THE MYSTERY FISH OF BONAVISTA NORTH: A MULTIDISCIPLINARY APPROACH TO RESEARCH AND MANAGEMENT OF A UNIQUE RECREATIONAL SALMONID FISHERY IN NEWFOUNDLAND

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The Mystery Fish of Bonavista North: A Multidisciplinary Approach to Research and Management of a Unique Recreational Salmonid Fishery in Newfoundland

By

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Abstract

In the Bonavista Bay North area of Newfoundland there is a unique population of salmonids that supports an extensive recreational fishery. In recent years the population has experienced a serious decline resulting in reduced angling quality. This thesis takes a multidisciplinary approach to research that attempts to overcome some of the problems associated with recreational fisheries management in Newfoundland. The multidisciplinary management approach was used to gather data necessary for successful management and conservation of the population by focusing on both the fish population and the anglers who exploit it. Data on the population's ecology and fishery were gathered by interviewing knowledgeable local anglers and by directly sampling the population. Data on the motivations and management preferences of anglers were gathered by conducting a survey of the general angler population.

The results demonstrate that the fish is an Atlantic salmon with a life history characterized by extensive use of the estuary in the pre-smolt stages followed by smoltification usually at age 3+ or 4+. The saltwater phase of the life-cycle is of short duration, lasting only two to three months, which results in smaller size and younger age at maturity and a higher incidence of repeat migration between freshwater and saltwater than in typical populations of anadromous Atlantic salmon. Results of the general angler survey demonstrate that anglers are motivated to fish for a number of reasons including, but not limited to, being outdoors, enjoying nature, relaxing, escaping everyday pressures, sharing experiences with others, and the sport of fishing.

Data gathered from anglers suggests that the most important reason for the population's decline is overfishing resulting from regulations that do not adequately protect the population. The data also demonstrate that there is widespread support among anglers for a new management initiative aimed at enhancing the fishery and protecting the population. The results of the study suggest that new regulations aimed at reducing the harvest and matching more closely the angling season and migration habits of the fish would be an acceptable means of protecting the population and improving fishing quality.

Based on the data gathered, specific regulations aimed at improving the fishery and protecting the population are recommended.

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Table of Contents

Page

List of Figures

Page

List of Tables

Page

CHAPTER 1: THE MYSTERY FISH OF BONAVISTA NORTH

1.1. The Southwest Pond Seatrout

In the Greenspond/Valleyfield Harbour area of Bonavista Bay North, Newfoundland, there is a population of an anadromous salmonid that has a life history with a number of unusual characteristics. The population, known locally as the seatrout, saltwater trout or Southwest Pond seatrout, is recognized by local people as being distinctly different from any other fish population in the area and is exploited and valued on the basis of a recreational fishery. Nonetheless, its existence is not formally recognized by the government departments responsible for recreational fisheries management in Newfoundland and Labrador and, therefore, it automatically falls under the provincial trout management plan. Reports by local anglers of declining population size and smaller fish suggest that past management under the trout plan has allowed over-exploitation of the resource and that a new management strategy is needed if the population is to support a sustainable recreational fishery.

There are a number of reasons to believe that the Southwest Pond seatrout fishery has sufficient social and economic value to the surrounding communities to justify developing a new management plan. The Southwest Pond seatrout already supports a fishery with a long history. Anglers who participate in the fishery are concerned that management of the population is not adequate and strongly support efforts to preserve and enhance the fishery. Furthermore, this unique fishery has the potential to attract anglers from outside the local area who are looking for new fishing experiences and thus bring economic benefits to the surrounding communities. The Southwest Pond watershed is located approximately 20 kilometres from the Indian Bay watershed, an area known throughout the province for its trophy brook trout angling. A well-managed Southwest Pond seatrout fishery would serve to further enhance the eco-tourism potential of the region. There is, in fact, already a group of highly motivated local people who have been working through the Indian Bay-Cape Freels Ecosystem Development Association to promote, enhance, and manage the Indian Bay fishery on a community watershed basis. These people have also expressed an interest in conserving and developing the fishery for the Southwest Pond seatrout.

The only documented information currently available on the Southwest Pond seatrout and its fishery are a small amount of informal data contained in two episodes[1] of the popular local television program "Newfoundland Outdoors". Developing a management plan and evaluating management success will require more extensive data on the population and its fishery that is collected with a more formal methodology. Information about the range and distribution of the fish, its life history and population dynamics is essential, but to assure management success it will be also be important to evaluate the current fishery and the range of benefits derived by people from it. In an attempt to overcome some of the problems associated with the current process of recreational fisheries management in Newfoundland and Labrador, the research presented in this thesis will take a multidisciplinary approach to collect some of this important data.

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1 "Mystery Fish" (1977) and "Greenspond Steelheads" (1981)

1.2. Problems with Recreational Fisheries Management in Newfoundland

There are currently two recreational fisheries management plans in effect in Newfoundland and Labrador. One of these plans regulates the fishery for anadromous Atlantic salmon (*Salmo salar*) and the other regulates the fishery for trout (mostly *Salvelinus fontinalis*) and ouananiche (non-anadromous Atlantic salmon). Under these management plans the province is divided into a number of management zones which differ only in the opening and closing dates of the fishing season. The trout management plan was revised in 1994 to include four management zones and was designed to reduce overall harvest of trout and to protect trout populations in the spring when they may be particularly vulnerable (Buchanan *et al.* 1994). Although there has been a great deal of information gathered on various trout populations in Newfoundland and Labrador (see Houston 1994), trout fishing regulations have little underlying scientific basis. Most of the past research has been undertaken as part of individual research agendas and has not been co-ordinated and linked to management issues. Thus, it has been difficult to incorporate these data into the management process.

The salmon management plan has been in effect for a number of years and has undergone many modifications since 1971 as managers have attempted to deal with increasing exploitation and decreasing stocks (Buchanan *et al.* 1994). Target spawning requirements (number of adult spawners per year) are calculated for each of the scheduled salmon rivers in the province and the fishery is managed to minimize the number of fish harvested each year to permit the targets to be met in each river system. Salmon runs are not monitored on a river-by-river basis however, but instead the health of salmon stocks throughout the province is assessed by monitoring the spawning escapement in a few index rivers (Chadwick 1995).

If management of the Southwest Pond seatrout, and Newfoundland and Labrador's recreational fisheries in general, is to be successful there are a number of fundamental problems with the current approach that must be overcome. The first problem is that the scale of management is too large to recognize differences that almost certainly exist between fish populations or fisheries in different areas. The 14 salmon management zones and four trout management zones currently used each cover an area large enough to include numerous populations, and even distinct races, of each species. This large scale management strategy does not recognize that individual populations may differ in such fundamental properties as their production, life history or autecology (Riley *et al.* 1993). It also does not recognize the fact that fishing effort is almost always unevenly distributed. The effect of taking this large-scale approach is that the harvest cannot be restricted on a population specific basis and thus, many populations of both trout and salmon are over-exploited. A more effective approach would be to manage individual populations or a number of ecologically similar populations with a management plan that is designed specifically to meet the management needs of those particular populations. This approach would be especially applicable to the Southwest Pond seatrout which has a number of features that are obviously distinct from any other known population of salmonids in Newfoundland and Labrador.

Management on a small scale has the advantage that it can be based on detailed data collected directly from the population. This will allow for an understanding of the ecological implications of harvesting and can lead to an estimate of the potential yield from each population. Specific management techniques can then be used to limit the harvest to a level that the population can sustain. A management plan of this type, due to its specificity to a local area (e.g. the Southwest Pond watershed), would also be more open to input from people who directly use the resource, making the management process more sensitive to local concerns and more open to the use of local knowledge.

The second problem with the current approach to recreational fisheries management in Newfoundland is that resource users are, for the most part, excluded from the management process. There is no mechanism to allow meaningful input from resource users into management decisions because the present practice of concentrating only on limiting the harvest does not recognize the fact that there are important social dimensions that need to be considered when managing recreational fisheries. The five member federal-provincial working group that drafts the management plans each year has the authority to solicit input from resource users, but is under no obligation to do so and is under no obligation to act on any recommendations made by user groups. Once drafted by the working group, the trout management plan undergoes no further review; the salmon management plan, however, must be approved by the Sports Fish Advisory Committee. One purpose of this committee is to allow representatives from organized angler groups and other users (e.g. outfitters and native groups) to review the plan before it is approved. The committee is, however, composed mostly from government with user group representatives in the minority. Thus, the management plan can usually be approved even with objections from the various resource users. Furthermore, it is also likely that the representatives from the organized angler groups do not represent the concerns of the majority of anglers because only a small number of the anglers in the province are members of these organizations. The result of all this is often a management plan that does not adequately address the concerns of the resource users. This tends to make the anglers (and also outfitters and native groups) distrustful of the people responsible for management decisions and new management initiatives, a situation which can lead to the plan and its associated regulations simply being ignored.

1.3. Another Approach to Recreational Fisheries Management

Recreational fisheries management has been defined as the process of working with a given aquatic habitat and assemblage of organisms for the benefit of people in a recreational setting (Weithman 1993). In this context, a successful Southwest Pond seatrout fishery will be defined as one that assures the sustainability of the fish population while at the same time tries to meet the desires and expectations of the people who exploit it. Viewing recreational fisheries in this way is useful because it makes explicit the fact that fisheries are managed for people and this necessarily leads to research and management that is multidisciplinary in nature, focusing not only on the fish but also on the people who angle for them. Such an approach moves recreational fisheries management away from the traditional Maximum Sustainable Yield orientation to something more akin to an Optimum Yield orientation. Optimum Yield refers to all social, economic and biological benefits derived from fisheries and is therefore definable and attainable for a specific fishery only through the formulation and consideration of a multidisciplinary database which must focus on fish biology and the social and economic benefits derived from the fishery (Malvestuto and Hudgins 1996).

1.3.1. *What does a Multidisciplinary Management Approach Require?*

To be effective, a multidisciplinary approach should be explicit at all stages of the management process. This will involve setting management goals that address, and are compatible with, the best interests of both the fish and the anglers. Management-related research should include aspects of the ecology and life history of the fish populations to determine the ecological implications of manipulating the harvest with fishing regulations, but it should also include research into the motivations and expectations of the anglers and their willingness to compromise on management decisions. Management objectives should be set with angler desires and motivations taken into account and anglers should be consulted throughout the implementation process. Monitoring should include changes in the fish populations and catch and effort of the fishery as well as the satisfaction of anglers, how they respond to new management techniques, and changes that they themselves perceive in the fishery. This approach is fundamentally different from the current approach because there is a research component directed specifically at the human dimension of the fishery and an active effort to integrate the resource users into the whole process of management. This approach, by essentially allocating part of the decision making authority to the anglers, should increase the legitimacy (i.e. acceptance) of the management plan (Felt 1990). Furthermore, allowing the resource users such involvement would develop within them a sense of responsibility towards the resource and reduce the chances of over-exploitation by placing those who will suffer the consequences of bad decisions in the position of being at least partly responsible for making them.

1.3.2. *Multidisciplinary Research and the Southwest Pond Seatrout*

Krueger and Decker (1993) outline five steps in the process of managing recreational fisheries: 1) choice of goals, 2) selection of objectives, 3) identification of problems, 4) implementation of actions, and 5) evaluation of actions. This scheme provides a useful framework for guiding research and management of the Southwest Pond seatrout. The purpose of the research on the trout and its fishery presented in this thesis is to focus mainly on the first three steps in the process outlined.

For the purpose of the present research, the goal (step 1) of managing the Southwest Pond seatrout will be **to provide a sustainable recreational fishery resource that meets the needs and satisfies and sustains the expectations of the people who exploit it.** This goal may change in the future because the goal of managing the Southwest Pond seatrout will ultimately be decided upon by the agency or group responsible for its management. In fact, following the Optimum Yield philosophy suggests that this goal be changed in the future to address economic concerns in addition to the biological and social concerns already addressed. The goal, as it is presently set, provides a basis for setting the initial objectives (step 2) of the research into management-related questions because to realize this goal requires knowledge both about the fish and their habits and about the people who exploit the fish population. The present research has two main objectives: 1) To gather information on the range, distribution, life history and ecology of the Southwest Pond seatrout population, and 2) To gather information about the benefits anglers derive from the resource and the attitudes of anglers as related to its management.

Achievement of these objectives will allow the identification of problems (step 3). Potential problems are varied but may be related to factors such as over-exploitation of the resource, strongly conflicting or irreconcilable views on management, differing expectations of the resource by different user groups, and the inadequacy of existing regulations to achieve desired outcomes.

The information gathered through the present research is viewed as beginning the process of building an information base from which the management process can continue to evolve. Based on the data collected about the fish, its biology and its fishery, a number of preliminary recommendations (step 4) will be made that may help improve the current state of affairs in the fishery. This will help in setting the next round of objectives that can lead to the attainment of a successful Southwest Pond seatrout fishery (step 5).

One of the advantages of taking a multidisciplinary approach to recreational fisheries management is that it allows the scope of the research to be broadened to include methods and sources of information that are not usually considered. The next chapter will begin the process of gathering information about the ecology of the seatrout by going directly to the people who have the most experience with and knowledge about the population i.e. the anglers who currently exploit the resource.

CHAPTER 2: TAPPING LOCAL KNOWLEDGE

2.1. Traditional Ecological Knowledge

There is an ever-increasing body of literature documenting the knowledge and understanding that certain societies possess regarding the resources and environment that they depend on for survival. This knowledge is generally referred to as traditional ecological knowledge (TEK). The concept is difficult to define precisely, but Mailhot (1993) has provided a preliminary, working definition of TEK as "the sum of the data and ideas acquired by a human group on its environment as a result of the groups use and occupation of a region over many generations". Much of the literature has documented the ecological knowledge possessed by various hunter-fisher-gatherer societies whose lives are intimately linked to the workings of the biological communities they exploit and depend on. In many of these societies there exists an indigenous or traditional management system which relies on this knowledge to ensure the sustainability of resources and thus the long-term survival of the people (Berkes 1988; Riewe and Gamble 1988; Johannes 1978; Dyer and McGoodwin 1994).

The information contained in TEK is acquired through an approach to understanding nature that is fundamentally different from the approach taken by natural science. The TEK approach is a holistic one in which conclusions about the workings of ecological systems are drawn from empirically derived data generated through the society's experiences with nature. The society's ecological knowledge is continually updated and expanded as new information pertaining to changing environmental circumstances that alter the behaviour of the biological communities, populations or ecosystems is gathered (Freeman 1992).

Traditional science takes a more reductionist approach to understanding nature. Complex ecological systems are studied by reducing them to their component parts and then studying each part individually. Science is based on a system of formulating and testing a set of alternative hypotheses which make predictions from theories, laws and paradigms arrived at through observations of nature. The outcome of the experiment to test an hypothesis leads to modification or rejection of the original theory, law or paradigm.

The laws, theories and paradigms contained in TEK are also formulated through induction from observation, but TEK is limited in its capacity to verify predictions. The aim of much applied scientific research is to understand nature so that it can be controlled through systems of management. TEK does not aim to control nature but to understand nature so that applying the knowledge allows resource users to increase the efficiency with which they are able to exploit natural resources without destroying the essential integrity of the system (Mailhot 1993).

