in the 1992 to 1997 period.

Chapter 3 : Biological Aspects of the Species

The Atlantic cod is characterized by its adaptability to different environmental and feeding conditions. It is this characteristic of flexibility which makes the cod such a particularly interesting and challenging research animal. Cod are found in both the North West and North East Atlantic and form populations or stocks. Until recently, one of the largest cod stocks in the world occurred off the Northeast coast of Newfoundland and Labrador - the Northern Cod stock. This stock inhabits NAFO statistical divisions 2J, 3K, and 3L, and range into divisions 2GH, and 3NO (Harris, 1990).

In fish farming, it is important to understand which environmental conditions the farm animal requires for survival, and growth in captivity. Even though environmental conditions close to the tolerance level are not fatal, they can be below optimum, which in turn can limit growth. The environmental conditions where one can expect good growth are therefore much more desirable than the tolerance level (Norway's Ocean Research Institute, 1985). The following parameters are examined to evaluate the potential suitability/limitations of cod grow out in the near shore waters of Newfoundland and Labrador.

3.1 Optimum Conditions for Grow Out

Along the coast of Newfoundland and Labrador the average temperature varies significantly, and there can be relatively large local temperature variations. Cod develop

plasma glycoproteins when in danger of freezing. With unusually low temperatures or when the cod are exposed to temperature shock, mortality can occur (NORI, 1985). Cod prefer a temperature range from 9-17 ^{0} C (Bohle, 1974). This also corresponds with the temperature where stomach evacuation rate, feed intake, oxygen consumption after feed intake, and probably other physiological processes are maximized. Maximum feed intake occurs at higher temperatures for small cod (30-45 cm) than for larger (70-80 cm) cod, with maximum intake for small cod at 16 ^{0} C and for large cod at 14 ^{0} C (NORI, 1985). Cod held in cages in the upper water column in the July to November period should experience good to optimum conditions in Newfoundland.

The body plasma in cod has a salinity of 10 ppt, which is much lower than the salinity of sea water. Cod will constantly lose water from the body through osmosis. To compensate for this water loss and to maintain the low salinity in the body fluid the fish must drink sea water. The salt from this water is eliminated through the gills and in the excrements. This elimination of salt is energy consuming (Lagher et al., 1977). Adult Atlantic cod can tolerate a salinity of 2-3 ppt at temperatures of 5-6 ^{0} C, but become visibly disturbed at salinity levels less than 4-5 ppt (Yin and Blaxter, 1987). Temperature seems to affect salinity tolerance, since in low salinity water cod become stressed and may experience mortality. Water with a relatively high temperature and low salinity seems therefore to be physiologically damaging for cod, but systematic investigations on the

effects of different salinity - temperature combinations on growth are not well known (Brett, 1979). Salinity will play a major role in site selection for grow out.

In fish farms with high densities of fish, the oxygen content can become a limiting environmental factor. The oxygen consumption is dependent on various factors including the water temperature, fish size, activity level, and whether the fish is digesting food or is stressed (Brett, 1979). The cod's oxygen consumption at rest (little swimming activity) and without food in its stomach is called the resting consumption (Brett, 1979). When the fish is fed to satiation, oxygen consumption rises rapidly. It takes several days after the meal before the oxygen consumption is down to the resting level again. With regular feeding, the cod's oxygen consumption is held at a high level. If the level of oxygen concentration in the water is below saturation, the cod fish will compensate by increasing the amount of water it pumps over its gills. This may affect the fish's appetite and overall growth. Therefore, in order to maximize growth, the oxygen level should be as close to saturation as possible (Brett, 1979).

The cod's swim bladder is formed at the larval stage as an outgrowth of the front part of the digestive tract (Ellertsen et al., 1981). This bladder functions as a buoyancy regulation organ, but also contributes to hearing by detecting the hydrostatic pressure differences and the sound waves (Hawkins and Rasmussen, 1978). When the cod's living depth increases so will the pressure. This will cause the swim bladder volume to shrink and force the cod to release gas into the swim bladder to maintain neutral buoyancy. With a shallower living

depth the surrounding pressure decreases and gas must be taken from the swim bladder to come into equilibrium. If the living depth and surrounding pressure reduces rapidly, the swim bladder can burst and the gas from this bladder will flow out of the vent. A ruptured swim bladder will usually heal (NORI, 1985).

In the sea, low frequency sound transmission is better than high frequency sound. For example, the cod's hearing is best at low frequencies. Both the inner ear, swim bladder, and lateral line system function as hearing senses (Tavolga et al., 1981). Cod can perceive the direction of the sound source if this source is close enough to the fish, and it can distinquish different frequencies (Schuif, 1975). Boat motors make low frequency sound and can easily scare cod. Still, cod seem to become easily accustomed to sound if it is exposed to it often (NORI, 1985).

Sight sense is well developed in cod and has several functions. First of all, it is used for locating and identifying prey as well as enemies. The lens in the cod's eye is round and moves backwards and forwards when the fish adjusts its sight to "near sight" or "far sight". When light conditions change, cod must adjust their sight to the new conditions. The maximum distance a cod is able to see an object at will depend on the turbidity of the water. In the spring plankton bloom, this may only be a few metres (Anthony, 1981).

During swimming cod use the muscle mass on both sides of the vertebral column. The white muscle comprise most of the muscle mass along the body. This muscle consists of muscle segments (myomeres) with connective tissue in between the segments. The dark muscle which has a high blood flow, lays just below the skin and is used for swimming at low speed. The white muscle is used for greater swimming speeds over short distances (NORI, 1985). Cod cannot swim faster than 2-3 body lengths per second for long periods (Soofiani and Priede, 1985). Large cod have a slower swimming speed expressed in body lengths per second than smaller cod (Wardle, 1977). The swimming pattern for cod during great speed is characterized by periods with fast swimming for a few seconds followed by a rest. After rapid swimming which causes an increased oxygen consumption, lactic acid accumulates in the white muscle creating an "oxygen debt" which can continue for more than a day (Soofiani and Priede, 1985). This causes stress on the fish and has a negative impact on growth. Future studies on texture of caged fish with high growth rates is necessary to ensure the quality of the flesh is optimized.

In nature, the cod's skin colour varies according to the environmental background. The colour of the skin is caused by pigment cells (chromatophores) which can contract and expand to change the cod's colour according to its surroundings. Cod detect the colours of the environment through sight, and then change the colour of their skin. Individuals in a population can have a body form which differs from cod in another location. While it is not known which factors determine body form, it could be genetic differences between populations or environmental factors when the cod are young (NORI, 1985). Site

selection should consider this factor since colour may affect potential markets for fresh head on gutted product.

Cod seem to feed more effectively in groups than alone. During the feeding and spawning migrations, schools can be observed to disperse when it gets dark. Cod can be taught to visit a feeding location by sound signals when feed is supplied (Midling et al., 1987). This type of learning is called conditional learning and is an important part of the cod's adjustment to the environmental conditions. Cod seem to have an excellent ability to adapt to changing environmental conditions, and learning seems to be an important part of this adaptation ability.

3.2 Migration Patterns

The principal fishing gear used to collect the starting stock in cod farming is the cod trap. This gear is essential because it acts as a holding pen for the cod until they can be moved to the cod farm (Fisher, 1988). Cod traps are set in places where the cod are known to migrate to shore in large numbers year after year, and where water depth and bottom conditions are suitable for mooring. The cod trap season is a short one and occurs during the annual inshore cod migration. This migration is tied to a similar inshore migration of capelin which usually begins in early June.

3.3 Adaptation to Farming

Wild caught cod can adapt rapidly to cage nets and learn quickly to take feed from the surface (Kvenseth, 1985). It takes about a month following capture until most of the fish are eating "dead feed" (Jobling, 1983). Several observations have indicated that cod are reluctant to go to the surface for food during sunlight hours, and that cod stay higher in the cage in the late afternoon and evening than during the day. Their appetite seems to be better in the afternoon, and poor appetite is recorded during sunlight (NORI, 1985). Cod react to unusual surroundings or unusual stimili by increasing oxygen consumption, even though there is no visible stress reaction by the fish (Sundnes, 1980). One should therefore disturb the fish as little as possible.