2.1.1. *Local Ecological Knowledge*

Indigenous peoples are not the sole holders of ecological knowledge generated through a group's experiences with nature over time. There are many industrial societies in which a segment of the population is also dependent to some degree on nature for their livelihood. The ecological knowledge possessed by these people is not 'traditional' in that its content and transmission are affected not just by the environment but by numerous aspects of modern society. Examples include the commercialization of the fishing industry, technological and industrial changes, formal education and movement of people between areas (Neis *et al.* 1994). Despite these differences, resource users in industrial societies continue to accumulate ecological knowledge through regular and continuous interaction with certain aspects of their environment. This knowledge is referred to as local ecological knowledge (LEK).

In rural Newfoundland, natural resources are used for both commercial and recreational purposes, e.g. the commercial fishing industry is a major source of employment and recreational activities such as hunting and fishing are an important part of the culture. A number of studies have documented the ecological knowledge of commercial fishers (Neis 1992; Felt 1993; Neis *et al.* 1995; Fischer *et al.* 1997), but there has been no investigation into the knowledge held by those who use natural resources for recreational purposes. Researchers have recently suggested that the ecological knowledge possessed by resource users represents a critical supplement to scientific understanding and that incorporating this knowledge into management would improve the capacity to manage the resources sustainably (Freeman 1992; Johannes 1981; Kloppenburg 1991; Mailhot 1993). Using local ecological knowledge in recreational fisheries management will require an understanding of the effectiveness of this system of understanding nature and will also require the development of a systematic methodology for collecting data from anglers and integrating it into the research and decision-making processes of management.

2.2. Local Ecological Knowledge and the Southwest Pond Seatrout

A number of factors suggest that gathering the ecological knowledge of the people who exploit the Southwest Pond seatrout is an appropriate starting point for management-related research. The lack of any documented information about the seatrout means that the resource users are the people who hold the most knowledge about the fish population and its habits. Collecting this knowledge using a detailed and systematic methodology would very quickly and dramatically increase the amount of documented information about the population. Information from the resource users about the range, distribution and migration patterns of the population will provide the data needed to design a scientific study to gather more detailed data about those aspects for which information cannot be provided by local people.

One area where local knowledge could be very useful is in identifying changes in the seatrout population and its fishery over time. Understanding past changes in the population will be very important for evaluating the current health of the population, however there has been no systematic monitoring of the population or its fishery in the past. Information from resource users who may have witnessed any changes that have occurred is, therefore, the only source of this valuable information. Furthermore, future changes in the population resulting from changes in management will be best recognized by resource users because they have the most experience with the population. Incorporating local knowledge into the management process will make management of the seatrout more sensitive to local concerns and is a very good way of involving the resource users in the management process.

The local ecological knowledge of Southwest Pond seatrout anglers was collected from 15 anglers during the winter of 1995. Individuals believed to be knowledgeable about the seatrout were identified by members of the Indian Bay-Cape Freels Ecosystem Development Association. Each individual was contacted by telephone and asked if they would participate in a survey to gather information on the seatrout. Individuals who agreed to participate were then interviewed using a standardized questionnaire that asked questions related to the seatrout's range, distribution, life history and fishery (Appendix 1). What follows is a summary of the information gathered through these interviews.

2.2.1. *Study area: the Southwest Pond Watershed*

The seatrout population inhabits the Valleyfield Harbour area of Bonavista Bay North and a river system that flows into the Southwest Arm of the harbour (Fig. 2.1). The river system, located adjacent to the highway leading to the island of Greenspond, is unnamed but its major feature is a large water body called Southwest Pond. The freshwater range of the seatrout consists of Southwest Pond and two of the brooks flowing into it. The brook flowing into the pond in the southwest corner is Black Brook. The brook flowing into the northwest corner is unnamed, but the area where it enters the pond is known as Headquarters. This section of the system consists of a series of smaller ponds connected by short sections of river. The first two ponds above Southwest Pond are called Little Southwest Pond and Otter Pond. Above Otter Pond is a large steady called Coakers Steadies or Coakers Rattles and above this is another series of small unnamed ponds. Above this series of ponds the river branches before crossing the highway (route 320). Immediately above the highway on the right branch is a pond called Starvation Pond.

Other fish known to inhabit the river system include smelt (*Osmerus mordax*), brook trout (*Salvelinus fontinalis*), eel (*Anguilla rostrata*), and stickleback (*Gasterosteus aculeatus*). One person also reported the presence of German brown trout (*Salmo trutta*) in the river system[2]. The most abundant fish in the river system is smelt which are found there in particularly great numbers in the winter. In August, when the smelt have gone to sea, the seatrout is the most abundant fish in the river system.

Southwest Pond is connected to the ocean by a larger, but relatively short (approximately 50m), brook. The Southwest Arm of Valleyfield Harbour is made up of a number of pond-like areas. At the bottom of the arm, where the brook enters, is a salt pond known as Saltwater Pond. This is connected to another pond-like area at the top of Southwest Arm by a short, narrow, shallow channel. These salt ponds are navigable from the sea by small boat to the top of Saltwater Pond

The saltwater range of the seatrout includes the Southwest Arm and Valleyfield Harbour south to Greenspond Island. There were two informants who reported that there may be populations of the Southwest Pond seatrout in the nearby Indian Bay River

[2] The range of brown trout in Newfoundland is thought to be restricted to the Avalon Peninsula. The reference to brown trout in this case probably stems from the local use of the name to refer to another type of fish, probably land-locked or juvenile Atlantic salmon.

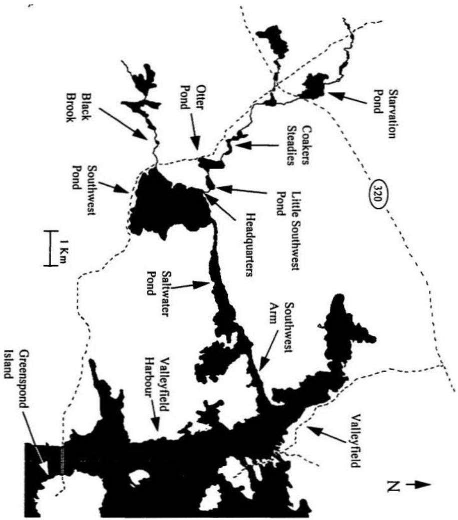

Figure 2.1 Map of the Southwest Pond river system and Valleyfield Harbour showing the locations described by respondents in the LEK survey. All of the names except Southwest Pond and those in Valleyfield Harbour are local names and, therefore, are not found on official maps.

system and one who believed that the fish may be found in a pond near Newport. These reports could not be confirmed by the informants however, as neither of them had any direct knowledge of these other populations.

2.2.2. *Description of the Southwest Pond Seatrout*

The fish are recognized as being distinct by local people and are known by a number of names including: seatrout, saltwater trout, steelhead, brook salmon, salmon, Southwest Pond trout and Mystery Fish of Bonavista North. All of the people interviewed believed that the fish are more like Atlantic salmon than any other type of fish; there was some disagreement, however, as to the exact species. Some people believe that, although they are very similar in appearance to salmon, the fish are actually some type of trout. Others believe that they are a "race" of small salmon that has a limited range in the ocean.

The appearance of the fish in both body shape and color is generally described as being very much like that of Atlantic salmon with the exception that the seatrout tend to be smaller than typical salmon. The fish are silvery on the sides and underneath and with a brown or black back (although some individuals may have a green back in saltwater) and a grey patch on the side of the head. They have dark spots on the sides and on the head. The fish are bright and silvery when they first enter freshwater from the ocean but this brightness begins to fade after a few weeks in freshwater. Most people reported that individuals of the Southwest Pond population can be distinguished from Atlantic salmon by a number of morphological characteristics. The head of the seatrout is shorter or more "snubby" than that of a salmon and the tail is less forked. In contrast to salmon flesh, which is deep pink in colour, the flesh of Southwest Pond seatrout is reported to range from white to very pale pink.

The size of fish caught in both freshwater and saltwater can be anywhere between 8 inches to 20 inches (3 pounds). When asked to give the size of fish caught most often, many people were not able to pick any one size that was most common. Those who did usually said the most common size was around 12 to 15 inches (1.5 to 2 pounds) or "around the size of a herring". The fish are reported to reach sizes of up to 10 pounds, but people generally consider an individual to be large when it reaches the 3-to-5 pound range (Table 2.1).

2.2.3. *Life History of the Southwest Pond Seatrout*

The fish begin to migrate to the ocean in the spring when the ice begins to leave the pond, usually around the middle of May. Fish caught during this time range from 6 inches up to 3 pounds or more. The fish in the 6-10 inch range are thought to be migrating to the ocean for the first time while the larger ones are probably fish that returned to freshwater the previous fall and spent the winter in the river system. These fish, called slinks, are dark in colour and very thin, suggesting that they do not feed well over winter. It is thought that when they do feed, their diet in freshwater is probably made up of smelt and aquatic insects. These food sources may be especially important for the juvenile stages. After the fish leave the pond in spring they are thought to spend the summer months in and around Valleyfield Harbour. There they are often caught as bycatch in commercial fisheries for other species such as herring (*Clupea harengus*) and smelt. People in the area have no knowledge of seatrout being caught outside of this local area and so believe that they do not move long distances in the ocean. The fish that return to the brook in the fall are much fatter than the ones that leave in the spring, suggesting that in saltwater they feed heavily and add weight quickly. The fish plant in Valleyfield is thought to provide a major food source for the trout while they are in the harbour. Offal is discharged directly from the fish plant and also transported in large amounts via boat to the entrance to Valleyfield Harbour and dumped. The fish are also thought to feed on "sea worms" and other invertebrates while at sea.

The fish begin to migrate back to Southwest Pond and the brooks above it in late July. This migration continues well into September with the peak run occurring in August. There are reports of runs occurring as late as October but these runs appear to have disappeared in recent years. The migrating fish are thought to be the same ones that left the pond in the spring and therefore have only spent two to three months at sea.

Spawning is believed to occur in October or November. None of the informants had actually witnessed the fish spawning, probably because the angling season is closed in the fall and anglers are generally not near the brooks at this time. A number of possible spawning sites were identified based on where fish appear to remain into the fall. The first is in the area above Otter Pond known as Coakers Steadies. This area is characterized by fast flowing, shallow water with a mud and gravel substrate. The second location is in Black Brook a short distance above Southwest Pond. This area is characterized by fast flowing, shallow water with a sand and mud substrate. The smallest individuals that become sexually mature are around 9 inches in length (however one person reported seeing spawn in a fish as small as 4 inches).

2.2.4. *The Southwest Pond Seatrout Fishery*

There is a fishery for the seatrout in both freshwater and saltwater. The majority of the fish caught are angled with lure or fly, however there are reports of past (and probably present) illegal netting activity in saltwater and in the estuary. There is a large by-catch of trout in various traps for other species including capelin (*Mallotus villosus*), smelt and herring. The type of trap gear used makes it possible to release most of the trout unharmed, however the general feeling is that some fishermen illegally keep many trout.

Angling is most productive in freshwater when the fish are migrating to the ocean in the spring or from the ocean in the fall. Fishing effort is greatest in Southwest Pond, particularly at the inflow of Black Brook and at Headquarters, however fish can also be caught in Saltwater Pond, Little Southwest Pond, Otter Pond and Coakers Steadies. The fish are much harder to catch by angling in the fall and anglers suggest that this is because they have spent all summer at sea feeding and are not very hungry when they return to freshwater. In saltwater the seatrout can be angled during June, July and August from various places along the shores of Valleyfield Harbour. The two most heavily fished areas are the fish plant wharf in Valleyfield and the causeway to Greenspond. There is a fishery that takes place through the ice during winter in Southwest Pond. This fishery is mainly targeted at the large smelt population that inhabits the pond in winter, but seatrout can also be caught during this time. A number of people reported that Otter Pond is a good place to catch seatrout in winter.

A good day's catch was reported by most people to be between one and five seatrout, well below the current provincial bag limit of 12 fish. A number of people said they would be satisfied with catching only one fish if it was in the two-pound range. Two of the informants reported that a good day's catch would be the 12 fish limit, but one of these people suggested that he would be satisfied to release some of his catch (see Table 2.1).

2.2.5. *Problems Recognized by Anglers*

Anglers report dramatic changes in the population of seatrout in recent years (Table 2.1). Many anglers are concerned that a marked decrease in the numbers of adult fish returning to the brooks to spawn coupled with an almost total disappearance of large fish (greater than 45cm) is an indication that the population is in serious trouble. It is believed that the construction of the road to Greenspond in the 1970's was one of the events that has led to the problems being experienced today. The road was built along the southern shore of Southwest Pond and has greatly increased accessibility to the whole system. This has led to serious over-exploitation because the current regulations do not adequately protect the population. Over-exploitation resulting from increased accessibility is especially serious in the spring when the fish are migrating to sea. They are very easy to catch by angling at this time, probably because they are just beginning to feed as the water warms, and people feel that too many trout are caught before they get the chance to reach the saltwater. The fish are not very good to eat after spending all winter in freshwater and a number of informants

Table 2.1. Angler's responses to questions about fish sizes, changes in the population over time and what can be done to improve the fishery. No. years is the number of years experience fishing for the seatrout; Average Size is the size usually caught by anglers; Size to Sea is the size at which the fish first go to sea; Size Mature is the size at which first become mature; Size Large is the size at which the angler considers a seatrout to be large, Good Catch is what the angler considers to be a good day's catch.

#	No. Years	Average Size	Size to Sea	Size Mature	Size Large	Good Catch	Past Changes in Population	Reasons for Changes	Management Suggestions
1	20-25	18-20 in (herring size)	-	-	21 in	4-5 fish	-	-	2-3 fish/day bag limit
2	50+	1-3 lb (but varies)	1 lb	12 in	22 in	12 fish	Less fish	Netting at sea Greenspond road	Open later in the fall
3	50+	12-16in	6-7 in	9-10 in	20 in	3 fish	A lot less fish	Greenspond road	Stricter bag limits Fly fishing only
4	12	10in-1lb (but varies)	8-10 in	-	18 in	5-6 fish	A lot less fish No big ones left	Netting at sea Greenspond road Spring fishery	More enforcement
5	12	10-12 in (but varies)	10 in	3-4 in	18-20 in	1 fish of 1-2lb	A lot less fish	Netting at sea Greenspond road Spring fishery	Closed in spring More enforcement 4 year moratorium
6	25	1/2 lb (but varies)	8-9 in	10-12 in	22-23 in	1 fish > 2lb	A lot less fish No big ones left	Spring fishery Lack of enforcement	Closed in spring Stricter bag limits
7	50	12 in-2 lb	-	10-11in	17-20 in 3-4 lb	12 fish (catch & release)	A lot less fish	Netting at sea Greenspond road	Licensed Stricter bag limits
8	15-20	1 lb	4-5 in	3/4 lb	18 in	6 fish	A lot less fish No big ones left	Spring fishery Number of anglers	6 fish/day bag limit
9	30	30-38 cm	-	-	50 cm	2 fish	A lot less fish No big ones left	Netting at sea Number of anglers Lack of enforcement	Release large fish More enforcement

Table 2.1. Cont'd

#	# Years	Average Size	Size to Sea	Size Mature	Size Large	Good Catch	Past Changes in Population	Reasons for Changes	Management Suggestions
10	40	15-16 in (herring size) (but varies)	15-16 in (herring size)	12 in	22-23 in	1-2 fish	A lot less fish No big ones left	Greenspond road Eel fishery	License Enforcement No eel fishery
11	15	12-15 in	Smolt size	2 lb	30 in	2-3 fish (5 lb limit)	Less fish	Netting at sea Over fishing	Stricter quotas Licensed
12	15	-	-	-	-	-	Less fish	Netting at sea Poaching	-
13	20	1-2 lb	6-8 in	7-8 in	28 in	2-4 fish	Less fish No big ones left	Netting at sea Greenspond road Overfishing (spring)	Stricter bag limits No spring fishery No winter fishery
14	40	1-2 lb (but varies)	-	12in	5 lb	2-3 fish	A lot less fish No big ones left	Lack of management Eel fishery	Stricter bag limits
15	20	Up to 7 lb (but varies)	1-2 lb (herring size)	Smaller than a herring	10 lb	3-4 smaller fish or 1 herring size fish	A lot less fish	Netting at sea Greenspond road Eel fishery	Stop netting and poaching More enforcement

feel that it is wasteful to catch the fish at this time because the same fish can be caught in much better condition in the fall.

Anglers are concerned that they seem to be the only ones who care about the health of the population. They reported that there is little, if any, monitoring of fishing activity or enforcement of regulations on Southwest Pond. Almost every informant agreed that a new system of management is needed if the population is to survive. Suggestions from various people included a licensing system, stricter bag limits, angling seasons that more closely match the migrations of the fish, more monitoring of the fishery, size restrictions, and elimination of the winter fishery. There were very strong feelings among some informants that overfishing during the spring migration to the sea must be stopped. There was also a great deal of concern over illegal netting of the fish in Saltwater Pond and Valleyfield Harbour (Table 2.1).

A number of the anglers expressed concern over the effects of the eel fishery that takes place in the rivers during the fall. Their opinion was that placing eel nets across the brooks kills many juvenile seatrout along with juveniles of other species and prevents the migration of adults to the spawning grounds. Anglers feel that the regulations governing the eel fishery do not adequately protect other fish species and that existing regulations are not adequately enforced. Many anglers believe that the seatrout population will not recover until something is done to diminish the impact of the eel fishery on other species.

2.3. Synthesis of the Local Ecological Knowledge

The majority of the people exploiting the Southwest Pond seatrout population do so through the recreational fishery, although it appears as though bycatch in other fisheries also contributes to the harvest. All of the people interviewed were anglers whose experience fishing for the seatrout ranged from 12 years to over 50 years. There were a number of aspects of the ecology of the population about which anglers possessed very detailed knowledge. One area where anglers were very knowledgeable concerned the distributional range of the population in both freshwater and saltwater and the temporal change in distribution caused by migration. Anglers were able to provide information about fish size at first migration to the sea and first maturity, the range of sizes found in the population, and feeding habits. They were also quite knowledgeable about the fishery and provided information on spatial and temporal variation in fishing effort and relative catch rates, gear usage and average catch. The information provided by anglers about changes in population size and structure over time suggests that early reports of declining population health may be correct. The anglers were not only able to provide these valuable data but also had good insight into possible causes and were able to suggest a number of solutions to the problems being experienced there now. Anglers were able to provide detailed information on the physical description and characteristics of the seatrout. Although every person recognized the fish as being salmon-like, there was some disagreement over whether the fish is a salmon or a trout. This lack of a precise identification is not surprising given that taxonomists often have to rely on very detailed morphological or biochemical data to identify closely related species.

There were a number of aspects of the ecology of the population that anglers were not familiar with. Although they were able to provide information on the size of individual fish at various stages of the life cycle, they were not able to determine how old a fish of a given size is. Without this information the growth rates, age at maturity, and age structure of the population cannot be determined. Although the anglers were aware of large changes in the size of the population over time, they were unable or unwilling to estimate the actual population size. The information about spawning location may not be very accurate because no angler reported having actually witnessed the fish spawning. The information not available from anglers can be collected by more scientific means however, and the information gathered from anglers provides a valuable database from which to design a more formal study to collect the data.

There was a high level of consistency between anglers in their answers to most questions. There was some variability in the answers to questions in which respondents were asked about timing of migration or sizes of fish; most of the responses to these questions, however, included ranges of times or sizes and there was a great deal of overlap between anglers in their answers. Although all of the informants agreed that the size of the population has been decreasing, there was some disagreement over the current health of the population. Older anglers who had fished the population before the effects of overfishing became apparent tended to believe that the population was in worse shape than those who had never experienced the population at a time of greater natural abundance.

The findings of this study demonstrate that resource use does not have to be commercial or subsistence in nature for the users to accumulate ecological knowledge through their association with the resource over time. In the case of the Southwest Pond seatrout, the sustained recreational use of this local population has led to accumulation of local knowledge about a number of aspects of its ecology and fishery. Many fish populations exploited for recreational purposes may not experience such sustained use by mainly local people, however the results suggest that anglers utilizing the a fish population repeatedly over time will become knowledgable about certain aspects of its ecology and fishery. This finding has a number of implications for recreational fisheries research and management and demonstrates the validity and importance of including anglers in research and management right from the beginning of the process.

The knowledge possessed by the angler population represents the sum of numerous observations by various individuals over many years. The result is that some of the information gathered from anglers is much more detailed than can ever be obtained by sampling the fish population over the same time period. For example, a survey to collect data on the distribution and migration patterns of the population would involve time-consuming and expensive sampling in both freshwater and saltwater. This same information can be collected from anglers over a period of a few weeks with minimal cost. Given the knowledge that some anglers hold, angler input may prove to be quite useful in designing sampling strategies and interpreting the results of scientific work. This may be especially so in situations such as in Southwest Pond where little scientific information is available about a resource which is already being exploited. When anglers have objections to current or proposed management strategies, these objections may be based in part on their own understanding of the workings of the environment. Therefore it would be wise to attempt to understand angler viewpoints when such objections arise because the anglers' interpretations of potential outcomes may be based on a much wider database than that normally available to scientists or managers.

The results of this study highlight the value of communication between anglers and the individuals and agencies responsible for managing the fishery. Scientists and managers can learn a great deal from the resource users if they are willing to make the effort to collect and understand that knowledge. This study demonstrates that many of the anglers are knowledgeable about and interested in the resource, and therefore are probably willing to learn from managers and scientists as well. In many cases, however, a feeling of trust must first be developed between anglers and those responsible for research and management. Gathering the knowledge of anglers and incorporating it into the management process is an excellent method of building this trust and can be an important early step in building further communication between anglers and managers.

The data gathered in this study does not contain the total local ecological knowledge of the people who angle for the seatrout of Southwest Pond. Every person familiar with the population will have made and formed his or her own observations and conclusions. Furthermore, it is not likely that the total ecological knowledge possessed by one person could be gathered in a few, relatively brief contacts.

The data gathered in this study highlights the areas where anglers can be most helpful in gathering data, however information from anglers does not contain the answers to many of the major questions about the ecology of the population. Although the data provided in this chapter will prove to be very useful, more information about the ecology of the population is required if management is to be successful. The data collected in this chapter will be used to design a more scientific study of the population that will build on and complement the information presented here. Data from both sources will then form the database from which successful management can evolve.

CHAPTER 3: AUTECOLOGY OF THE SOUTHWEST POND SEATROUT

3.1. Introduction

3.1.1. *The Need for Biological Data*

The design, application and monitoring of a sustainable recreational fishery management plan requires knowledge of the biology and ecology of the species, population or stock to be managed. If sustainable exploitation is a goal of management, one important information requirement necessary to prevent over-exploitation is an estimate of the number of fish that can be removed by the fishery without negative impact. Making this estimate requires information about the population's size and production which in turn depend on recruitment, growth and mortality rates. Also important from a conservation viewpoint is knowledge of the habitat required by the population at all stages of the life cycle and knowledge of where or when fish are most vulnerable to fishing or other human activities and thus may require special protection. Beyond these minimum information requirements for resource conservation, scientifically collected data on an exploited population is necessary if the goal of management is to maximize the benefits that the recreational fishery provides. The ecological characteristics of a fish population must be assessed to determine the benefits, both in terms of fish yield and recreational experiences, that can be derived by anglers. Furthermore, if economic benefits are to be realized from a fishery it will be important to be able to define the product in terms that anglers relate to. These terms will include fish habits, numbers of fish available to each angler, size of fish in the catch, timing of the fishery, and habitat or environment to be fished.

The practice of managing recreational fisheries with harvest regulations is an accepted means of enhancing and protecting fish populations (Noble and Jones 1993) and is widely used to control the recreational harvest of fish in Newfoundland. The effectiveness of individual regulations at protecting or enhancing a fishery will depend in part on the biological and ecological characteristics of the population being managed. For example, slot limits to protect fish of a certain size to allow them to be caught at a more desirable larger size will be counter-productive if the increased density of fish in the protected size range results in reduced growth that keeps them from reaching the desired size. Management with regulations is therefore more likely to be successful if regulations are chosen with consideration of how they will interact with the ecological characteristics of the exploited population.

In the above example, data on length and age distribution, growth rate, and density dependent effects on growth rate require evaluation before such a regulation is implemented. After regulation began, the parameters would then need to be monitored, along with other parameters such as abundance, recruitment and fish condition to determine whether the new regulation is having the desired effect.

Time series of detailed biological and ecological data can be used to study the dynamics of exploited populations. The field of population dynamics involves the study of rates of growth, mortality and recruitment within a population and how these rates change with exploitation. Studies of population dynamics often lead to models that predict fish yield at various stock densities or rates of fishing. In Newfoundland, stock recruitment relationships for anadromous populations of Atlantic salmon are used to predict the adult stock size that maximizes recruitment and thus, the number of fish available to the fishery. Constructing these stock recruitment relationships requires data on adult and smolt numbers, sex ratios of adults, number of eggs per adult female, and an estimate of the production potential of various habitat types and the relative abundance of these habitats within the river system (O' Connell and Dempson 1995). Population dynamics and associated yield models play a crucial role in managing commercial fisheries where the object is usually to obtain the maximum sustained yield (MSY) from the fishery. Although the goal of managing recreational fisheries is to derive benefits beyond MSY, knowledge of the dynamics of an exploited population is important for predicting the effects of harvesting fish through recreational fisheries and may prove useful for setting harvest levels to maximize the overall benefits derived from individual fisheries.

3.1.2. *Data Requirements and the Southwest Pond Seatrout*

Data requirements for managing recreational fisheries usually include, but are not limited to; growth of individuals, feeding habits, migration, mortality (both fishing and natural), reproduction (sex ratios, fecundity, recruitment, age at maturity), abundance, size (length and age frequency distribution, condition), habitat requirements and the production potential of the habitat. The Southwest Pond seatrout is a unique case because, while it already supports an expanding recreational fishery, no data have been collected concerning its biology, ecology or life history. Before any effort can be made to study the size of the population, its recruitment or mortality, or to study its dynamics, research must be first directed at gathering basic information about the population such as its range and distribution, migrational habits, growth, age at maturity, and fecundity. Accurate identification of the species will also be important because it will allow new data to be evaluated against to other information available about the species. Some of these important initial data were collected through the LEK study of Southwest Pond anglers and this information can now be built on through direct study of the fish population. The purpose of this chapter is to provide data on a number of aspects of the ecology, biology and life history of the Southwest Pond seatrout. The data to be reported includes size frequency, age and growth rates, age at maturity, migration, sex ratio, condition, fecundity and species identification.

3.2. Materials and Methods

3.2.1. *Field Procedures*

Sampling of the Southwest Pond seatrout population was conducted from May to October 1995 and July to October 1996. Information gathered from anglers through the LEK study (section 2.2.3) suggested that there are three distinct phases of the life history of the population that support three separate fisheries. The survey was designed to sample each in turn; migration to the sea in the spring (sampled in May 1995), the saltwater phase (sampled in June and July 1995), and the spawning migration to freshwater in the fall (sampled during the periods of July to October 1995 and July to October 1996).

Sampling sites were chosen based on information about the distribution of the population obtained from anglers in the LEK survey and additional sites were sampled periodically to test the accuracy of the information. The locations of all sites sampled are shown in Fig. 3.1. Sampling during the seaward migration in the spring was conducted from the southern shore of Southwest Pond (site 1). Sampling in the sea during summer was conducted at locations on the Greenspond causeway (site 17), the western shore of Greenspond Island (site 19), the site of the old fish plant on Pool's Island (site 18), the southern shore of the Southwest Arm of Valleyfield Harbour (site 16) and Saltwater

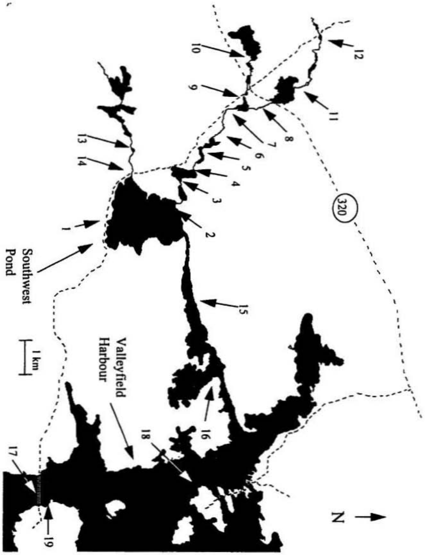

Figure 3.1. Map of the Southwest Pond river system and Valleyfield Harbour showing the sites sampled throughout the survey.

Pond (site 15). Sampling during the spawning migration in the fall was conducted throughout Southwest Pond (but mainly at Headquarters (site 2) and the mouth of Black Brook (site 14)), Little Southwest Pond (site 3), Coakers Steadies (sites 4 and 5) and areas in the upper reaches of both Black Brook (between sites 13 and 14) and the stream above Coakers Steadies (sites 6 to 12).

Angling with bait was used to sample fish during both the spring survey in Southwest Pond and the summer survey in the ocean and angling with an artificial fly was used during the fall migration. A fyke net was placed in Southwest Pond at Headquarters from September 5 to September 10 1995; its use was later discontinued as it was found to be much less efficient than angling. All sampling occurred during daylight hours which was usually between 8am and 9pm. All fish captured were measured for fork length (FL, to the nearest 0.5 cm) and the date and location of capture were recorded. Most fish were released unharmed, although a random subsample of fish was collected throughout the survey for subsequent detailed analysis.

Data on individual fish were also collected by sampling the catch of anglers fishing for the seatrout. This method of data collection could possibly produce a biased sample, especially if anglers are selective in the fish that they retain. However, few of the anglers whose catch was sampled reported releasing any of their catch. Assuming that differences in angler skill level do not significantly influence the selectivity of angling, this method was probably sufficient to produce a non-biased sample. Fish in the catch of anglers who agreed to cooperate were measured for fork length (FL, to the nearest 0.5 cm) and weight (W, to the nearest 0.1 g) in 1995 and length only in 1996. When possible, the heads of these fish were collected for removal of otoliths for age determination. Six anglers who participated in the LEK survey were provided with a log book and agreed to record their fishing activity, number of fish caught (including releases) and, when possible, the length of each fish. They were also asked to freeze the heads of all retained fish and turn these in with the completed log book at the end of the fishing season. All of the log books were returned at the end of the 1996 fishing season and a number of anglers also provided frozen whole fish for further analysis.