3.4 Feeding and Growth Rates

The cod's food varies greatly with age, environment, and season. Prey size increases with fish size which in turn decreases the competition between the different size groups. Cod are generally seen as opportunistic feeders, and eat what is available at the time. Immediately after capture, fish will be kept "off their feed". This period could last anywhere from five days to three weeks depending on holding conditions after capture, transportation of stock, initial holding in grow out pens, etc.. After being taken from the traps to the holding pens, fish have post-capture stress and require a period of adjustment to their new surroundings. Also, cod in July are glutted with capelin and need a period of time to evacuate their digestive tract (Lee, 1988).

Food conversion and growth are dependent on many factors such as temperature, stress, feed composition, size of fish, etc.. The general rule of thumb followed in feeding fish is to feed at a rate of 6% of the stock weight every second day to achieve a predicted weight gain of 1% per day (DFA, 1998b). If we look at the latest records of cod grow out achieved in 1997 (see Table 3.1), the growth rate recorded indicate that cod can double their weight over a period of just three months when fed a diet of capelin and squid (Warren, 1998). There is a huge requirement for feed as each pound of growth requires in excess of 3 pounds of whole feed fish such as capelin, herring, etc.. Assuming a food conversion ratio (FCR) of 3:1, a farm starting with 50,000 pounds and producing 100,000 pounds of fish would need in excess of 150,000 pounds of feed (DFA, 1998b).

Table 3.1: Growth Rates per Site for 1997 Trap Cod Grow Out Project.

Fisher	Location	Growth Period (Days)	Growth in % (Weight Gain)
Wilfred Hedderson	Noddy Bay	63	48
Melvin Reid	Neddies Harbour	77	88
David Dicks	Little Harbour	112	NA
Donald Pomeroy	Great Paradise	130	NA
Wesley Williams	New Harbour	112	128
Wilfred Williams	New Harbour	112	117
Lindo Pitcher	Hearts Content	98	38
Derrik Barrett	Old Perlican	112	NA

Source: Department of Fisheries and Aquaculture, 1998b.

Even in feeding, it is important to reduce stress as much as possible since stress leads to increased susceptibility to diseases and increased mortalities. Thus, stress has immediate economic implications. Therefore it is important that the effects be recognized in the

rearing environment (ie. feeding schedules and amounts, food additives, and a minimization of handling stress) (Jobling, 1988).

3.5 Mortality

A mortality rate of approximately 1% is expected during the transporting phase from cod traps to holding pens (Curtis, 1991). In many cases the mortality rate is caused by the change in environment, in particular the water temperature, and gas saturation.

If the fish are held in a location close to their point of capture, there should be less of a problem of adjustment to the new environment. During the 3 to 4 months of captivity, a mortality rate of 1% per month is forecasted (Curtis, 1991). These mortalities should be removed from the cages on a regular basis to prevent the release of infective bacteria into the pens.

3.6 Diseases and Parasites

The crowded conditions arising from high densities in fish farming facilities make it important to have a good knowledge of methods of preventing and treating bacterial, viral, and fungal diseases (Dutil, 1993). It is important that anyone planning to rear fish should have a good knowledge of the most common diseases.

There are two conditions to be particularly aware of - vibriosis caused by the bacteria Vibrio sp. and Trichodina. Vibriosis mainly occurs in late fall in large cod. Symptoms portray blood extravasation (haemorrhagic areas) around the eyes, mouth and forehead, but seldom on the belly itself. Characteristic signs of sick fish are greyish, swollen dorsal and pectoral fins, together with increased mortality and reduced appetite. Affected fish will start to founder at the surface of the water. Larger fish sometimes lose their eyes as a result of vibriosis attacks. Trichodina is a one - celled parasite which attacks the skin and mucous membranes. Affected fish display abnormally low appetite (NORI, 1985).

Parasites are undesirable in cod farms for two reasons. First, they can sometimes cause death, either directly or indirectly, by making the fish more vulnerable to disease. Second, parasites can reduce the market value of the fish by making it unappealing to consumers, and costing a lot to remove. As is often the case for organisms in the natural environment, cod play host to a variety of parasites. The best known parasites of cod are nematodes (cod worms) of the family Aisakidae (Dutil, 1993).

Chapter 4: Economic Aspects

As mentioned earlier, one of the major problems that has faced the cod trap fishery for the past four decades is the fact that these traps catch mostly small fish (DFO, 1983b). The catching, handling, processing, and marketing of small fish are more difficult than for large fish. The economic impacts of small sized fish catches are:

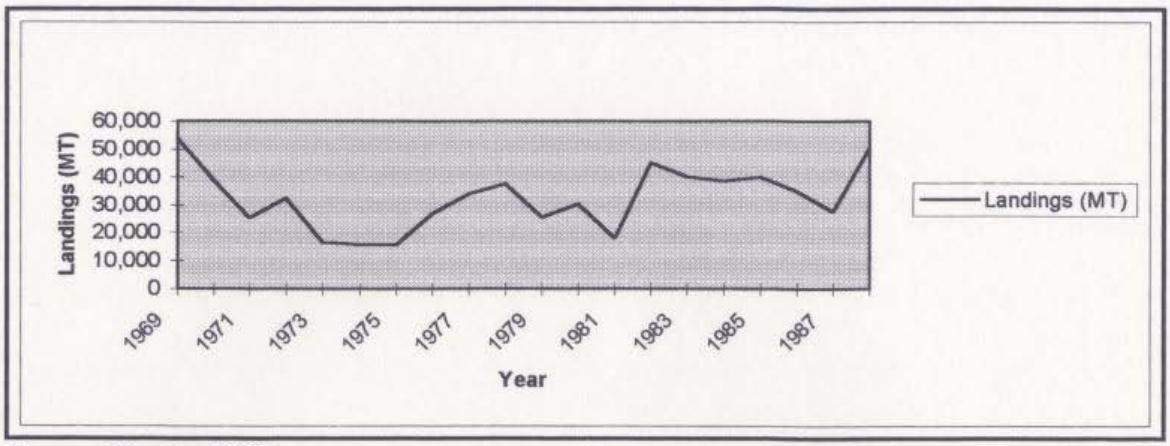
- the fisher gets a lower price for his catch
- the processor pays less for his raw material, and gets a lower price for his marketed product
- the processor has higher production costs because of lower plant productivity
- plant workers will in the long run earn less income because of lower plant productivity
- fishers have to spend more time culling, bleeding, and gutting the fish when the catch is of small size.

In addition to the size problem, trap cod are usually "glutted" with capelin which leads to rapid deterioration in the quality of the flesh. Fish texture, already softened by the warmer summer temperatures of shoal water, may be further softened by extended holding times at the plant. During times of high landings fishers often dump fish which they can't sell because the plants are running at capacity. Processors in an effort to handle as much of the catch as possible, have often been forced to process all of the trap catch into block product (DFO, 1983b).

The cod trap season is a short one, usually starting with a slow period of quite small catches in May or early June, peaking rapidly in June or July, and tapering off just as rapidly to another low catch period in August. From a harvesting point of view, cod grow out not only allows for a doubling of your catch, but it allows for an extension of your fishing season or operations with a higher rate of return. Prices are much higher for cod in the late fall/early winter than in mid summer. As well depending on the scale of the operation it may provide some additional employment in the given area. From a processors viewpoint, cod grow out is the answer to many of their processing and marketing woes addressed earlier. It allows them to schedule production and meet market demands on cue. Overall, the economic returns from the cod resource by utilizing cod grow out are much greater than the traditional cod trap fishery.