3.2.2. *Laboratory Procedures and Data Analysis*

All whole fish retained throughout the survey (n=48) were immediately frozen in the field and then returned to the lab where they were stored, along with the fish and heads turned in by anglers, at -10°C for up to 4 months. Immediately prior to further analysis, all fish were thawed at room temperature and their fork length (FL, to the nearest mm), head length (HL, from the tip of the snout to the farthest opercular edge to the nearest 0.1 mm) and weight (W, to the nearest 0.1g) measured. A scale sample was removed from the left side of each fish from an area between the lateral line and the dorsal fin and later used in age, growth and migration history analysis. Each fish was dissected and its sex determined by examination of the gonads. Ovaries from mature females (n=14) were fixed in 10% formalin and then stored in either 10% formalin or 85% ethanol. Eggs were separated from the surrounding ovarian tissue and the total number of ripening eggs in each ovary was counted.

Length and weight data were collected from an additional 35 fish sampled throughout the survey. Condition of each fish for the total of 83 individuals was estimated by Fulton's condition factor ($K=W/L^3$). Analysis of variance was used to test for differences in condition between fish in the spring sample and fish in the fall sample. Fish caught in saltwater during the summer were excluded from this analysis due to the small sample size obtained.

Using data on head length and fork length collected from the 48 individuals retained and an additional 52 individuals sampled from anglers, a predictive linear regression equation was calculated to allow fork length to be estimated from head length. This equation was then used to calculate an estimate of the fork length of individual fish from heads that were collected from anglers throughout the survey (n=66).

Eight fish were randomly selected from the fall 1996 sample and subjected to genetic analysis. While the fish were still frozen, a 1-2 g flesh sample was removed from the left side immediately posterior to the dorsal fin. The frozen samples were placed in sterile 15 ml tubes and delivered to Bio-ID Corporation at Memorial University. A 100 mg subsample was taken from each of the 8 flesh samples and subjected to the DNA typing procedure known as Forensically Informative Nucleotide Sequencing (FINS). Through this process, DNA was extracted from the sample and a specific segment of the isolated DNA amplified. The nucleotide sequence of the amplified DNA was determined and a phylogenetic analysis was carried out on this sequence to determine the closest relative in a database of known nucleotide sequences of salmonid fish.

Scales removed from the fish prior to dissection were stored dry in paper envelopes. A subsample of scales was removed from each sample and any regenerated scales (i.e. those lacking a distinct nucleus) in this subsample were removed while viewing under a dissecting microscope at 18X magnification. The remaining scales were then cleaned and mounted between two glass slides to facilitate age determination. The circuli pattern on the scales was viewed using a scale projector at 50X magnification. Annular growth checks indicating reduced growth during winter periods were discerned using the criteria defined by Power (1969), and the age of the fish at capture was estimated by counting the number of annuli on the scale. Sea growth was distinguished from freshwater growth by the presence of widely spaced circuli on the scale and areas on the scale where sea growth was evident were recorded.

From each sample, three scales that showed the clearest distinction between winter and summer growth were selected and the distance from the scale focus to each annulus and to the scale margin was measured (to the nearest 0.02mm) along the longest oral radius of each scale. In cases where measurements on one of the three scales varied widely from the other two this scale was discarded and the average of the other two was used. When measurements taken on the three scales varied widely the three scales were discarded and three more scales were selected for measurement. Linear regression was used to calculate the relationship between scale radius and fork length for all scales measured. This equation was then used to estimate fork length of at the time each annular mark was formed on each scale. The estimated fork length at each age for each fish was determined by averaging the length estimated by the two or three scales measured from each fish.

Sagittal otoliths extracted from fish sampled in the survey were stored dry in glass vials until age determination. Otoliths were placed in a container containing glycerin and viewed on a black background with a binocular dissecting microscope using transmitted and reflected light at 12X to 25X magnification. When viewed in this manner clear borders were observed between hyaline and opaque zones radiating outward from the nucleus. Of the 154 otoliths examined, 150 (97.4%) were readable. Otoliths from fish caught in the spring had a hyaline zone on the outer edge and otoliths from fish caught in the summer and fall had an opaque zone on the outer edge. It was therefore concluded that opaque zones are deposited during periods of rapid growth in the summer and hyaline zones are deposited during periods of slow growth in the winter. Assuming that these fish hatch in the spring, as do other salmonids in Newfoundland, a full year of growth would be represented by a hyaline zone followed by an opaque zone. The age of each fish was therefore estimated by counting the number of hyaline zones deposited after the first summer.

A subsample of 27 fish was selected for analysis of otolith microchemical characteristics as indicators of the migrational histories of these individuals. Also included in this analysis were otoliths from three anadromous Atlantic salmon sampled from the Humber River on the east coast of Newfoundland in 1995. Data collected from the Humber River samples were used to compare the migrational histories of the Southwest Pond seatrout to the migrational history of a typical anadromous Atlantic salmon in Newfoundland. The rationale, procedures and results of this analysis will be described separately in section 3.4.2.

3.3. Survey Results

3.3.1. *Results of the Spring Survey*

Sampling during the seaward migration in the spring was conducted at site 1, however fish caught by anglers fishing in other areas of Southwest Pond were also sampled. Seatrout were abundant in Southwest Pond at the beginning of the spring sampling period (May 6, the opening day of trouting season) and were easily caught by anglers. By May 28, however, the seatrout had disappeared from the Southwest Pond river system and, although the trouting season remained open, most anglers had ceased fishing. No data on the fish were collected in the spring of 1996, however during a survey of anglers fishing on Southwest Pond conducted at this time seatrout were observed to be abundant in Southwest Pond from the opening of the trouting season (May 6) until the last week in May.

Ninety-two fish were sampled during the spring survey. The minimum data collected from each fish were fork lengths. Otoliths for age determination were obtained from 61 of these individuals, weight was obtained from 41 of these individuals and eight of these individuals were retained whole for further analysis. The samples ranged in fork length from 21.1cm to 59.4cm with a mean of 30.2 cm. The length frequency distribution of all fish sampled in the spring survey is shown in Fig 3.2. The age of the 61 fish from which otoliths were obtained ranged from four to eight years with the modal age being four years. There was a great deal of variation in length within each age class resulting in a large overlap in the range of sizes at each age. Length at age data and the number of fish sampled from each age class are given in Table 3.1. The mean condition factor of fish sampled in the spring was 0.84 (n= 41, max.= 1.07, min.= 0.68). All of the fish were immature, but many of the females were observed to have small eggs beginning to develop in the ovaries, suggesting that these fish would mature later in the same year.

Table 3.1. Mean length (L) at age and the range of sizes within each age for fish sampled in the spring survey

Age	n	Mean L	Min L	Max L	Std
3	1	21.5	-	-	-
4	47	29.4	16.4	37.9	3.8
5	15	32.9	26.4	43.5	4.5
6	1	40.5	-	-	-
8	1	59.4	-	-	-

Data collected on all fish retained during the spring survey (n=8) are included in Table 3.3.

3.3.2. *Results of the Summer Survey*

The saltwater environment was sampled during the summer of 1995 at site 15 in Saltwater pond and sites 16, 17, 18 and 19 in Valleyfield Harbour. Sampling in saltwater was not very successful and only 15 fish, including 5 from the catch of anglers fishing from the Greenspond causeway, were sampled during June and July. The mean length of the 15 fish was 20.1 cm, much less than the mean length in both the spring and fall samples, suggesting that the summer sample is not representative of the population. All of the fish sampled in saltwater were immature except one age 3+ male sampled from an angler on June 27 (FL = 20.6cm). The gonads of this fish were turning white and were slightly swollen, indicating that it would possibly mature later in the fall. The data collected from all fish retained in the summer survey (n=10) are included in Table 3.3.

The 15 fish in the summer sample included four immature parr taken from Saltwater pond on June 14. A large number of parr in the range of eight to 18 cm were

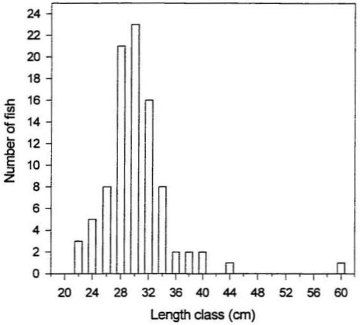

Figure 3.2. Length frequency distribution of all seatrout sampled during the spring survey.

observed in Saltwater Pond throughout June and July 1995 and 1996, indicating that the juvenile fish make extensive use of this estuary at least in the summer.

The poor sampling results in saltwater are probably due to a number of factors including the large area of Valleyfield Harbour and the inaccessibility of many areas of the shore line. Information from anglers that many fish are caught in capelin and smelt traps throughout the harbour suggests that sampling in saltwater could be improved by using trap gear rather than angling.

3.3.3. *Results of the Fall Survey*

Sampling of fish making the spawning migration back to freshwater in the late summer and fall began on July 15 in 1995 and July 25 in 1996. In 1995 seatrout were first observed in Southwest Pond on August 18 when a number of trout were seen at Headquarters. Reports from anglers fishing the week prior to this date suggested that the migration began around August 10-15. In 1996 there were seatrout already at Headquarters when the survey began on July 25 and anglers reported seeing trout in Southwest Pond as early as July 15. Reports from anglers in both years and information gathered in the LEK survey (Section 2.2) indicate that the run in 1995 was later than usual.

Seatrout were observed in Southwest Pond throughout the fall survey but seemed to congregate mainly where water flowed into the pond at Black Brook and at Headquarters. Shortly after the seatrout appeared in Southwest Pond they also were observed in Little Southwest Pond and Coakers Steadies where they could be found throughout the fall surveys. The furthest point upstream where seatrout were observed was at site 7 where three trout were sampled on September 10, 1995. Sites 8 to 12 and sections of the brook between sites 7 and 12 and sites 9 and 10 were sampled between August 28 and 30, 1995, and October 5 and 8, 1996, however there was no evidence that the seatrout had migrated this far upstream. Site 13 and all sections of Black Brook below were sampled on August 25 in both 1995 and 1996. There was no evidence that the seatrout had migrated past the point where the road crosses Black Brook immediately above Southwest Pond. It is possible that the fish do not migrate any further up Black Brook, however it is also possible that they had either migrated past site 13 before it was sampled or the fish may not migrate further into the brook until later in the year.

Spawning of seatrout was not observed in either 1995 or 1996. A number of fish sampled on Oct 15, 1995 were in very ripe condition and would have spawned very

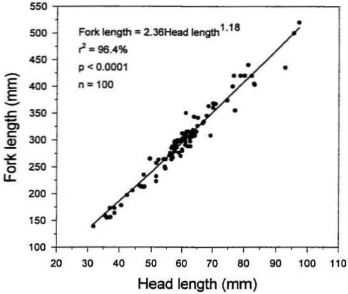

Figure 3.3. Plot of fork length against head length for 100 seatrout sampled during the spring, summer, and fall surveys. The regression equation was used to estimate individual seatrout fork lengths from the lengths of seatrout heads collected from anglers throughout the survey.

shortly after that date. Most sections of the river above Southwest Pond as far as site 12 and Black Brook as far as site 13 were surveyed for possible spawning habitat 1995 and 1996. A small amount of suitable habitat was observed between site 6 and site 7, however no suitable habitat was observed in Black Brook above site 14. There are large gravel shoals in Southwest Pond itself at both Headquarters and the Black Brook outlets and in the short section of Black Brook between the pond and the point where it crosses the highway. Although spawning was not observed, fish were observed at these sites throughout most of the fall surveys. It is possible that these locations are important spawning locations for the seatrout.

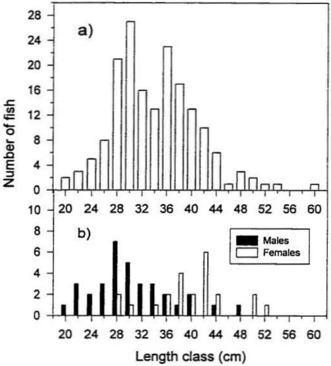

Figure 3.4. Length frequency distribution of (a) all seatrout sampled during the fall survey and, (b) the subsample of seatrout sampled in the fall for which sex was determined

Data on both fork length and head length were obtained for 100 seatrout throughout the entire survey. Linear regression revealed a strong and significant relationship between fork length and head length (Fig. 3.3). This relationship was used to estimate the fork length of 64 seatrout from heads turned in by anglers at the end of the fall surveys. The total number of fish sampled in the fall survey was 173. Minimum data collected from each fish was fork length. Otoliths were obtained for age determination from 72 of these individuals, sex was determined for 57 of these individuals, and weight was obtained from 42 of these individuals. Fork length of fish sampled in the fall ranged

Table 3.2. Mean length (L) at age and the range of sizes within each age for fish sampled in the fall survey

Age	n	Mean L	Min L	Max L	Std
3+	12	24.9	19.7	28.8	3.09
4+	41	34.3	24.7	42.0	4.75
5+	15	36.9	23.2	44.0	5.79
6+	4	49.6	48.5	51.0	1.10

from 21.3cm to 60.0cm with a mean of 34.1cm. Sex was determined for a subsample of 57 fish. Twenty-three (40%) were female and 34 (60%) were male. The majority of these fish were mature however this subsample did include two immature females (FL = 34.2cm and 30.0cm) and three immature males (FL = 26.4cm, 27.6cm and 31.0cm), representing 8.7% of the subsample. The length frequency distribution of all fish sampled during the fall survey is shown in Fig. 3.4a and the length frequency of the subsample of 57 fish for which sex was determined is shown in Fig. 3.4b. Both of these length frequencies show a bimodal shape. The mean length of all fish sampled in the fall survey was 34.1 cm; the mean length of males was 30.4 cm, significantly less than the mean length of females at 39.6 cm (ANOVA $p<0.0001$).

Age was determined for 72 of the individuals sampled in the fall. The ages of these fish ranged from 3+ to 6+ years with the modal age being 4+ years. Length at age data and number of fish sampled from each age class are given in Table 3.2.

Egg counts were performed on the ovaries of 14 female seatrout. Fecundity of females ranged from 544 to 2226 eggs per fish. Linear regression revealed a significant effect of fork length on female fecundity.(Fig. 3.5). The number of eggs per centimeter of fork length ranged from 19 eggs/cm to 54 eggs/cm with a mean 34.2 eggs/cm. The

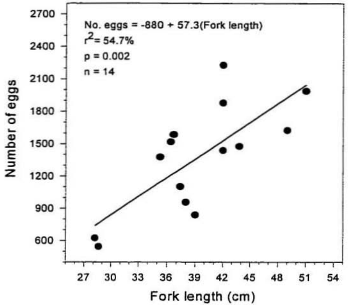

Figure 3.5. Plot of total fecundity against fork length for 14 mature female seatrout sampled during the fall survey

mean condition factor of fish sampled in the fall was 1.23 (min=0.86, max=1.47, n=42), significantly greater than the mean condition factor of 0.84 of the fish sampled in the spring (ANOVA, $p<0.0001$). Data collected on all fish retained in the fall surveys are included in Table 3.3.

The DNA extraction performed on the eight fish samples yielded sufficient amplified product for analysis. The nucleotide sequences obtained from all eight fish were identical and were compared with DNA sequences contained in the data base of the Bio-ID Corp. The nucleotide sequences obtained from the eight samples were consistent with them being identified with very little doubt as Atlantic salmon (*Salmo salar*) (Bartlett and Davidson, Bio-ID Corp).

Table 3.3. Sample number (Sam.), date and location (Loc.) of capture, length, weight, age, age at smoltification (Sm. Age), number of summers spent at sea (Sea Sum.), sex and maturity state of all fish analyzed throughout the spring, summer and fall surveys. Swp is Southwest Pond, VH is Valleyfield Harbour and Est. is Saltwater Pond.