4.1 Newfoundland and Labrador Cod Trap Landings

The history of cod trap landings is one of ups and downs. Catches in one year may be excellent with fishermen getting more fish than they can handle, while in other years there may be a complete reversal. While the cod trap is used throughout Newfoundland and Labrador, the majority of the catch occurs in NAFO area 2J3KL (Northern Cod) where recent landings range from 15,000 to 50,000 MT (see Figure 4.1).



Source: Harris, 1990.

Figure 4.1: Cod Trap Landings for NAFO Area 2J3KL.

The cod trap fishery has played and may continue to play a very important role in the economy of Newfoundland and Labrador. This fishery has been associated with a spatial and temporal variability in landings (Chen, 1993). This method of fishing is the most efficient method of taking large quantities of cod fish and if properly managed it can play an even greater role in the inshore fishery of this province. It is therefore imperative that full economic advantage be taken of the quantities of cod fish that annually migrate to the inshore area (DFO, 1977).

4.2 Product Form

Due to government restrictions, the two main forms of cod export from this province are fillets and block. Since most of the fish landed in cod traps are small and of poor texture, a majority of this fish ends up being processed into cod block. Traditionally cod block has been worth a lot less that fillets in the market so the result is that the processors receive less for their product and in turn, the fishers receive less for their catch. The end result is that the potential economic return is not fully received for this resource. By placing these same fish into cages and feeding them for a 3 month period, the same resource would provide much greater return to the economy. Let us look at a simplified example.

- fisher harvests 10,000 pounds of cod which can be sold in 1997 for $0.45 a pound

  = $ 4,500

- fisher places this same 10,000 pounds of cod into a cage and feeds it for 3 months

- end result; @ 20,000 pounds of cod (assuming 0 mortality) which was sold in 1997 for an average of $1 a pound

  = $ 20,000

- a difference of **$15,500** and while a fair sum of this will go for feed and other costs, the fisher/farmer will still see a good return

- consider that there is an additional **$15,500** generated from this same resource that goes into the economy of the Province

In the 1997 experiment, the only two product forms marketed were fresh fillets and head-on gutted. These are the forms that generated the most return in the given market and this is likely to be the case in the future. However, there may be other potential high priced markets for this fish - the salt fish market of Greece and Italy (Parsons, Personal Communication, 1998). This could be worth exploring in the future as the amount of farmed cod increases.

One major concern with fresh fillet product produced from the farmed cod is that it experienced a great deal of gaping. A fillet is said to gape when the individual myomeres of muscle come apart, giving the fillet a broken and ragged appearance. This happens when the material that binds the myomeres together, known as connective tissue, breaks down. There appears to be several causes of gaping, one of which is the rigor process (Stroud, 1968).

Rigor (rigor mortis) means the stiffening of the muscles of an animal shortly after death. Immediately after death the muscles of an animal are soft and limp (pre-rigor condition).

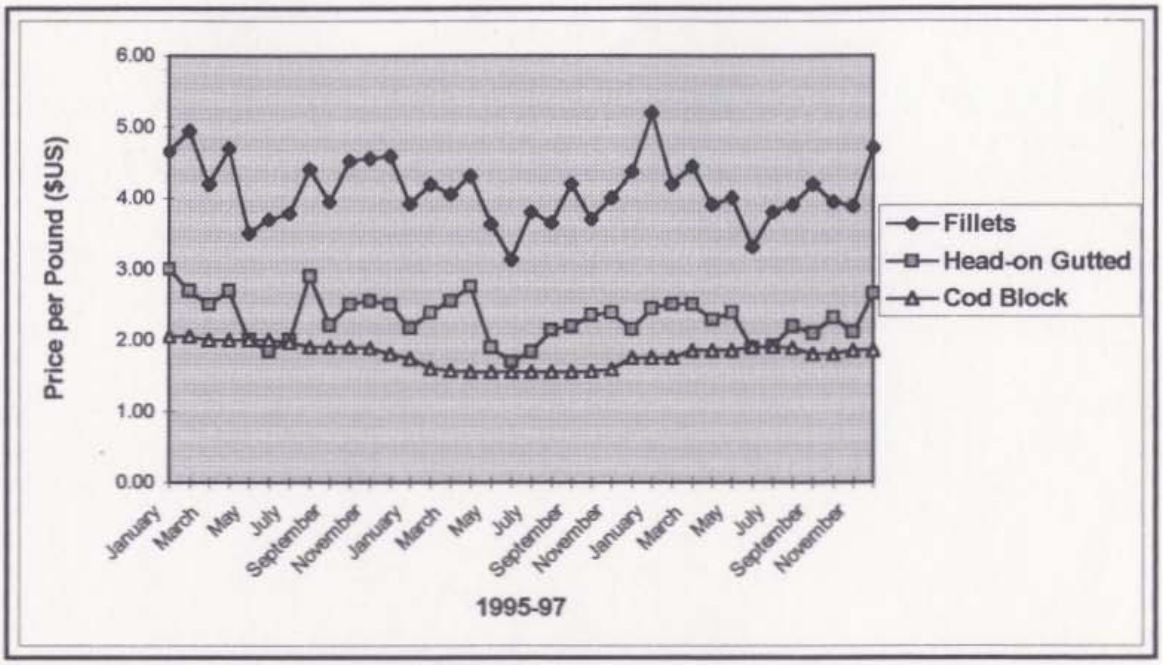
Eventually the muscles begin to stiffen and harden, and the animal is then said to be in rigor. After some hours or days the muscles gradually begin to soften and become limp again. The animal has now passed through rigor, and the muscle is in the post-rigor condition (Stroud, 1968).

Rigor results from a series of complicated chemical changes in the muscle of a fish after death. The process is not fully understood, but it is known that factors like the physical condition of the fish at death, and the temperature at which it is kept after death can markedly affect the time a fish takes to go into, and pass through rigor. The higher the temperature when it goes into rigor, the greater is the rigor tension and the weaker the connective tissue becomes. Thus the higher the temperature, the more the flesh will gape. However, strangely enough, if the temperature is lowered so much that the fish starts to freeze while it goes into rigor, the connective tissue is again weakened, and gaping occurs (Stroud, 1968). This is a very complicated process that requires more research.

4.3 Markets/Prices

The 1997 study focused its marketing efforts on the Northeastern United States because of the attractive exchange rate and the positive history of marketing cod products in this area. This has been and will likely continue to be a lucrative market for Newfoundland

cod products (farmed or wild). Historically, fresh fillets receive a much higher price than cod block in this market. Fresh fillets is on the upper part of the pricing scale, while cod block is on the lower end. Head-on gutted cod usually ranges somewhere in between (see Figure 4.2).



Source: Seafood Price-Current, 1995-97.

Figure 4.2: Average Monthly Prices Of Cod Products in the New England Area for a Three Year Consecutive Period; 1995-97.

The above figure also shows another important concept that should not be overlooked. The price paid for cod products is generally much higher in the November to March time frame than for the other times of the year. The cod trap fishery of Newfoundland coincides with a weak market for cod. This seasonal fluctuation in market price can be

addressed by holding and growing the fish until the optimal market conditions in the November to March period.

4.4 Government Regulations

Ordinarily, cod fish cannot leave this province in head-on gutted or head-off gutted forms. These fish have to be processed to a further state before being exported, and the processing must be done by a licensed processor. In 1997, a temporary exemption for the export of cod in head-on gutted and head-off gutted forms was obtained for the period of November 26, 1997 to December 19, 1997 from the Minister of Fisheries and Aquaculture (DFA, 1998b).

The Lieutenant - Governor in Council may make regulations which relate to the regional distribution of processing licenses, the development of the fishing industry of the province, and other matters that are not directly related to fish quality (DFA, 1997). The minister may issue licenses under this act subject to the conditions that the minister considers to be appropriate.