Sam.	Date	Loc.	Length (cm)	Weight (g)	Age	Sm. Age	Sea Sum	Sex	Maturity state
F47	April 97	Swp	28.0	174.3	4	3	1	M	immature
F1	May 95	Swp	31.8	241.0	4	3	1	F	maturing
F2	May 95	Swp	28.3	179.8	4	3	1	F	maturing
F3	May 95	Swp	22.8	101.6	4	3	1	M	maturing
F4	May 95	Swp	25.8	115.8	4	3	1	M	immature
F5	May 95	Swp	23.8	99.6	4	3	1	M	maturing
F16	May 95	Swp	26.4	176.1	5	4	1	M	immature
F22	May 95	Swp	27.3	173.3	4	3	1	F	maturing
A5	May 95	Swp	40.5	n/a	6	3	2	F	spent
A9	May 95	Swp	43.5	n/a	5	n/a	n/a	M	spent
A25	May 95	Swp	36.8	377.7	5	4	1	n/a	n/a
A51	May 95	Swp	59.0	n/a	8	3	5	M	spent
F11	June 95	VH	17.3	53.7	3+	3	0.5	F	immature
F12	June 95	VH	17.3	45.2	3+	3	0.5	F	immature
F13	June 95	VH	17.8	62.0	4+	4	0.5	M	immature
F14	June 95	VH	13.9	27.0	3+	3	0.5	M	immature
F15	June 95	VH	21.5	99.4	3+	3	0.5	F	maturing
F18	June 95	VH	21.3	109.8	4+	4	0.5	F	maturing
F19	June 95	VH	20.6	98.0	3+	3	0.5	M	maturing
F27	June 95	Est.	15.9	42.3	3+	-	-	F	immature
F28	June 95	Est.	15.5	40.1	3+	-	-	F	immature
F29	June 95	Est.	15.6	43.2	3+	-	-	M	immature
F30	June 95	Est.	16.4	52.4	4+	-	-	M	immature
F6	Aug. 95	Swp	30.9	374.9	4+	4	1	M	mature
F7	Aug. 95	Swp	30.6	358.1	4+	4	1	M	mature
F8	Aug. 95	Swp	28.2	285.6	4+	n/a	3	M	mature
F9	Aug. 95	Swp	34.2	474.3	4+	3	2	F	mature
F10	Sept. 95	Swp	36.7	630.4	4+	3	2	F	mature
F17	Sept. 95	Swp	19.7	93.6	3+	3	1	M	mature
F20	Sept. 95	Swp	33.4	456.6	4+	3	2	M	mature
F21	Sept. 95	Swp	28.0	252.5	3+	3	1	M	mature
F23	Sept. 95	Swp	35.5	640.3	5+	4	2	M	mature
F24	Sept. 95	Swp	28.6	297.6	4+	3	2	F	mature

Table 3.3. Cont'd

Sam.	Date	Loc.	Length (cm)	Weight (g)	Age	Sm. age	Sea Sum.	Sex	Maturity state
F25	Sept. 95	Swp	37.4	691.8	5+	4	2	F	mature
F26	Sept. 95	Swp	40.3	873.7	4+	3	2	M	mature
F31	Aug. 96	Swp	29.7	335.6	4+	4	1	F	immature
F32	Aug. 96	Swp	30.0	296.4	4+	4	1	M	mature
F33	Aug. 96	Swp	22.3	129.8	3+	3	1	M	mature
F34	Aug. 96	Swp	28.8	297.0	4+	4	1	M	mature
F35	Aug. 96	Swp	28.8	307.8	4+	4	1	M	mature
F36	Aug. 96	Swp	27.6	286.7	4+	4	1	M	immature
F37	Aug. 96	Swp	26.4	207.2	3+	3	1	M	immature
F38	Aug. 96	Swp	23.2	161.1	5+	5	1	M	mature
F39	Aug. 96	Swp	27.0	254.7	3+	3	1	M	mature
F40	Aug. 96	Swp	27.1	273.0	3+	3	1	M	mature
F41	Aug. 96	Swp	26.7	246.7	4+	4	1	M	mature
F42	Aug. 96	Swp	25.0	205.1	3+	3	1	M	mature
F43	Aug. 96	Swp	21.3	126.4	3+	3	1	M	mature
F44	Aug. 96	Swp	29.1	336.7	4+	4	1	M	mature
F45	Aug. 96	Swp	24.7	208.8	4+	4	1	M	mature
F46	Aug. 96	Swp	21.3	141.7	3+	3	1	M	mature
G1	Aug. 96	Swp	38.0	632.7	5+	4	2	F	mature
G2	Aug. 96	Swp	33.5	504.2	4+	3	2	M	mature
G3	Aug. 96	Swp	31.3	365.0	5+	4	2	M	mature
G6	Aug. 96	Swp	33.7	474.1	4+	2	3	M	mature
96-7	Sept. 96	Swp	51.0	1336.7	6+	n/a	n/a	F	mature
96-8	Sept. 96	Swp	49.0	1291.9	6+	4	3	F	mature
96-9	Sept. 96	Swp	48.5	1017.5	6+	3	4	M	mature

3.4. Growth and Migration Results

3.4.1. *Information from Scales*

The scales of the 48 individuals retained throughout the survey were examined for age, growth and migrational characteristics. There was not always a clear distinction between winter and summer growth, especially at younger ages, making recognition of annuli difficult on many scales. The first annulus was absent from the scales of some individuals and often difficult to discern in others. When present, the first annulus was usually only three to four circuli from the nucleus. Absence of the first annulus may have been caused by its failure to form due to the growth rate of the fish, however it may also have been a result of scales being sampled from an area on the fish that does not contain the site of first scale formation (Power 1969). Absence of the first annulus will result in the age obtained from the scale being one year less than the actual age of the fish, therefore ages obtained from scales lacking the first annulus were adjusted upward by one year. After adjustment, scale age agreed with otolith age in 44 out of 46 individuals (95.7%). When scale and otolith age differed, the otolith age was taken to be correct because aging from otoliths tended to be less ambiguous than aging from scales.

Although annuli at early ages were difficult to discern, almost all scales showed an obvious and marked transition between slow juvenile growth and more rapid adult growth after which annuli, when present, were easily discernable (as per Power 1969). This transition, which occurred shortly or immediately after a winter, was most likely due to smoltification with the subsequent rapid growth almost certainly occurring in saltwater. One 'year' of sea growth consisted of 8-15 well spaced circuli with a total width of about one quarter or less of the total radius of the scale. This relatively small amount of sea growth indicates a short saltwater growth period, probably only the length of one summer. Smoltification, as indicated by the marked increase in growth rate, occurred at age three in 26 individuals, age four in 16 individuals, age five in one individual and was not observed to have occurred in 6 individuals.

All of the fish sampled in freshwater had previously migrated to sea at least once and sometimes twice. The circuli pattern on the scales of all of the eight fish examined from the spring survey (mean FL = 26.8cm) indicated one summer of sea growth prior to capture. Seven of these individuals were 4 years old and one was 5 years old. These individuals had smolted the previous spring and migrated to sea where they spent one summer before migrating back to freshwater to overwinter. It is possible that some of these fish had matured and spawned the previous fall, however spawning marks were not observed on scales from any of these fish. It is likely that all eight fish would have migrated back to sea again the following summer. The gonads of five of the eight fish were beginning to mature, indicating that at least these fish would have returned to freshwater and spawned later in the year.

Twenty-one of the fish analyzed from the fall also had only one summer of sea growth on their scales. These individuals had smolted the previous spring and were returning from their first summer at sea when captured. These fish ranged from 3+ years old to 5+ years old. Eighteen of the individuals (mean FL = 26.6cm) were mature and would have spawned later that fall, however three individuals (mean FL = 29.0) were immature and would not have spawned that year. Scales of six individuals sampled during the migration back to freshwater in the fall (mean FL = 34.9 cm) had two summers of sea growth representing two consecutive summers at sea with the intervening winter spent in freshwater. Four of these individuals were 4+ years old and had smolted at age 3 and two of the individuals were 5+ years old and had smolted at age 4. Five of these individuals were mature and would have spawned later that fall, however one 4+ individual was immature and would not have spawned. It is possible that some of these individuals had spawned the previous fall after their first migration, however spawning marks were not observed on any of the scales from these individuals.

The scales of one mature 5+ female sampled in the fall (sample F8) did not show any post-smolt growth although there was evidence of enhanced growth in the final one or two summers of life. This individual was somewhat silvery in appearance suggesting migration to the sea, however this silvering was not as intense as in other individuals sampled in the fall and the size of this fish was less than other 5+ individuals. This individual also had brown fins like those of a juvenile in the parr stage which indicated that it may not have smolted or may have been a resident. Given these conflicting observations it is difficult to determine the migrational history of the fish based on these data alone.

The scales of the seven fish analyzed from Valleyfield Harbour in the summer (mean FL = 18.1 cm) showed only the beginning of sea growth, revealing that these fish had smolted the previous spring and recently migrated to sea. Four of these individuals were 3+ years old and the other three were 4+ years old. The scales of the four parr sampled in the Saltwater Pond estuary did not show any post-smolt growth, confirming that these individuals were indeed still in the parr stage.

Scales of at least 26 of the 46 individuals showed increased growth marked by wider than normal circuli in one or more of the pre-smolt years of life. Observations of parr in Saltwater Pond suggest that this increased growth may be due to migration of parr to the estuary, however the circuli spacing during these periods was not as wide as during post smolt growth making it difficult to determine whether this growth occurred in freshwater or saltwater. Because it was not known exactly what this growth represents or how reliable it is at characterizing the migrational habits of the fish it was not used to attempt to reconstruct movements of individual fish in the pre-smolt phases of the life cycle.

Length-at-age back-calculated from the scales of the 45 individuals and length at age of capture from all fish sampled throughout the survey are plotted in Fig. 3.6. For the purpose of measuring annuli, the location of the first annulus was estimated on scales where it was not evident. Back-calculated lengths consistently underestimated the length

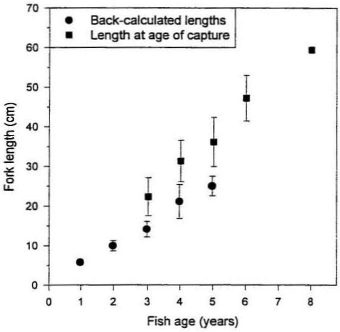

Figure 3.6. Average length at age of capture and average length at age back-calculated using scales of Southwest Pond seatrout. Back-calculated lengths consistently underestimated length at age of capture therefore back-calculated lengths were not included in further analyses.

at each age relative to the length at age of capture. It is assumed that length at age of capture is more reliable because the length of the fish was obtained by direct measurement of fork length or head length. The unreliability of the back calculation method may have been due to a number of factors including the difficulty distinguishing between summer and winter growth, failure to find the first annulus on some scales or the small sample size used.

3.4.2. *Information from Otolith Microchemistry*

Fish otoliths can act as storage units for a wide range of environmental information, revealing past growth rates as well as important life history and environmental transitions (Radtke 1984; Townsend *et al.* 1989). A relatively new technique for extracting information from otoliths is the analysis of microchemical characteristics by electron microprobe techniques to reconstruct past environmental and life history events of individual fish. Most fish otoliths are composed of aragonite which is deposited rhythmically in alternating protein-rich and carbonate-rich layers as the fish grows (Degens *et al.* 1969). Trace elements can contaminate the aragonite deposited in the otolith during formation and, due to its similar valence (2+) and ionic radius (Sr = 0.113 nm, Ca = 0.099 nm), strontium is one of the more common trace elements found in otoliths. The quantity of strontium deposited in the otolith is directly related to the quantity of strontium in the endolymph surrounding the otolith (Kalish 1989), which in turn depends on a number of physiological and environmental factors.

One of the more important environmental factors affecting the concentration of strontium deposited in the otolith is the salinity of the water in which the fish is living. Large differences in Sr/Ca concentration have been found when comparing otoliths of fish sampled from freshwater and marine environments due to the much lower concentration of Sr in freshwater (0.07 ppm) than in saltwater (8 ppm). Differences in environmental concentration of strontium reflected in the portions of the otolith deposited in each environment have been used to reconstruct the migrational histories of individual fish from diadromous populations (Casselman 1982; Radtke *et al.* 1988; Kalish 1990; Secor 1992; Rieman *et al.* 1994; Limburg 1995; Radtke *et al.* 1996). The main purpose of the following research was to use trace element analysis of otoliths to provide migrational data about individual Southwest Pond seatrout. By correlating microchemistry data with otolith macrostructure (i.e. annuli) it should be possible to determine the timing and duration of each seaward migration of individuals prior to capture. This information, combined with data from scale analysis and length and sex data collected from the fish, can be used to reconstruct the life history of individuals and examine variation in life-history within the population.

3.4.2.1. Application of the Microprobe Technique

Analysis of Sr/Ca concentration in sagittal otoliths from 27 seatrout and three typical Atlantic salmon was performed at the School of Ocean and Earth Sciences and Technology, University of Hawaii. Otoliths of Atlantic salmon from the Humber River were analyzed to allow the typical Atlantic salmon life history to be compared to the life history of the Southwest Pond seatrout. The samples were prepared for analysis by mounting each otolith on a 2.5 cm diameter glass disk and then grinding on the distal surface to reveal a section through the core region. A wavelength dispersive electron microprobe was used to obtain quantitative measurements of strontium and calcium concentration along a transect across the ground surface of the otolith. This analysis involves bombarding the sample with a narrowly focused electron beam and measuring the wavelength and energy dispersion of the resultant X-rays. The X-ray wavelength and energy dispersion are related to the identity and quantity of the element being analyzed, in this case strontium and calcium, and therefore can be used to measure the concentration of these elements at specific points on the sample. Further details about the analytical conditions and procedure can be found in Radtke *et al.* (1996). Strontium and calcium concentrations were recorded at a series of 90 to 120 data points (depending on the length of the transect followed) spaced at approximately 10 m increments along a transect from the core to the edge of the dorsal lobe. X-ray intensities were corrected and computed using the ZAF method (Reed 1975) and final elemental concentration presented as ratios of weight percentages. Relative measurement error percentages were measured according to Radtke *et al.* (1996). Measurement error values were in the range of 3% to 5%. Strontium and calcium concentration ratios were multiplied by 10^3 for graphical presentation.

After the microprobe analysis was complete the otoliths were returned to Memorial University for correlation of otolith macrostructure with microprobe data. The otolith preparations were cleaned with ethanol to remove the carbon coat applied prior to microprobe analysis. The samples were then examined under a binocular dissecting microscope at 75X magnification to reveal both annuli and the burn mark left by the microprobe. Because grinding increased the transparency of the otoliths, the right, unground, otolith was also viewed under the same conditions to ensure that annuli on the ground (microprobe) sample were correctly identified. Measurements along the microprobe scan line, from the outer to the inner margin of each successive opaque and hyaline zone, were taken to the nearest m. The position of the hyaline and opaque zones were correlated to the analysis points from the microprobe data which allowed ages to be assigned to the microprobe analysis points and provided a time series of environmental history for each fish.

3.4.2.2. <u>Patterns in Sr/Ca Concentration</u>

Inspection of the distal face of Southwest Pond trout sagittae using transmitted and reflected light revealed clearly defined annuli within most otoliths. Sagittal otoliths of Southwest Pond seatrout were morphologically different from sagittal otoliths of the Atlantic salmon sampled from the Humber River. The outermost opaque zones of the otoliths from the Humber River salmon were very wide (up to half the width of the otolith in some areas), thick, and heavily calcified on the distal surface. This heavily calcified zone appears to be formed during the full year of post-smolt growth at sea that these salmon typically experience. This zone was absent from most of the Southwest Pond seatrout sagittae. There was a small amount of thickening observed on the margin of some of the seatrout otoliths, however the zone that contained it was much narrower and the calcification much less extensive than on the otoliths from the Humber River samples.

Measurements of Sr/Ca concentration were obtained for 26 Southwest Pond seatrout and three Humber River salmon. The measured ratios of Sr to Ca ranged from < 9×10^{-4} to approximately 9×10^{-3} . Within the transect across each otolith the ratio of Sr to Ca was variable, however distinct regions of high (usually $>3 \times 10^{-3}$) Sr/Ca concentration were observed in most otoliths. These prominent peaks in Sr/Ca concentration were interpreted as the chemical signature of time spent in an environment of higher salinity. These peaks were usually associated with opaque (i.e. summer) zones, however a number of samples had peaks that appeared to be associated with hyaline zones. It is possible that some individuals overwinter in an environment of higher salinity, however it is also possible that measurement error associated with microscopy and the electron microprobe resulted in Sr/Ca peaks occasionally being erroneously associated with winter rather than summer growth zones (Radtke *et al.* 1996). In most cases, if a large part of the Sr/Ca peak occurred in an opaque zone, it was assumed that the peak was associated with this zone.

There was an initial Sr/Ca peak associated with the nucleus of the otolith in six individuals (samples F5, F9, F25, A25, G2 and 96-9). Kalish (1990) demonstrated that a peak in Sr/Ca concentration in the otolith nucleus of progeny of anadromous parents is due to the presence of strontium sequestered in the egg yolk proteins during the seawater phase of ovarian development of the fishes' female parent and subsequently deposited in the otolith primordia during larval development. Lack of this initial peak in the other seatrout samples does not imply non-anadromous parentage because no effort was made to directly sample the primordium. Thus this area was sampled by chance in some otoliths and not in others.

Anomalous readings were recorded at some point on six of the 26 seatrout samples. Samples F20 and A9 had very high (>6) Sr/Ca concentration at the start of the microprobe transect. This was probably not due to accumulation of Sr in the developing egg as reported by Kalish (1990) because this high ratio continues into the first summer in both samples. This result may be due to contamination of the otolith or failure of the microprobe scan to go through the core. The remaining data from sample F20 appears normal and demonstrates migration throughout life. The Sr/Ca concentration of sample A9 shows a decreasing trend throughout life however it does appear to show migration in a number of years. Sample F10 showed unusually low Sr/Ca concentrations and sample 96-8 showed unusually high Sr/Ca concentrations throughout life. The Sr/Ca profiles of both individuals, however, did show distinct regions of relatively high and low Sr/Ca concentration that were interpreted as evidence of migration between environments of differing salinity. The Sr/Ca concentration of sample 96-7 remained relatively high throughout and did not appear to show any evidence of migration. This individual was 51.0 cm in length and a known migrant caught during the fall migration. Repeating the microprobe analysis did not significantly alter the data therefore it appears as though the migrational history of this individual was not well recorded in the otolith microchemsitry. This was the only individual of the six showing anomalous readings that was not included in further analysis.

3.4.2.3. Individual Life History Profiles

A representative life history profile of an Atlantic salmon sampled from the Humber River (H3) is shown in Fig. 3.11. There are no large Sr/Ca peaks above 3×10^{-3} in the first three years however there is a large peak associated with the heavily calcified zone beginning in the fourth summer and lasting a full year. This individual shows the expected life history profile of an anadromous Atlantic salmon in Newfoundland; three years of continuous freshwater residence followed by a full year of sea residence associated with increased growth rate as indicated by a wide opaque zone on the otolith. This is consistent with the life history of salmon in the Humber River (Blair 1965). The other two salmon sampled from the Humber River had very similar life history profiles.

The life history profiles of Southwest Pond seatrout (Figs. 3.7 to 3.11) displayed a number of characteristics that distinguish them from the life history profiles of a typical Atlantic salmon. Most seatrout life history profiles had a Sr/Ca peak in at least one of the pre-smolt years of life. Except when they occur in the first summer of life, these peaks tend to be smaller than ones that occur after smoltification, suggesting that they may be due to residence in an environment with lower salinity than that of the fully marine environment. Observations of numerous parr in the Saltwater pond estuary and the small size of the fish at this age suggest that these peaks represent migration to the estuary early in life. This is consistent with information from the scales of many seatrout that show increased growth in some of the early years of life suggesting movement to an environment of higher productivity. The relatively large height of the Sr/Ca peaks that occur in the first summer of life may be due to the small size of the fish at this time. Peaks representing first migration to the estuary as a pre-smolt occurred in the first summer of 15 individuals, the second summer of three individuals and the third summer of two individuals. Only one individual, sample F3 (Fig. 3.7), did not appear to have migrated to the estuary as a juvenile. Multiple peaks indicating multiple migrations were common throughout the pre-smolt phases of many individuals.

Smoltification and subsequent migration to the ocean appears to be indicated in most life history profiles by a marked increase in Sr/Ca concentration, usually in the fourth or fifth summer, representing migration to the fully marine environment at this time. Post-smolt peaks representing migration to the ocean usually occurred in all subsequent opaque zones, confirming that migrations are undertaken annually and that the length of time spent at sea with each migration is approximately the length of one summer. Smoltification, as indicated by a relatively large Sr/Ca peak after the second summer, appeared to occur at age two in three individuals (samples F8, G6 and A9), age three in 13 individuals (samples F1, F2, F3, F4, F5, F9, F10, F20, F21, A5, A51, G2, and 96-9) age 4 in eight individuals (samples A25, F7, F23, F24, F26, G1, G3 and 96-8), and age 5 in one individual (sample F25).

Six of the individuals analyzed were captured after their fourth summer of life. Samples F1, F2, F3, F4, and F5 were four year old individuals caught in the spring and F21 was a 3+ year old individual caught in the fall. The Sr/Ca profiles of these individuals are shown in Fig. 3.7. In the profiles of these six individuals a relatively large peak in the fourth summer (i.e. age 3+) associated with increased growth, as indicated by the width of the opaque zone, suggests smoltification at age 3 followed by migration to the sea in the fourth summer and back to freshwater in the fall. The individuals caught in the spring probably would have returned to sea for the following summer while the individual captured in the fall would have overwintered in freshwater. All of these samples, except sample F3 which was the smallest four year old analyzed, showed evidence of migration to the estuary in the pre-smolt years.

Ten of the individuals analyzed were captured after their fifth summer of life. Samples F7, A9 and A25 were five year old individuals caught in the spring and samples F8, F9, F10, F20, F26, G2 and G6 were 4+ year old individuals caught in the fall. The Sr/Ca profiles of these individuals are shown in Fig. 3.8 and Fig 3.9. The profiles of samples F8, and G6 suggest smoltification at age 2 and migration to the sea in the next three summers. Sample F8, a 28.2 cm female, was not as silvery in appearance as other fish caught in the fall and had brown pectoral and pelvic fins like those of a juvenile in the parr stage. The migrational history of this individual could not be inferred from the scales due to conflicting observations. The scales of this individual showed no post-smolt growth and the opaque zones on the otolith associated with the peaks indicating migration were relatively narrow demonstrating that this individual had migrated to a saline environment three times and became sexually mature without smolting. The appearance of sample G6 was the same as other fish caught in the fall, however the size of this individual was considerably smaller (33.7cm) than would be expected from an individual that had made three post-smolt migrations and was close to the average size of

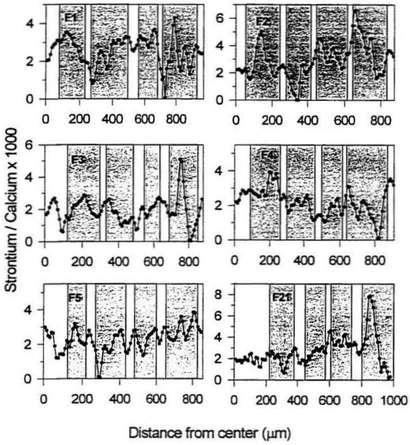

Figure 3.7. Strontium/Calcium profiles of the six Southwest Pond seatrout captured after four summers of life. Dark zones represent regions of summer growth and light zones represent regions of winter growth on the otolith. Sr/Ca peaks greater than three are thought to represent time spent in saltwater except in the profile of sample F5 where saltwater residence is probably represented by peaks greater than two.

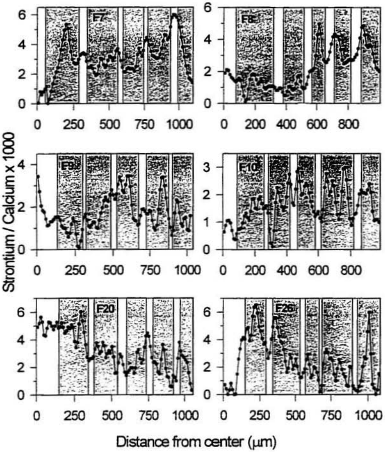

Figure 3.8. Strontium/Calcium profiles of six of the Southwest Pond seatrout captured after five summers of life. Dark zones represent regions of summer growth and light zones represent regions of winter growth on the otolith. Sr/Ca peaks greater than three are thought to represent time spent in saltwater except in the profiles of samples F9 and F10 where saltwater residence is probably represented by peaks greater than two.

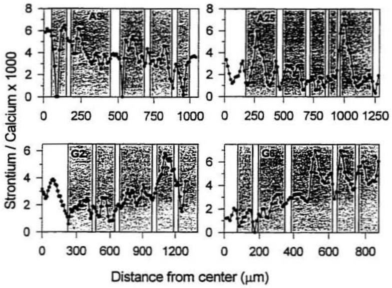

Figure 3.9. Strontium/Calcium profiles of four of the Southwest Pond seatrout captured after five summers of life. Dark zones represent regions of summer growth and light zones represent regions of winter growth on the otolith. Sr/Ca peaks greater than three are thought to represent time spent in saltwater.

fish that had made two post-smolt migrations. This individual may have smolted at two years with a subsequent slow growth rate, however the peak in the third summer could also represent migration of the fish as a pre-smolt, probably to the estuary, with post-smolt growth occurring in the final two summers before capture. This individual may also have migrated to the estuary in the second summer.

The Sr/Ca profiles of four individuals captured in their fifth year indicate smoltification at age 3 (samples F9, F10, F20, and G2) and migration to sea in the next two summers. Grinding the otolith of sample G2 resulted in the removal of the outermost opaque zone and, therefore, loss of the Sr/Ca data in most of the final (fifth) summer of life. The silvery appearance and high condition of this individual when it was caught during the fall migration indicates that it was at sea in the fifth summer and the Sr/Ca profile demonstrates that it had also been to sea in the fourth summer and was therefore a repeat migrant. The largest Sr/Ca peak occurs in the fourth summer of the life history profile of sample F10 and this is associated with a wide opaque zone on the otolith, suggesting smoltification at age 3 and migration to sea in the two subsequent years with the peaks in summers two and three representing migration to the estuary. The scales of this individual, however, had a small amount of post-smolt growth only in the final (fifth) summer of life indicating smoltification at age 4 and only the subsequent summer at sea. Given the large size of this individual (36.7cm) it seems more likely that the first year of post smolt growth was not well represented on the scales and that the migrational history inferred from otolith microchemistry is correct.

Three of the individuals captured in their fifth year appear to have smolted at age four and migrated to sea only in one summer prior to capture. The Sr/Ca profiles of samples A25, F7 and F26 show a large peak in the fifth summer, indicating first migration to the sea in the summer before capture. Examination of scales of sample F26, however reveals that this individual underwent two years of post-smolt growth. This indicates that the smaller peak in Sr/Ca concentration occurring in the fourth summer of this individual also represents post-smolt growth at sea and that this individual was a repeat migrant that had actually smolted at age 3. All three individuals had migrated to the estuary in their first year of life and F26 and F7 continued to migrate throughout the parr stage.

The age at smoltification of one of the individuals captured in the fifth year (sample A9) was difficult to determine due to the declining Sr/Ca ratio observed throughout life. This individual appears to have migrated to an environment of high salinity in summers one, two, three, and four and possibly in winter three. The largest peak after age two is in the third winter suggesting smoltification at age two and migration to sea in the next two summers with migration in the fifth summer being skipped. It is possible that migration in this summer did occur but due to the declining Sr/Ca ratio it was not well represented in the migrational profile. Due to the anomalous readings obtained for this sample these data should be interpreted with caution.

Six individuals were captured after their sixth summer of life. Sample A5 was a six year old captured in the spring and samples F23, F24, F25, G1, and G3 were 5+ year olds captured in the fall. The Sr/Ca profiles of these individuals are shown in Fig. 3.10. A relatively large Sr/Ca peak in the fourth summer of sample A5 suggests smoltification at age 3 with previous migrations to the estuary. This individual also shows a peak in the sixth summer indicating migration to sea in the summer before capture. The Sr/Ca concentration in the fifth summer, however, remains relatively low suggesting that this individual did not migrate this summer or that a migration in this summer was not well represented in the otolith microchemistry.

Four of the samples caught after six summers (samples F23, F24, G1 and G3) smolted at age 4 and made two subsequent migrations to sea before capture. Grinding the otolith of sample F23 resulted in the removal of the outermost opaque zone and, therefore, loss of the Sr/Ca data in most of the sixth summer of life. This individual had a large Sr/Ca peak in the fourth summer indicating migration to sea and was caught as a mature individual returning from the sea in the sixth summer. The scales of this individual confirm that it was indeed a repeat migrant. Sample G1 appears to have migrated to an environment of high salinity late in the first summer and then remained there for the duration of the parr stage. Increased growth and a peak in Sr/Ca concentration in the fifth and sixth summers suggest smoltification at age 4 and migrations to sea in the two subsequent summers. The low in Sr/Ca concentration that is interpreted as overwintering in freshwater in the fifth winter is still above 3×10^{-3} suggesting that migration between freshwater and the estuary, if it occurred in the pre-

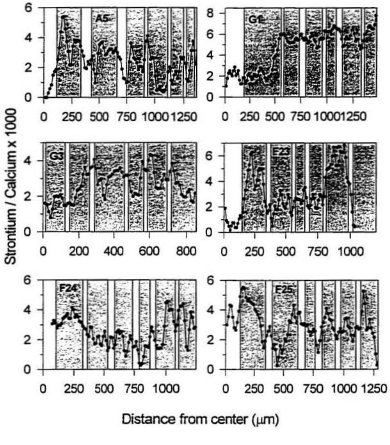

Figure 3.10. Strontium/Calcium profiles of the six Southwest Pond seatrout captured after six summers of life. Dark zones represent regions of summer growth and light zones represent regions of winter growth on the otolith. Sr/Ca peaks greater than three are thought to represent time spent in saltwater.

smolt years, may not have been well represented in the otolith microchemistry. A relatively large peak in the fifth summer and a smaller one in the sixth summer of the life history profile of sample G3 suggests smoltification at age 4 with subsequent migrations in the next two summers. Sr/Ca peaks in the second, third and fourth summers suggest migration to the estuary in these years. The peaks representing these migrations continue into the second, third and fourth winters suggesting that this fish may have overwintered in the marine environment. Sample F24 had large peaks in summers five and six, the last two summers prior to capture, indicating that this individual was also a repeat migrant that had smolted at age 4. Sample F25 had Sr/Ca peaks in the fourth, fifth and sixth summers. The largest of the three peaks occurred in the sixth summer suggesting smoltification and subsequent migration at age 5. Examination of the scales of this individual, however indicates smolting at age 4, therefore the Sr/Ca peaks in summers five and six represent migration to sea and the earlier peaks represent migration to the estuary.