For the cod grow out farmers of this province, as the Act is at present, no cod can leave this province in a whole state. However, this is not to say that such an event will never occur. The Minister has the descresion to make an exemption provided it is justified. He has an obligation to see that the resource in question yields the best economic returns to the fishers, the processing industry, and the citizens of Newfoundland and Labrador. If this can be provided by exporting whole dressed cod, or the quality of the final market product can be improved by shipping out a whole product, then it is likely to occur. A reasonable assumption in this case would be that not all farmed cod will have to be filleted to be exported, nor will it all be exported whole. There should be a balance somewhere in the middle. This is a very important issue that should be addressed in the future if this industry is to grow and prosper.

Chapter 5: Analysis of 1997 Trap Cod Grow Out Project

As already discussed, the basic concept for cod farming involves harvesting low value trap cod in summer and transferring the fish to sea cages for grow out and sale in late fall. Although this concept was successfully pioneered nearly thirteen years ago, it has never been commercialized. One of the biggest limiting factors for development was the Northern Cod moratorium in 1992. This virtually removed the supply of small trap cod for potential grow out. The closure of other areas of the Province in 1994 resulted in fishers not being able to access any fish. Even with pressure from the industry, researchers, and the Province to allow fish to be captured, grown out, and then released into the wild, the Federal Government would not allow such a venture. Such an initiative could have not only helped the overall stocks, but it would have provided valuable research into the entire grow out process and formed the basis of a future cod grow out industry.

In 1997, the reopening of the cod fishery in several NAFO areas meant that fish were available for cod farming. The FFAW in conjunction with a number of fishers who already had licensed aquaculture sites recognized the need for fishers to add value to reduced quotas of cod, through farming. This resulted in a proposal being submitted to the Aquaculture Component of the Economic Renewal Agreement to establish a number of fisher operated cod farms around the island to test and demonstrate technical feasibility

and profitability. In addition, given that cod farming using fish from cod traps is only a seasonal endeavor (June to December), it was important to see if expensive farm cages and equipment such as wellboats were essential to the overall operation.

The main objective of this cod grow out project was to assess the economic viability of such a venture. Was it profitable to undertake cod farming on a small scale, low technology level? The growth potential of wild cod over a particular time frame in aquaculture operations where the fish can be fed to satiation had to be measured, even though this was done by earlier researchers. Quality of farmed cod products, as well as its acceptability, pricing, and market interest was a key concern. It was also important to raise any key issues for future consideration.

5.1 Resource

In total, 70,383 pounds of cod was distributed to eight small scale cod farms. With the exception of those fishers in Trinity Bay where commercial fishing remained closed, participants were responsible for acquiring the cod required to stock their farms. Two of the ten fishers were unable to secure fish for their farms, and consequently farming operations did not materialize. The operator in Burgeo was faced with the problem that cod trap fishing was not traditionally conducted in his area. Although an attempt was

made to take live fish from hook and line gear, he could only gather 50 pounds of cod to stock his cage. The other fisher was from St. Lawrence and he was unsuccessful in his trap fishing (DFA, 1998b).

Fishers in Placentia Bay and on the West Coast conducted typical trap fishing procedures to obtain their starting stock (see Table 5.1 for starting stock of all sites). Fish for Trinity Bay farms was purchased from fishers in Southern Harbour, Placentia Bay. An agreement was reached with four licensed fishers to purchase their fish at a price of $0.55 per pound. The high price paid in 1997 to those four fishers was due to the fact that a low quota (10,000 tonnes) meant a short season. Combined with this was the fact that these fishers were uncertain about the extra work and time to successfully deliver live fish. As a result, farmers were in a weak bargaining position (DFA, 1998b).

Table 5.1: Farm Sites and Production in 1997.

Fisher	Location	Starting Round Weight (lbs.)	Final Round Weight (lbs.)
Wilfred Hedderson	Noddy Bay	10,397	15,389
Melvin Reid	Neddies Harbour	6,986	13,153
David Dicks	Little Harbour	4,000	990*
Donald Pomeroy	Great Paradise	9,000	250*
Wesley Williams	New Harbour	10,000	22,800
Wilfred Williams	New Harbour	10,000	21,700
Lindo Pitcher	Hearts Content	10,000	13,819*
Derrik Barrett	Old Perlican	10,000	5,346*
Total		**70,383**	**93,447**

* denotes that there were fish lost during the grow out period

Source: Department of Fisheries and Aquaculture, 1998b.

5.2 Harvesting Operations

Fish grown in Trinity Bay had to be transported from Placentia Bay by a specially equipped tanker truck. All other fish was moved using towing cages. Harvesting of the cod intended for the cod farms was a fairly simple procedure. Preferably the headline of the holding pen is sewn to the headline on the back of the trap where the fish are to be "dried up". As the fish are gathered, sufficient weight is attached to the headlines to

submerge the side of the pen and the trap to a depth where the fish can swim from the trap into the pen. Another method, though less efficient, is to sew a cod bag (a panel of netting with the edges sewn together to form a long bag commonly used to hold excess catches taken in cod traps) onto the head, or cut and dry the fish out into it. The bag is then towed to the holding pen located in a position to access cod from a number of traps.

The concept for this project was to do it as cost effective as possible. This meant only buying necessary equipment where possible. Following is a list and brief description of some of the equipment used for this project.

Holding Pens

- Nets (12m x 10m x 5m, knotless 45mm square mesh) were purchased from Seaforest Plantation Ltd. and modified.
- Modifications involved adding floats to the headline and mooring these at the farm site.
- The use of these pens voids the requirements for a wellboat.

Grow out Pens

- Construct and install roof on holding pen.

- 50m circumference double collar HDPE plastic (poly pipe) aquaculture cage with 5m deep net.

Towing Cages (two types)

- Sea Forest 3m x 4m single collar HDPE plastic.
- Cod Bag (Noddy Bag) rigged with rigid cable or wire hoops intermittently along the length.

The cod harvested (46,000 pounds) in Placentia Bay for the four farms in Trinity Bay were towed from the fishing ground in the 50m plastic cage and moored at Southern Harbour for a period sufficient to allow for the digestion of stomach contents. This was to prevent the fouling of transport water as a result of regurgitated matter. At this point the fish were weighed and loaded into a tanker truck equipped with oxygen support. Four loads of 10,000 pounds each were delivered to each of the farms in Trinity Bay. The transport of cod either by towing in sea cages or truck did not pose any serious concerns other than the cost which varied depending on volumes to be trucked and the distances involved. In this case, truck transport added an additional $0.10 a pound to the cost of the starting stock (DFA, 1998b).

After the fish were transferred to the grow out pens, fishers followed up with feed and monitoring. Food conversion and growth are dependent on a number of factors such as temperature, stress, feed composition, size of fish, etc. (see Table 5.2 for total feed used and food conversion ratios for each site in 1997). The general rule of thumb followed in feeding the fish was to feed at a rate of 6% of the stock weight every second day (DFA, 1998b).

Table 5.2: Total Feed Used and Food Conversion Ratios for 1997.

Fisher	Location	Feed Amount (lbs.)	Food Conversion Ratio
Wilfred Hedderson	Noddy Bay	19,945	4:1
Melvin Reid	Neddies Harbour	23,736	3.8:1
David Dicks	Little Harbour	8,000	NA
Donald Pomeroy	Great Paradise	11,517	NA
Wesley Williams	New Harbour	47,305	3.7:1
Wilfred Williams	New Harbour	47,331	4:1
Lindo Pitcher	Hearts Content	33,980	NA
Derrik Barrett	Old Perlican	22,578	NA

Source: Department of Fisheries and Aquaculture, 1998b.

As can be expected, there is a huge requirement for feed as each pound of growth requires in excess of three pounds of whole feed such as capelin, herring, and squid. As a result, a

farm producing 100,000 pounds of fish would need approximately 150,000 to 200,000 pounds of feed. Most of the feed used in these grow out trials was frozen and partially thawed. Those fishers who didn't have enough feed in 1997 had the option of buying it for $0.23 a pound. Given that this can add a tremendous expense to one's operation, fishers are encouraged to supplement their feed requirements through wild harvests of bait fish such as herring and capelin, but only as long as the particular seasons are open and quotas are available.

A key to this operation is the ability to control production and implement the handling requirements necessary to produce a top quality product on a consistent basis. As the production from the project farms would be somewhat new to the industry, critical assessment of the product could be anticipated. Therefore it was decided at the outset that handling of the fish would strictly adhere to recommended handling requirements for cod.

5.3 Processing Operations

In early November of 1997, Newfoundland processors were invited to submit proposals for the purchase/processing of the farmed cod from this project. The final result of this process was that Woodman's Sea Products would process the cod produced on the east

coast for a fee for service basis. Seafreeze Ltd. would do the same with the west coast product, but they also marketed the fresh fillets on a commission basis.

Raw material available from the East Coast (Placentia and Trinity Bays) was processed at Woodman's Sea Products, New Harbour. Processing costs for head-on gutted was $0.35 per pound and $0.90 per pound for fresh fillets. These processing costs included transportation to the plant, ice, labour, and packaging (except gel packs and absorbent sheets). The processing cost for fresh fillet produced by Seafreeze Ltd. was $0.80 per pound. This included transportation to the market, ice, labour, and packaging (DFA, 1998b). See Appendix 1 for 'Processing Procedures' and 'Product Quality'.

5.4 Marketing Activities

At a meeting involving all participants, it was decided that the fish would be sold to various markets to test product acceptability and pricing. It was decided that given the amount available for market, and the attractive exchange rate and market contacts, it would be appropriate to concentrate in the North Eastern United States as opposed to mainland Canada. It was also agreed that 80% of available farmed cod would be test marketed in this region of the United States, while the balance would be sold locally by the fishers/farmers. The product destined for the United States would be split approximately

50/50 between fresh fillets and fresh head-on gutted. A temporary exemption for the export of cod in an unprocessed state was obtained for the period November 26, 1997 to December 19, 1997 from the Minister of Fisheries and Aquaculture (DFA, 1998b).

Sample shipments were sent to two different buyers in the United States, so that feedback on the product could be obtained. Initial reaction was very favourable and both buyers indicated a willingness to work with Newfoundland producers to market cod in the New England area. The next step was to proceed with commercial shipments. Given the positive results of the samples, the two companies (Bristol Seafoods and North Coast Seafoods) were approached with respect to purchasing quantities of head-on gutted and fillets. It was agreed that because of the amount of product available and the desire not to create competition between these companies, future shipments would be sent to Bristol Seafoods only.

Later discussion with Bristol Seafoods indicated that they are willing to work with Newfoundland producers to market farm raised cod. Their preference is for head-on gutted product which they could process to their customer's specifications or sell round to their customers for processing at their own facilities. The quality of head-on gutted cod was excellent during and after processing. Colour and texture were excellent as well. Seafreeze Ltd. marketed fresh fillets to their established customer base in the United

States. Two of the companies who bought the product, Stavis Seafoods and Slade Gorton of Boston, were contacted. They reported that the quality of the fish was good and they would have no problems repeating orders. The average prices received for head-on gutted and fillets were $1.60 and $3.18 (Canadian) (DFA, 1998b).

Another marketing concept which was considered was the auction system. A sample of 1,800 pounds of head-on gutted cod was trucked to Portland for sale on the Portland Fish Exchange. The sale occurred just after the United States Thanksgiving Holiday at a time when United States boats were unable to fish because of poor weather. The amount of product available for sale at the auction was limited and as a result, this cod was purchased by North Coast Seafoods to satisfy an immediate market requirement at a price higher than the average price of $1.12 US per pound. The return on a second shipment was significantly lower because market conditions had changed. The price received was significantly lower than the average of $1.12 US a pound. This provided a good example of the fluctuations in the auction market and the need to be willing to gamble on the market to obtain a favorable price for one's product (DFA, 1998b).

5.5 Summary

The main objective of the 1997 cod grow out project was to assess its economic viability. The results were very positive. In the absence of government assistance, cod grow out can be economically viable provided certain considerations are not over looked. For example, a cursory look at 1997 data suggests that a reduction in price paid for live cod must be achieved if cod farming is to be profitable. No doubt as commercial cod fisheries reopen around the Province, this cost will diminish.

The 1997 efforts in cod grow out proved that it could be profitable on a small scale, low technology level. Growth potential surpassed expectations in some cases. The overall quality of the farmed cod products was good and market feedback was encouraging. There were some questions raised about certain operational and policy issues that required further study and additional research before cod grow out can be brought to a commercial level in Newfoundland.

Many in the fishing industry have viewed aquaculture as competition rather than as an opportunity. Indeed, cod grow out should be perceived as an opportunity - a way to enhance what is already there. However, it is important that fishers can demonstrate the biological and economic issues of cod farming. Initiatives such as the one in 1997 will go

a long way in making cod grow out a commercial reality. Success in 1998 will be a key factor in determining the future development of the trap cod grow out industry in Newfoundland.

Chapter 6: Business Structure

One of the ways to minimize the financial risk of the cod grow out operation is to minimize costs. The operation of independent farms on a small scale by fishers is compatible with this approach. Fishers are able to provide the required material and labour at a nominal cost, thereby minimizing the risk and maximizing the economic return at harvest. For example, a cod trap fisher should be able to provide the starting stock and a significant portion of the required feed for a two cage farm at little or no extra cost. In addition, through their own efforts, help of family members, and technological assistance from an aquaculturalist, one could handle all the husbandry and harvesting activities.

A four cage farm could be operated by several fishers or a trap crew to achieve the same results with a nominal cost for inputs. They would all share in the economic return as opposed to receiving a wage for their efforts. The only cost (risk) in this process is the benefit the operator(s) would have received for the starting stock by selling it to the local plant when caught, versus waiting out the three month grow out period at which time the operator(s) would potentially receive a return compounded by the growth and the higher prices paid for the superior product.

Ideally, processors and fishers should be partners in this sort of enterprise (Warren, 1997). Processors have access to male capelin for feed and ample freezing capacity, plus they have marketing expertise. Fishers have the expertise to operate the farms and deliver a high quality product. It's a sensible partnership according to Mr. Larry Yetman, an Aquaculture Program Officer with the Department of Fisheries and Oceans. The uneasy relationship which exists between fishers and processors is historic in origin and will be difficult to change.

6.1 Investment and Equipment

Cod farming is not reserved for cod trap fishers but these fishers have a definite advantage in that their catch is taken alive. Their amount of investment should be minimal, given that they already own a great deal of the required equipment. Fish caught by either hook and line, or gillnets are often not suitable for grow out. Existing trap fishers are able to provide the required inputs at a nominal cost, thereby minimizing the risk and maximizing the economic return at harvest.

The cages in which the cod will be held account for the bulk of the investment. These cages can be very elaborate , or very simplistic in design. In its simplest form, a holding pen will be adequate for the new farmer. Table 6.1 summarizes the basic investment

required for a two cage farm. In the investment summary it is projected that the most viable participants will be licensed cod trap harvesters who already own a great deal of this equipment.

Table 6.1: Typical Investment for a Two Cage Cod Grow Out Farm in Year 1.

Requirements	Price
2 nets	$10,000
round trap cod if necessary	$0.40 per pound (Approximately)
average feed cost	$0.15 per pound ($0.07 + $0.08 for freezing)

Source: Trinav Consultants Limited, 1998.

6.2 Operating Costs and Revenues

Operating costs for such a venture would include fish, feed, labour, fuel, repairs, and cage maintenance. All costs have a variable degree of assumption attached. Ideally all operating costs should be minimal, but the costs should be realized. For example, if we look at 1997, then the starter stock could cost as much as $0.55 per pound and feed another $0.23 per pound.