Three individuals were captured after 7 summers of life. Samples 96-7, 96-8 and 96-9 were all 6+ individuals captured in the fall. The Sr/Ca profiles of samples 96-8 and 96-9 are shown in Fig. 3.11. Sample 96-9 smolted at age 3 and migrated to sea in the next four summers with the height of the Sr/Ca peak declining with each subsequent sea migration. Sample 96-8 showed relatively high Sr/Ca ratios throughout life, however there was evidence of migration in the data as this individual had higher Sr/Ca ratios in the fourth, fifth and sixth summers indicating smoltification at age four and migration to sea in the following three summers. Migration back to freshwater is not well represented in the Sr/Ca profile in the intervening winters, however it is not likely that this individual spent two full years at sea as it was considerably smaller than would be expected. Due to the anomalous data the Sr/Ca profile of this individual should be interpreted with caution. Sample 96-7 also showed anomalous readings and was therefore excluded from the analysis.

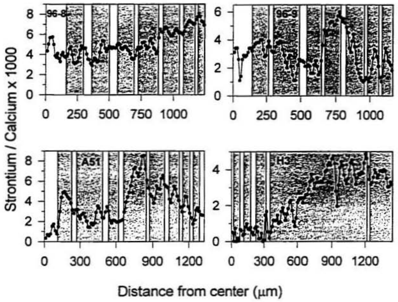

Figure 3.11. Strontium/Calcium profiles of the two Southwest Pond seatrout captured after seven summers of life (samples 96-8 and 96-9), the one individual captured after eight summers of life (A51), and a typical Atlantic salmon sampled from the Humber River (H3). Dark zones represent regions of summer growth and light zones represent regions of winter growth on the otolith. Sr/Ca peaks greater than three are thought to represent time spent in saltwater except in the profile of sample 96-8 where saltwater residence is probably represented by Sr/Ca greater than five.

One individual, sample A51, was caught in the spring after eight summers of life. The Sr/Ca profile of this individual is shown in Fig. 3.11. This individual spent the first, and possible the second, summer in the estuary before smolting at age 3 and then migrating to sea in each of the five subsequent summers. It is likely that each of these peaks represents a separate migration rather than continuous sea residence because, although this individual was larger than average (59.4cm), it was considerably smaller than would be expected of a salmon that had spent five full years at sea. Examination of the gonads of this individual indicated that it had spawned the previous fall. The numerous migrations made by this individual and maturation of most other individuals after one or two migrations suggest that this individual had probably spawned in at least one other year as well.

3.4.2.4. Matching of Circuli Pattern and Otolith Microchemistry

Both otolith microchemistry and scales of 15 individuals (samples F1-F5, F7-F10, F20, F21, F23-F26), were analyzed for migrational characteristics. Among the 15 individuals there was strong agreement between migrational histories inferred from scales and from otolith microchemistry. Smolt age was most easily determined from scales because these structures showed a marked change in the circuli pattern associated with a change in growth rate after smoltification. High otolith Sr/Ca concentration in the summers after smoltification confirmed that the subsequent rapid growth seen on the scales did in fact occur at sea. Smolt age could be determined from the otolith microchemistry of most individuals because the Sr/Ca concentration typically showed a marked increase associated with migration to sea after smoltification. Assuming that smoltification does not occur before age two, the largest Sr/Ca peak after the second summer marked the year of smoltification as seen on the scale in 11 out of the 15 (73.3%) individuals. In one of the individuals where smolt age inferred from scales and otoliths did not agree (sample F10) it was believed that the otolith microchemistry was more likely to be correct than the circuli pattern on the scale. The coloration and lack of post-smolt growth on the scales of another individual (sample F8) indicated that this individual had not smolted, however the Sr/Ca profile demonstrated that this individual had migrated to sea in the last three summers. In this case, examination of the Sr/Ca profile alone would lead to the erroneous conclusion that this individual had smolted at age two. The Sr/Ca profiles of the remaining two samples where otolith and scale data did not agree (samples F25 and F26) did display a Sr/Ca peak representing migration to the sea in the summer following smoltification, however there was a larger peak a year later associated with a second migration to sea that was interpreted as the first post-smolt migration.

Although the circuli pattern on the scales showed evidence of migration to the estuary, this migration was more easily detected in the microchemistry data. Of the 15 samples for which both scale and microchemistry data were available there were a total of 31 peaks in the Sr/Ca profiles that were thought to be due to residence in the estuary, however only 15 of these migrations were evident on the scales of the same fish.

Neither scales nor otolith microchemistry showed any evidence of recording a spawning event. Scales were analyzed from only 5 fish that were likely to have spawned a sufficient amount of time in the past for a spawning check to have formed on the scale. Although no spawning check was detected on these scales it is not known whether these fish did in fact spawn. Previous spawning most likely occurred in a number of samples for which microchemistry data were collected (e.g. A51, A5) and, although multiple migrations were detected in these samples, there was no way to tell whether they had spawned from the Sr/Ca data.

3.5. Comparing LEK to the Results of the Survey

Data on the seatrout population's range, distribution, migration patterns, physical description and life history have been collected through both the LEK survey (Chapter 2) and direct study of the population. Much of the information gathered in the LEK survey of seatrout anglers was consistent with what was learned through direct sampling of the seatrout population. The physical description of the seatrout provided by anglers (Section 2.2.2) was very accurate. Anglers reported a change in appearance and condition between spring and fall caught fish which was supported by data collected from the seatrout population. Anglers also reported that the flesh of the seatrout had an unusually white or pale pink coloration which was also consistent with what was found by examining individuals sampled from the seatrout population. The other morphological differences between typical salmon and the seatrout reported by anglers (i.e. head and tail shape) were not examined in enough detail to determine the accuracy of this information.

Although extensive data on the populations range, distribution and timing of migration were not collected through direct study of the population, the available data were consistent with the data provided by anglers. The life history suggested by anglers was also consistent with the life history as revealed through otolith and scale analysis. Although the scale and otolith studies provided much more detailed data about individual fish, the most unique feature of the life history i.e. the short duration of the saltwater phase, was recognized by anglers.

The size range of fish in the population as indicated by anglers was fairly consistent with what was learned by sampling the population. When asked to give the average size of fish caught, anglers usually provided a range of sizes and the range of sizes provided by most anglers was close to the actual average size of fish sampled from the population. The size at which anglers considered an individual to be large was near the upper end of the length frequency distribution. Anglers tended to overestimate the size at which the seatrout first go to sea, probably because the fish at this stage of the life history are too small to be easily caught by anglers. The size at first migration provided by anglers was closer to the average size of fish caught in the spring prior to making the second migration to sea.

The results demonstrate that anglers can possess accurate knowledge about the fish populations that they exploit. Some information contained in the LEK of Southwest Pond seatrout anglers such as changes in the population over time could not be validated because this information was not available from any other source. The relative accuracy of the other information provided by anglers suggests that this information is probably accurate as well. Although the data collected through more traditional scientific methods is more accurate, the results demonstrate that the LEK of experienced anglers represents an alternate and reliable source of data.

3.6. The Ecological Position of the Southwest Pond Seatrout

The results of the genetic analysis of the Southwest Pond seatrout samples revealed that these fish are, in fact, Atlantic salmon, *Salmo salar* (Section 3.3.3). Atlantic salmon are common throughout Newfoundland in both anadromous and non-anadromous forms. The non-anadromous form, known locally as ouananiche, spends its entire life cycle in freshwater and may reach sizes of up to 48 cm (1.2 kg) (Scott and Crossman 1964). Populations of ouananiche are often prevented from moving between freshwater and the ocean by an impassable barrier, however populations do occur in locations that are accessible to the ocean. Individuals of anadromous salmon typically spend two to four years as juveniles in freshwater before smolting and migrating to sea where they remain for one to two full years before returning to their natal rivers to spawn. When at sea the movements of some salmon may be extensive and some individuals from Canadian rivers are known to migrate as far as the Greenland coast. Salmon that spend only one year at sea before returning to freshwater (grilse) typically reach weights of 1.4kg to 2.7 kg (50cm to 63 cm) however multi-sea-year salmon can reach weights of up to 9.1 kg (95cm) or more (Scott and Scott 1988).

The life history of the Southwest Pond seatrout is characterized by migration to the estuary in one or more years of the juvenile stages with some individuals migrating as early as the first summer of life. Smoltification occurs in the spring, usually at age three or four but may also occur at age two or age five. After smolting the fish begin to make annual migrations of short duration to the sea. These migrations begin in the spring, usually in May, and last for three to four months before the fish return to freshwater to overwinter. Many of the fish will become sexually mature during the first migration to sea and subsequently spawn when they return to freshwater in the fall, however some migrating individuals appear to delay maturation until after the second migration. The high incidence of repeat migration means that many individuals have the opportunity to spawn multiple times throughout their lives. With the exception of the use of the estuary, this migrational pattern is similar to that seen in anadromous Arctic char (*Salvelinus alpinus*), and anadromous brook trout (*Salvelinus fontinalis*), two other salmonid species native to Newfoundland.

The life history of the Southwest Pond seatrout is unusual for Atlantic salmon in a number of respects, one of which is the apparently widespread use of the estuary by juveniles. The use of the estuarine environment by Atlantic salmon parr has been reported from eastern Canada (Cunjak *et al.* 1989; Power and Shooner 1966; Huntsman 1945; Hutchings 1985) and from Russia (Kasakov 1994). While there have been observations of some estuarine parr returning to freshwater in the fall (Hutchings 1985; Cunjak *et al.* 1989), it appears that most are larger individuals in a pre-smolt phase that eventually smoltify in the estuary and continue their seaward migration. Use of the estuary by the Southwest Pond seatrout appears to be more extensive than that reported from other populations. Otolith microchemistry of the Southwest Pond seatrout demonstrates that almost all of the adult fish examined had been to the estuary at least once as juveniles. Furthermore, parr of this population were often found to have entered the estuary very early in life and to have made a number of subsequent migrations between freshwater and the estuary before eventually smolting and migrating to sea. It is not known whether smoltification actually occurs in the estuary, however it is likely given the extent to which the parr make use of this environment.

The salinity tolerance of Atlantic salmon parr is known to be limited and inversely related to body size (Cunjak *et al.* 1990). To avoid high mortality, especially at small sizes, the parr must be able to find areas in the estuary where they can take refuge from high salinities. Saltwater pond is approximately 2.5 km in length and gradually narrows to about 10m-15m where the brook flows into the inner estuary. The outer portion of the pond is separated from the Southwest Arm of Valleyfield Harbour by a shallow sill that restricts seawater input. Given these conditions it is likely that a long salinity gradient occurs lengthwise through the estuary. Furthermore, the long narrow shape of Saltwater

Pond results in a sheltered location that probably minimizes mixing of deeper saltwater with overlying freshwater. Given these conditions, it seems possible that juvenile seatrout in the estuary can remain in water of fairly low salinity while making brief excursions into areas of higher salinity. Larger parr, including the ones that were caught during the survey, were seen farther out in the estuary in water of higher salinity. Evidence of higher salinity in the outer estuary is provided by the presence of a marine fish, *Tautogolabrus adspersus*, at the sampling site there. There may be a higher mortality associated with residence in the saline environment of the estuary, however this may be offset by the higher growth rate that the surviving parr experience.

The reason for such extensive use of the estuary is not clear, however the proximity of the spawning locations could be a contributing factor. Many of the fish are believed to spawn in the stream only a short distance above Southwest Pond or on gravel shoals at the stream outlets in the pond itself. The distance between the estuary and these locations is only a few hundred meters, most of which is the lacustrine habitat of Southwest Pond. Any movement downstream by recently hatched or older juveniles, either by displacement due to environmental conditions (i.e. flooding) or migration in search of suitable habitat, would likely result in movement into the estuary. Further work is needed to identify the mechanism responsible for initiating migration to the estuary and its effect on the population's production. Nevertheless, it is evident that Saltwater Pond is an important rearing habitat for juvenile Southwest Pond seatrout and should be considered as such for management purposes, including special protection for that habitat.

The second unusual aspect of the Southwest Pond seatrout life history is the short duration of the saltwater phase and the associated high rate of repeat migration. After smolting, the seatrout migrate to sea in May and return to freshwater in July through October with the majority of the run occurring usually in August. An individual going to sea early and returning late could conceivably spend almost six months at sea, however the typical length of time at sea is probably on the order of two or three months. This short amount of time at sea means that the fish cannot possibly migrate far and observations of seatrout in saltwater throughout the summer by anglers and commercial fishermen suggests that many of the fish do not leave the immediate vicinity.

There appears to be a relatively high rate of survival to repeat migration in the Southwest Pond seatrout population. Of the 46 individuals that had migrated to sea and subsequently returned to freshwater, 16 (34%) were repeat migrants having made at least two migrations to sea and 5 (11%) had made three or more migrations. Dymond (1963) reported a repeat spawning rate of between 5% and 34% for selected Atlantic salmon rivers in eastern Canada. Information collected from anglers indicates that the number of large fish in the Southwest Pond seatrout population has declined drastically, probably due to over-fishing, suggesting that the natural survival rate is probably higher than indicated by the data presented here. This relatively high survival rate is probably due to the short duration of sea residence which allows the fish to avoid much of the potentially high mortality associated with residence in that environment. The small size of the Southwest Pond river system and the close proximity of the spawning sites to the ocean means that migration upstream and subsequent spawning are probably less stressful than in other populations resulting in a higher post-spawning survival. Furthermore, a small percentage of the migrating fish do not mature in each year thus eliminating the stress due to maturation and spawning in these years and further increasing the probability of survival.

The short duration of the sea phase results in a small size and relatively young age at maturation. Eighty-three percent of the fish migrating back to freshwater after one summer at sea were maturing in preparation to spawn that fall. These fish were all 3+ or 4+ years old, a full year younger than they would have been had they spent a full year at sea. A rough estimate of growth during each successive migration to sea can be obtained by taking the difference between the average length of fish sampled before and after each migration. This gives an average increase in length of 8.4 cm during the first migration to sea and 8.5 cm during the second migration to sea. The average size of recently smolted individuals captured from the sea early in the summer was 18.5cm. Assuming smoltification at age 3, a length of around 18cm at smoltification, and growth of 8.5 cm during each migration, a Southwest Pond seatrout would have to reach an age of 7+ and make at least 5 separate migrations to sea in order to reach the size of a typical salmon that spends a full year at sea. To reach the size of a small multi-year salmon that spends at least two years at sea a seatrout would have to reach an age of at least 9+ and make 7 migration to sea. Few salmon live beyond 9 years in eastern Canada (Scott and Scott 1988), however Power (1969) reported ages to 11 years in Ungava. If the short duration of sea residence results in increased survival, it is possible that an unexploited Southwest Pond trout population would contain some individuals of this age.