One of the critical elements in the analysis of the financial viability of an independent cod farm operation is the extent of self-sufficiency with regard to starting stock and feed. The degree of self-sufficiency will vary with each individual fish farm and will be dependent primarily on the efforts of the owner/operator as well as the relative success of the fishery for any given year in the area where the fish farm is located. Below is an example of gross revenues generated from a cod grow out farm (see Table 6.2).

Table 6.2: Gross Revenues Generated From a Sample Cod Grow Out Farm.

Item	Price	Income	Expenses	Balance
20,000 lbs. starting stock	$0.40 per lb.		$8,000	-$8,000
feed/80,000lbs.	$0.15 per lb.		$12,000	-$20,000
harvest weight of 32,000lbs.	$1.00	$32,000		$12,000

Source: Trinav Consultants Limited, 1998.

The fish farmer purchases 20,000 pounds of cod as starter stock for an average market value of $0.40 per pound. They are fed a total of 80,000 pounds of feed while in the holding pens which costs another $12,000. The weight of the fish doubles in

approximately 100 days for a total weight of 40,000 pounds. However, the round weight conversion to head-on gutted is 80% which yields 32,000 pounds of product. This then sells for a market price less costs of $1 a pound, or $32,000. The end result is a balance of $12,000 not accounting for fuel, repairs, etc. (Trinav Consultants Limited, 1998). As mentioned, operating costs vary. However the above illustration is a good example. Such an analysis would demonstrate that the independent owner-operated cod farm is a viable venture.

6.3 Processing Costs

As with any seafood product, the cost of processing depends largely on the finished product. Market niche will determine how the product will be processed, and this in turn will determine the processing costs. For example, it costs more to process a filleted product than to process a round head on gutted product. If we look at the 1997 example again, the cost for producing head-on gutted cod was $0.35 per pound. Fresh fillets were processed for $0.90 per pound in one case and $0.80 per pound in the other (DFA, 1998b). These processing costs included transportation to the plant, ice, labour, and packaging.

Processors know well the costs of processing and the given market demands. Their experienced labour force, and state of the art machinery, allow them to process the

products in question as cheaply as possible. Processors adhere to a strict code of practice which ensures a quality product. This is of utmost importance in today's market structure.

Processing costs associated with the historical cod trap fishery of years ago may not correspond to the costs associated with processing cod grown in cages. Caged cod is much larger and thicker in general than wild cod. This in itself will relate to lower processing costs for the farmed cod. Plus, farmed cod allows processors the ability to offer a top quality product consistently. From a processor's and marketer's viewpoint, this is extremely important. Given that the fish are consistently bigger would suggest that the yields from farmed fish are greater (Fisher, 1988). The ability to schedule production and to produce directly for the market will also produce significant returns.

6.4 Licensing Requirements

A successful cod farm must have access to a good site. Although there are many such locations, it is important for farmers to investigate sites in terms of the biological limitations outlined earlier and obtain a license. Three separate authorizations are possible: a 'developmental license' which allows a pilot project to test a site, but does not permit commercial sale. The license fee is $100 per species/site a year. It is associated with a permit to occupy Crown Lands. The fee for a permit to occupy is $115 and a rental fee of $4 per hectare renewable annually. The other option is a 'commercial license' which, renewed annually, authorizes commercial operation. This license fee is $100 a year.

Associated with this license is a crown land lease, the fee for which is $115 plus $100 for a document fee, and a rental fee of $4 per hectare per year. You must also pay for a Crown Land survey of your site. With these two aquaculture licenses, one needs a Water Rights Authorization under Section 20 of the Department of the Environment Act. There is a one time document fee of $200 plus a $115 non-refundable application fee (DFA, 1998c).

Cod farming licenses are issued by the Province under The Aquaculture Act, 1985 and The Aquaculture Regulations, 1988 (although some federal requirements must also be met). The full process is explained in the following documents:

1. A Guide to the Aquaculture Licensing Process.
2. Introduction to the Finfish Farm Development Plan.

Preparation of the development plan is very important as it must be properly completed before the application for a license can be approved. The plan covers the first five years of operation. A plan must include such information as:

- water temperature, salinity, currents, depth, shelter, wave action, and Arctic ice conditions
- a site location diagram
- and the number of cages, expected growth, and proposed production levels

The time from submission to approval can be 2 - 3 months. Many separate departments have to review the application. The Registrar will place a public notice in a local paper asking for comments before deciding on the application. Applications go to the Registrar for forwarding to the relevant departments and agencies, including the Canadian Coast Guard which must approve the site under the Navigable Waters Protection Act (Sea Forest Plantation Limited, 1993a).

6.5 Site Selection

The correct choice of site in any fishing operation is vitally important since it can greatly influence economic viability by determining capital outlay, and by affecting operating costs, rate of production and mortality factors (Beveridge, 1987). When a fish farming facility is to be placed in the sea, one should have as great an understanding as possible of the physical and biological conditions at that location. Knowledge of how to culture the species to be farmed is also important. A thorough location selection process reduces the environmental impact on the fish, which in turn affects growth and immunity against disease and parasites. An investigation of conditions such as wind, waves, and ice are important to prevent damage or wreckage (Johnson and Olafsen, 1985).

In assessing a locality, the following factors should be investigated:

- temperature

- salinity
- oxygen condition
- current condition/water circulation
- wind and waves
- land and sea floor topography
- freshwater/ice conditions
- pollution
- distance to closest farming facility

The investigation of the location can either be done by the fish farmer or by companies or organizations which specialize in this. Although much of the data required must be collected by survey work and analyses of water samples, invaluable information can also be gained by talking to local people about prevailing weather conditions and the occurrance of toxic blooms or pollution. Consultations with them on the establishment of a cage farm may also help avoid problems of poaching and vandalism.

6.6 Live Fish Transportation

Although Sea Forest Plantation Ltd. has demonstrated that it is possible to transport live cod with very low incidents of mortality, it is very unlikely that such an option will be viable in a commercial setting. For the purposes of this paper, live fish transportation will pertain to movement by water.

Transportation by water can be divided into four categories. One can use tanks on board a vessel, the vessels hold itself, an open hold vessel, or by a towed cage/bag. This last method is the most common method for short distance fish transportation. It allows for ready access to water exchange and it reduces handling. However, it is a very slow process, especially when the fish are towed in a cage. It is important to note that knotless netting is recommended for the cage to reduce damage to the fish (Anonymous, 1993).

6.7 Overwintering

One of the major advantages of cod grow out is that it allows one to hold its product until market conditions are optimal. To take advantage of optimal market conditions it may require fish to be overwintered for at least several months. It has been proven that one can make money by keeping cod from the trap season to late fall, but the question that remains is how much more could one make by keeping them an additional month or two. No doubt the market conditions are better, but what are the environmental parameters for the fish.

A sheltered cove which freezes over early, particularly where a small brook runs out, is best for overwintering. Fish will generally not feed between late December and early April because of the cold water. As a result, these fish will lose weight. For example, a study done in the winter of 1993 showed that cod fish lost 17% of their average weight due to spawning and overwintering (Sea Forest Plantation Limited, 1993b). If overwintering to

any degree is to be a part of the grow out strategy. it is important to examine its costs and financial rewards.

7.0 Future Considerations

As with any new industry, there are bound to be growing pains. Initiatives such as those in 1997 will go a long way into heading this industry into the right direction. Even though all those people involved in last years project would admit that the overall project was a success, the real evaluation of success should be by the interest generated for 1998 and beyond. If preliminary records are any indication, the project was very successful. More than 39 fishers want to get involved in the cod grow out business for 1998, even though there is no promise of any funding to help offset the costs (Warren, 1998). Such interest is a reflection of the success achieved by those involved in last years pilot project and is an indication that the potential for this type of aquaculture is finally being recognized by those involved in the fishing industry.

Mr. Larry Yetman (DFO, St. John's) said, "The key to this whole thing is that we've got fishermen doing it themselves. It's not government or some big corporation or anyone else from outside the community. It's all being operated by fishermen and when they see fellow fishermen succeeding at it, then that's all the encouragement they need to get involved themselves." (Warren, 1998). This is a very important ingredient and was a definite stumbling block to the early development of cod grow out.

7.1 Outlook for 1998

In 1997 only 8 fishers were recruited to investigate the feasibility of cod grow out operations, even with the added incentive of a subsidy to purchase the live fish, to transport them to the given sites, and to construct the grow out pens. Given the increase in potential participants for 1998 despite the absence of funding is a success story in itself. It is anticipated that the biological and financial success of the project can be duplicated as well.

The Department of Fisheries and Aquaculture has a new policy for issuing cod farming licenses in 1998. As cod farming develops as a commercially viable venture, a policy for issuing new licenses is necessary to ensure that this new aquaculture sector develops in an orderly fashion. Individuals and companies who have cod farming licenses will continue to hold them, and will be eligible to purchase cod from licensed cod trap harvesters. New aquaculture licenses for cod aquaculture or grow out will be issued only to licensed cod trap harvesters. For new entrants in cod farming in 1998, only 20 developmental licenses will be issued, with priority given to harvesters in areas where a limited cod trap fishery may be undertaken (Anonymous, 1998).

Licenses will be issued based on receipt of an application from cod trap harvesters who have access to cod and have made arrangements to secure an adequate supply of feed. They must also provide equipment and cages necessary for, and agree to participate in a

farmed cod marketing program. There is a limit of 20 new developmental licenses this year, in addition to 30 previously issued licenses. First priority for new licenses will be given to cod trap harvesters in zones where cod trap fisheries are pursued. If however, fewer than 20 applications are received from harvesters in these zones, consideration will be given to applications from harvesters licensed for cod trap fishing in other zones (Anonymous, 1998).

If the success of 1997's pilot project can be duplicated in 1998 on a larger scale, then interest will surely increase. This is another step into building the foundation for what promises to be a viable commercial undertaking for this Province. This potential industry is faced with many uncertainties and questions that will need to be addressed before it can assume its role in the economic development of rural Newfoundland. The future looks bright for cod grow out. Even though there was a period of stagnation in its development, the timing has never been better for its resurgence.

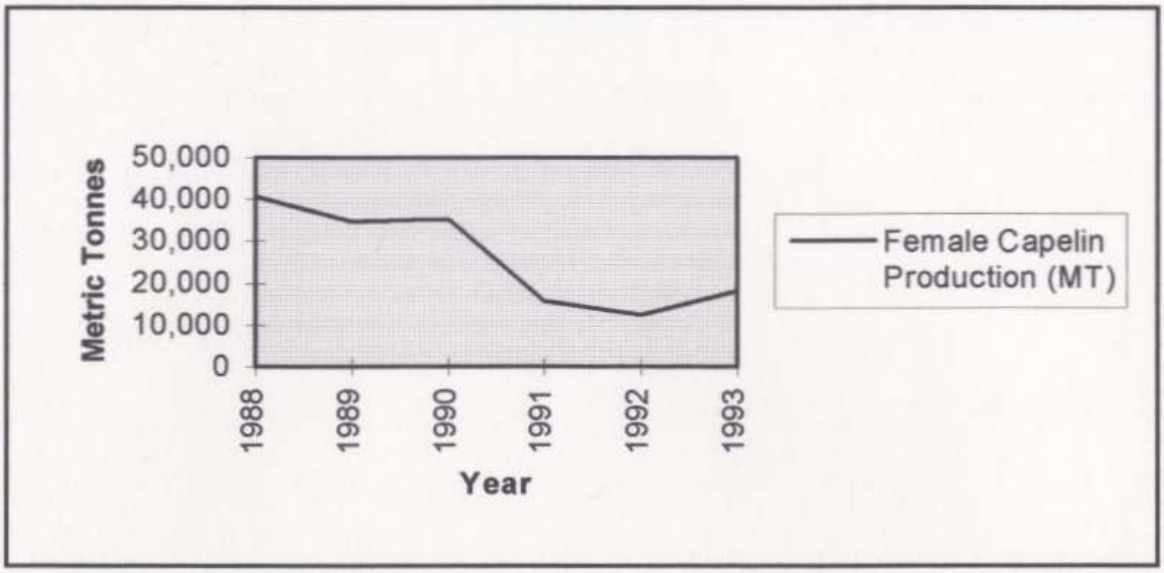
7.2 Areas for Further Research

If the cod grow out industry is to grow beyond 1997 levels to become an actual commercial industry, there are many details to be worked out. One of the key issues to be addressed is access to the resource. In 1997, grow out operators ended up paying a premium price for their fish, probably as a result of the fact that nobody was quite sure

how well the transfer of live fish from cod traps to pens would work. It is hoped that in 1998, the asking price will be closer to actual market price.

Then there is the question of obtaining adequate feed. It takes approximately three pounds of feed to produce one pound of growth which can be a substantial amount of feed for a particular operation and indeed a potential industry in the making. The question that arises is if cod grow out is to become an industry someday, at what level will it be? Better phrased, what level can we support? If we look at the female capelin production numbers from 1988 to 1993 (see Figure 7.1), and consider the workings of such a fishery, then it is easy to extrapolate numbers of male capelin being landed in the range of 40 million pounds in most years (DFA, 1998a). A factor of 2.3 is used to generate total landings versus pack out product (Blackwood, Personal Communication, 1998). These numbers have the potential to produce 15,000 MT of growth from an original starting stock of 5,000 MT of cod. Total production of farmed cod could be in the neighbourhood of 20,000 MT.

In 1993, it was predicted that the maximum production from cod farms would be 15,000 MT given the available pelagic stocks (Sea Forest Plantation Limited, 1993c). This is probably a more conservative estimation given the uncertainty of the capelin fishery. This may seem far fetched at present, but it could be a realistic goal in the future.



Source: Department of Fisheries and Aquaculture, 1998a.

Figure 7.1: Total Female Capelin Production (MT) for 1988-93.

In 1998, operators will have to secure an adequate supply of capelin, squid, or herring before they can become operational. This wasn't an issue for participants in 1997, but without the availability of any government funding in 1998, operators will have to carry the cost of feed themselves. Feed prices will be a significant concern.

There are also concerns about how the fish from grow out operations will be marketed. In 1997 the province eased its restrictions on the export of unprocessed fish to allow it to be marketed in head-on gutted form to obtain the highest possible returns. Whether or not a similar exemption will be made in 1998 and beyond remains to be seen.

If cod grow out is to expand into the future, there are many issues which will have to be addressed. As growth of the industry continues, these issues will surely expand and will have to be dealt with. Below are some key issues for future consideration.

7.2.1 Harvesting Issues

- Fish taken from the trap are not weighed as the stress of weighing immediately on site would compromise the health of the fish and raise mortality levels. Acceptable mechanisms to accurately weigh fish at point of capture without stress and loss need to be developed.

- Fishers and managers have no immediate way of knowing how much fish is involved which increases the likelihood of quota overruns.

- Risk of dispute between the seller and buyer.

- Methods to remove and account for by-catch such as pollock and haddock need to be addressed. (DFA, 1998b).

7.2.2 Processing Issues

- Processing time, in terms of the rigor mortis process, needs to be investigated.

- Excessive gaping of fillets is a major concern.

- To achieve and maintain continuous markets, extra care and strict adherence to product specifications must be taken. (DFA, 1998b).

- Restrictions into the export of unprocessed fish from the province need to be redefined to include cod grown in captivity to be treated as any other aquaculture species.

7.2.3 Marketing Issues

- Cod farmers dependent on a supply of fish from fishers must be aware of the price their farming operation can afford to pay bearing in mind that additional transport costs might be required. This can only be determined if specific markets and prices are previously identified

- Transportation options, such as air freight, less than truck load and full truck load, need to be assessed in terms of cost and condition of product upon delivery.

- To ensure that a high market quality product is achieved, it must arrive on time and in good condition.

- Identify additional markets to ensure a proper product mix to achieve the highest returns possible.

- Determine if fish should be held longer during winter months to take advantage of higher market prices. (DFA, 1998b).

7.2.4 General Issues

- Technical issues, such as, cod nutrition need to be examined more closely. The available cod diets need to be assessed to determine which ones provide optimum growth and flesh quality. Cod being grown during the summer may not take commercial feed readily and will need to be weaned.

- Access to stock. The unpredictability of the fishery poses a problem in planning and commitment - commitment is difficult without fish. Constructing nets, contracting feed, etc. has to be done in the fall and spring prior to the opening of the cod fishery. With no assurance that fish to stock the farm will be realized, the investment necessary may not be forthcoming.
- Access to feed sources. Fishers can supplement their feed fish requirement through wild harvest but only so long as seasons are open and quotas are available. Special quotas and seasons for aquaculture were not accepted by DFO. Freezing capacity may require the involvement of processing plants.

- Site suitability. December through to February provide the best market opportunities for farmed cod. Therefore, sites that remain ice-free during this period would be ideal.

- De-gilling fish removes the main source of bacteria, thus, slowing the enzyme process responsible for the decay of fish. This would ensure a higher quality product upon market arrival.

- Ability of farmers to purchase fish to stock their farms. (DFA, 1998b).

8.0 Summary and Conclusions

While all players have come to accept the fact that drastic action was required in the area of resource management in the fishery of this Province, they also believe that new initiatives are necessary for its long term survival. One such initiative is the idea of cod farming in Newfoundland and Labrador using the 4 to 5 year old wild fish from the cod trap.

8.1 The Future of Cod Grow Out in Newfoundland and Labrador

If the results from the 1997 cod grow out project are any indication of the potential of such a venture, the future for cod grow out in Newfoundland seems very promising. Not only can cod double their weight from July to mid-November and improve their quality, feed costs can be reduced by using locally caught species in fresh form, and in frozen form when out of season. Some of this feed can be male capelin which has been discarded in the past.

Such a potential industry will have to assure that the farmed cod is marketed at the highest possible price when demand is highest so that the harvester can be assured of a profit. The cod farmer must be better off financially than if he sold the fish originally during the traditional cod trap season when markets are depressed and prices are lower (Anonymous, 1998).

8.2 Conclusions

The greatest challenge facing fisheries resource managers in the future is to maximize the economic and social benefits while minimizing the biological impacts. It is fair to assume that the fishery of this province will never be the same again - change is inevitable. Given the varying nature of the inshore cod trap fishery, cod grow out offers the possibility of considerably augmenting the earning potential of the fishery without interfering with its traditional conduct (Fisher, 1988).

Due to the biological limitations on the Northern Cod resource, the fishery of the future will no longer be volume driven. Fishers will likely experience low quotas as the cod fishery reopens around the province. These same fishers will be forced to do more with less amounts of fish so that they can increase their earning potential.

The benefits of cod grow out address many of the fundamental problems experienced in the fishing industry today. However, it is unrealistic to think that this can take place in every cove and harbour of this province. Geographic conditions dictate otherwise and site assessments which include access to resource will determine the location of future farms.

There is great potential for grow out rearing of young cod harvested from Newfoundland's traditional trap fishery to increase the value of the fish harvested and thereby increase the incomes of inshore fishers. While the biological evidence is in place

for such an industry to unfold, social, cultural, and logistic issues remain even before such a venture is proven economically. Given that all studies done to date on cod grow out have focused on biological aspects, the economic analysis is lacking. While the potential for cod grow out exists, there is more work required on economic, biological, and ethical grounds before we run headlong into it.

Given the past problems associated with large quantities of low valued trap cod generally available in Newfoundland and Labrador in June, July, and August, it is obvious that an opportunity exists to increase the value of this fishery. The high growth rates obtainable in net cage culture in combination with better quality and higher market prices from the period of late November to March suggests that an economically feasible cod grow out operation is possible (Vardy, 1986). If it is to make a difference to outport communities and the fishing industry in general, it will have to be structured in such a way that optimizes the overall benefits of such a venture. This may involve partnerships with the processing industry, and/or cooperatives being established in different regions of the province.

8.3 Recommendations

Many unanswered questions require additional research. Important policy issues need to be addressed before cod farming can be brought to a semi-commercial level in Newfoundland. To achieve this goal we should:

- Implement a co-ordinated and controlled expansion of the trap cod grow out project beyond 1998 according to provincial and federal policy regulations. This should be achieved by having one group or individual responsible for the project and co-ordinating all activities (ie. harvesting, processing, and marketing).

- Review all available information with respect to the rigor mortis process of farmed cod. This is a very important process to be understood for it can correspond to better market value. Rigor may affect the quality in three ways:
  - toughness and high drip loss
  - gaping in fillets
  - and shrinkage of fillets

- Hold a significant number of cod overwinter to determine whether this marketing strategy is feasible given Newfoundland's climatic conditions. This will not be possible for a lot of sites due to ice conditions, but it should be explored in those that can.

- Explore other or optional marketing strategies. As the industry grows it may be necessary to identify other market niches.

- Evaluate different feed options. Cod nutrition is a very important issue. Attention has to be given to the available cod diets to assess which ones provide optimum growth and flesh quality.

- Allow fishers to obtain licenses to purchase feed fish such as herring, capelin, and squid directly from other fishers. This will go a long way in helping to make cod grow out a viable industry.

- Fishers should be granted permits to catch a certain amount of feed fish. This could be similar to the permit granted to lobster fishers, and should only be granted if freezing capacity is not available.

- Partnerships between the growers and processors should be established wherever possible. It is important to take advantage of each other's expertise and capital equipment when possible.

- Cooperatives can be arranged for growers in different regions of the province. Growers can share in expenses thereby decreasing individual expenses, and share in the rewards of added marketing strengths.

- A permanent exemption for the export of cod in head-on gutted and head-off gutted form has to be granted. This could prove to be the major stumbling block for this new industry. Fish grown out from wild capture have to be treated as other aquaculture products so that they can access the most lucrative markets.

- New entrants should be required to have some training in the field of aquaculture before being granted a license. Proper husbandry techniques will prove vital to the success of this industry as it develops.

- The economic viability of cod grow out has to be studied in far greater detail. Projects such as those in 1997 will go a long way in providing the necessary information to demonstrate whether or not such a venture is economically viable.

- Potential logistical, cultural, and social difficulties which may arise from cod grow out have to be addressed.

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APPENDIX

Processing Procedures

Processing Procedures for Farmed Cod

Head-on Gutted (HOG)

- De-iced manually (without water)
- Size Graded
  - Small (<3.5 lbs.)
  - Market (3.5 – 10 lbs.)
  - Large (>10 lbs.)
- Packaged
  - 50 pounds of fish per Styrofoam carton
  - Ice placed in bottom of carton
  - Plastic bag placed in carton
  - HOG fish placed (heads and tails)
  - Plastic bag folded over and down into carton
  - Ice placed on top of plastic bag
  - Carton covered with Styrofoam, taped, and labeled
- Palletized and transferred to chill room to await truck

Fresh Fillets

- Manually de-iced or de-iced in hopper with water
- Machine filleted (Woodman's) and hand filleted (Seafreez)
- Machine skinned
- Manually trimmed and V-boned
- Size Graded
- Packaged
    - 10 pounds per styrofoam carton
    - Gel pack or ice placed in bottom of carton
    - Plastic bag placed in carton
    - Skinless, boneless fillets placed (skin side up)
    - Plastic bag folded over and down into carton
    - Carton covered with styrofoam, taped, and labeled
- Palletized and transferred to chill room to await truck
- Average finished product fillet yield = 42.8%