Repeat migration and multiple spawning results in a large number of year classes present during spawning. In 1996 there were mature individuals sampled from four year classes (ages 3+ to 6+) and the capture of one 8 year old individual in the spring of 1995 indicates that at least one other year class (7+) can be present in some years. Many anglers report the presence of larger fish in the past and, in fact, reported the capture of one nine pound individual from the brook below Southwest Pond in the summer of 1995. Although the data are limited, there is no indication of multi-sea-year salmon in the Southwest Pond trout population which suggests that these large fish were also repeat migrants. If so, this would likely increase the number of year classes that can potentially be present during spawning to six or more. Male salmon in Newfoundland are known to mature precociously in the parr stage (Dalley *et al.* 1983), however it is not known if this occurs in the Southwest Pond seatrout population. If precocious maturation does occur, this would further increase the number of year classes present at spawning. A life history strategy that maximizes the number of year classes present during spawning is thought to be an adaptation that increases the effective population size, reduces inbreeding, and helps maintain genetic diversity in small populations (Saunders and Schom 1985).

There is a marked difference in the size of males and females in the fall sample resulting in a bimodal length frequency distribution. There appears to be two factors contributing to this bimodal pattern. One factor is the high survival rate to a second migration to sea. The lower mode of the distribution is centered near the average size of fish that have made one migration to sea and the upper mode is centered near the average size of those that have made two migrations to sea. The other factor appears to be related to differences in the growth rate of males and females. The fact that the upper mode is centered on the mean size of females and on the average size of fish that made two migrations might suggest that there is differential survival of males and females. This does not appear to be the case, however, as the group of fish sampled that had made two migrations consisted of an equal number of males and females.

Life history characteristics of populations are thought to evolve in response to environmental and physiological influences on age-specific survival, fecundity and growth (Williams 1966; Schaffer and Elson 1975; Murray 1979). The Southwest Pond seatrout population's evolutionary response has been to reduce the duration of the saltwater phase and mature at a smaller size and younger age. The small body size at maturity results in lower age-specific fecundity relative to the typical anadromous life history, however increased survival due to the short sea phase and relatively easy and short upstream migration most likely results in greater average lifetime fecundity than would be achieved by the typical salmon life history in this river system. The short and relatively easy upstream migration may have indirectly contributed to the evolution of a small body size by reducing the selective pressure to achieve a larger size which may be necessary to ascend larger river systems. There may be greater selective pressure on females to be larger and therefore increase fecundity as suggested by the positive correlation between female fecundity and body size and the larger average size of mature females within each sea-age class.

The younger age and smaller size at maturity may also be related to the use of the estuary by a large proportion of the juvenile population. Life history theory predicts that increased juvenile growth relative to adult growth will lead to increased reproductive effort and reduced age at maturity (Hutchings 1993). Although juvenile and adult growth were not directly measured, salmon parr have been shown to have higher growth rates in an estuarine environment (Hutchings 1985; Cunjak 1992) and evidence of increased growth at young ages is seen on the scales of some Southwest Pond individuals. If enhanced growth leads to increased fitness or increased production, then migration to the estuary in this population may be an adaptive phenomenon. The purpose of this study was not to investigate life history evolution in the Southwest Pond seatrout, therefore the data gathered are not adequate to test hypotheses regarding the evolution of this life history strategy. Nevertheless, it is clear that the Southwest Pond seatrout represents a unique adaptation to local environmental conditions in Atlantic salmon.

The results of this component of the research demonstrate that a management plan to ensure the conservation and protection of the Southwest Pond seatrout is a worthwhile goal. Furthermore, it is largely achievable based on data gathered by local people and already available combined with a minimal investment in a normal scientific survey. This population of Atlantic salmon represents a unique adaptation to local conditions and, as such, can be considered an evolutionary significant unit (ESU) (Waples 1995). Extinction of this population would represent a significant loss to the ecological and genetic diversity of this species. Furthermore, due to its uniqueness, this population has the potential to yield a wealth of information about local adaptation and evolution of life history in response to specific conditions. The unique characteristics of this population also demonstrate that it has the potential to provide an angling experience not available elsewhere. The population is therefore valuable not only for scientific purposes but also for the sociocultural and economic benefits that can potentially be provided, indeed already are being provided, to neighboring communities. The sociocultural benefits derived from the fishery will be the subject of the next chapter. Consideration of these benefits along with the biological data provided in the current and previous chapters will provide the information necessary to begin the process of developing a management plan that will allow the maximum benefits to be derived from the Southwest Pond seatrout population.

CHAPTER 4: WHY ANGLERS ANGLE AND THE IMPLICATIONS FOR MANAGEMENT

4.1. Assessing the Angling Population

Numerous authors have argued that fishery management requires an understanding of the fishery-related values held by the resource users (Krueger and Decker 1993; Weithman 1993; Fedler and Ditton 1994; Malvestuto and Hudgins 1996). The goal of managing the Southwest Pond seatrout to provide a sustainable recreational fishery that will maximize the social benefits derived from the resource dictates that a research component be directed specifically at the human dimensions of the fishery. Just as ecological research is needed to provide data on fish life history and population parameters, sociological research is needed to evaluate the sociocultural benefits derived by anglers and to understand their attitudes towards management of the resource. This type of information will allow a management plan to be designed that meets the desires and expectations of the anglers and provides a quality angling experience.

The social benefits derived by anglers from the angling experience will be inextricably linked to their motives for fishing. Most scientific studies of angler motivations have found that fishing experiences involve many dimensions other than catching fish. Driver and Knopf (1976) suggest that the list of potential reasons for fishing is long but that the most important reasons appear to be experiencing nature, developing skills, pitting wits with those of the fish, being with friends or family, sharing skills with others, mental change and relaxation, exploring, learning, exercising, getting food, taking a trophy, testing equipment, being re-invigorated and escaping from the pressures of everyday life. More recent research suggests that variation in the relative importance of these motives tends to occur between angler subpopulation groups or between subpopulation groups and the angler population at large (Fedler and Ditton 1994). The uniqueness of the Southwest Pond seatrout population leads to the expectation that the motivations and expectations of the anglers fishing it will differ from those of anglers fishing other populations in Newfoundland and elsewhere. This means that the extrapolation of sociological data gathered from other angler groups to the Southwest Pond angler subpopulation may not be possible.

Fishery-specific information about the motivations and satisfactions of the Southwest Pond anglers will be important in predicting their response to particular management actions. Management of a fishery usually involves interfering in the fishery with the object of shifting it towards the most desired social benefit, usually via laws and regulations (Augero and Lockwood 1986). There is a wide variety of regulations available to recreational fisheries managers, including seasonal and daily bag limits, size or slot limits, gear restrictions, closed seasons, and catch-and-release (Noble and Jones 1993). Most anglers have strong opinions about harvest regulations (Johnson and Martinez 1995) and these opinions are likely to depend upon fishery-specific motivations and expectations. If certain regulations are deemed unnecessary or unacceptable by anglers, fishing satisfaction will be low, compliance with regulations will be low and the management plan will be compromised. If regulations are selected with consideration of the types of regulations anglers will or will not support, conflicts between managers and anglers will be reduced and the probability of successful management will be increased.

There is limited information available about the angler population of Newfoundland and Labrador (Department of Fisheries and Oceans 1988; Canadian Wildlife Service 1993; Frampton 1994), and there is no information available about various angler subpopulations such as those who angle for the Southwest Pond seatrout. It is this type of context-specific information that will prove to be the most useful for managing recreational fisheries (Fedler and Ditton 1994; Johnson and Martinez 1995; Malvestuto and Hudgins 1996). The purpose of the work reported in this chapter was to gather the sociological data on the Southwest Pond seatrout anglers that will allow a management strategy to be designed so that long-term public use and enjoyment of the resource is maximized. The specific objectives were: 1) To determine the relative importance of selected fishing motivations within the Southwest Pond seatrout angler population ; and 2) to gather public input and opinions on a number of potential regulations for managing the Southwest Pond seatrout fishery.

4.2. Design of the Angler Survey

A personal, on-site survey of people angling in Southwest Pond was conducted from May 8 to May 20 and August 1 to August 21, 1996. These periods were selected for surveying because they correspond to the timing of migration of fish to the sea in the spring and from the sea in the late summer, and thus represent the peak of the spring and summer fisheries. Surveying was conducted on randomly chosen days during these periods. An attempt was made to contact every angler observed fishing during sampling times. During the spring period when angling effort was concentrated along the southern shore of the pond, anglers were spotted by driving along the road adjacent to this shore. In August, when effort was concentrated at Headquarters, a boat was used to reach people angling at this location. Anglers fishing from shore were approached while fishing and asked whether they would be willing to participate in the survey. Boating anglers were approached, whenever possible, when they finished fishing and returned to shore.

Anglers who agreed to participate in the survey were first asked to rate the importance of each of 21 possible reasons for fishing in Southwest Pond. These single item motivational indicators were adapted from previous studies of angler motivations (Knopf *et al.* 1973; Driver and Knopf 1976; Driver and Cooksey 1977; references in Fedler and Ditton 1994). The relative importance of each item was measured on a five point rating scale ranging from (1) not important to (5) extremely important. For analysis, motives were grouped into five categories : (1) psychological and physiological, (2) natural environment, (3) social, (4) fishery resource, and (5) skill and equipment (from Fedler and Ditton 1994). The importance of each item was evaluated using the two-step scoring procedure described by Gilbert (1977 (in Hicks *et al.* 1983)) (see Appendix 2).

To gain insight into anglers' views on specific management options, anglers were asked whether they would approve or disapprove of nine possible regulations for managing the Southwest Pond fishery. These regulations were then ranked according to level of angler support as determined by the percentage of anglers who answered in the "approve" category. This section of the survey also included an open-ended question that allowed anglers to suggest alternate methods of improving the seatrout fishery.

Additional information collected by the survey included the approximate age of the angler, town or residence, type of fish usually sought when fishing in Southwest Pond, how many years they had been fishing in Southwest Pond and whether they had seen any changes in fishing over that time. Because the purpose of the survey was to describe the motivations and attitudes of the anglers, these additional data were used for descriptive purposes only.

4.3. Results from the Angler Survey

4.3.1. *The Nature of the Sample*

During the twenty days in which the survey was conducted a total of 81 Southwest Pond anglers were approached and asked to participate in the survey. Seventy-nine people agreed to participate and were subsequently interviewed. Fishing pressure over the study period, however, was greater than 81 people per twenty days as many of the survey participants were observed angling on more than one day but were only surveyed once. Of the 79 people surveyed, 63 were surveyed during the spring fishery and 16 during the fall fishery.

The modal age group of the anglers surveyed was 36 to 45 years with 30.4% of respondents falling in this category. The second most frequent age category was the 25 to 35 year category with 24.1% of respondents. The distribution of the remaining categories was: 21.5% less than 25 years of age; 10.1% between 46 and 55 years of age; 7.6% between 56 and 65 years of age; and 6.3% over 66 years of age. Average fishing experience on Southwest Pond was 14 years with a range of 1 year to 70 years. Most of the people angling in Southwest Pond were fishing for the Southwest Pond seatrout. Thirty seven percent of the respondents reported fishing mainly for the seatrout and 48% reported fishing for the seatrout and either brook trout or smelt. Only 15% of the respondents said they usually fish only for brook trout. Seventy-seven percent of the respondents were from the surrounding communities of Wesleyville, Valleyfield, Pool's Island, Greenspond, Brookfield and Badgers Quay. Fourteen percent of the respondents were from the Gambo/Gander/Dover area and 9% were from the St. John's/Mt. Pearl area.

4.3.2. *Responses Regarding Fishing Quality*

Changes in the quality of fishing over time observed by Southwest Pond anglers are listed in Table 4.1. Over one half of respondents reported catching fewer fish or smaller fish than in the past. Twenty-seven people reported no change in fishing quality over time and only 7 people reported that fishing quality was better now with larger fish or more fish than in the past. The average fishing experience of those people reporting a decrease in the quality of fishing (fewer fish, smaller fish, more people or more poaching) was 19.6 years. The average fishing experience of those anglers reporting no change in fishing quality over time was 5.7 years, and the average fishing experience of those anglers reporting an increase in fishing quality (more fish or larger fish) was 5.4 years.

Table 4.1. Changes in fishing quality over time observed by anglers in Southwest Pond and the frequency of each response.

Change in fishing quality	Frequency
Fewer fish	43
No change	27
Smaller fish	7
More anglers	4
More fish	4
Larger fish	3
More poaching	2

4.3.3.. *Responses Regarding Motivation*

The percentage of respondents who answered in each importance category and the overall rating of each motive are listed in Table 4.2. Psychological-physiological motives for fishing in Southwest Pond were rated somewhat to very important. In this category the highest- rated reason for fishing was "to relax" which 49.4% of respondents rated very important and 26.6% rated extremely important. "To escape the daily routine" and "to pass time" were rated moderately important while "to get some exercise", "to experience new and different things" and "to relive memories" were rated only somewhat important.

Table 4.2. Percentage of anglers who answered in each importance category for each of the 21 motivational items. The total score for each item is also given. Highlighted text represents the overall rating for each item.

	Importance					
Motives	Not	Somewhat	Moderate	Very	Extremely	Score
Psychological and physiological						
Escape the daily routine	13.9	11.4	**35.4**	31.6	7.6	164
Get some exercise	27.8	**21.5**	17.7	30.5	2.5	125
To relax	3.8	2.5	17.7	**49.4**	26.6	231
Relive memories	36.7	**16.5**	15.2	25.3	6.3	117
New or different experiences	38.0	**16.5**	15.2	27.8	2.5	111
To pass time	11.4	11.4	**30.4**	34.2	12.7	178
Social						
Get away from others	40.5	**17.7**	13.9	19.0	8.9	109
Be with family or friends	7.6	11.4	20.3	**45.6**	15.2	197
Meet other people	25.3	12.7	**25.3**	30.4	6.3	142
Natural environment						
To be outdoors	0.0	0.0	3.8	54.4	**41.8**	267
Enjoy or observe nature	1.3	1.3	17.7	**50.6**	29.1	241
To be close to the water	15.2	7.6	**27.8**	27.8	21.5	184
Fishery resource						
Challenge or sport of fishing	5.1	8.9	20.3	**40.5**	25.3	215
Catch at least one fish	11.4	15.2	15.2	**32.9**	25.3	194
Obtain fish to eat	20.3	29.1	**19.0**	21.5	10.1	136
Catch a trophy fish	31.6	17.7	**13.9**	26.6	10.1	131
Obtain fish to sell	**98.7**	1.3	0.0	0.0	0.0	1
Catch a limit of fish	46.8	**22.8**	12.7	10.1	7.6	86
Skill and equipment						
Develop fishing skills	45.6	**16.5**	11.4	24.1	2.5	96
Test skills against others	**60.8**	15.2	12.7	8.9	2.5	61
Test equipment	**62.0**	12.7	10.1	15.2	0.0	62

Table 4.3. Percentage approval by Southwest Pond anglers of nine possible regulations for managing the Southwest Pond fishery.

Management alternative	% approval
Minimum size limit	96.2
Seasonal bag limit	88.6
Catch and release during designated times	74.7
License with a moderate fee	73.4
Reduction in the daily bag limit	57.0
Eliminate spring fishery and lengthen fall fishery	55.7
Maximum size limit	54.4
Shorter fishing seasons	27.8
Fly fishing only	25.3

Social motives, which deal with the desire to interact with other people, were also rated somewhat important to very important. "To be with family or friends" was rated highest in this category with 45.6% and 15.2% of respondents rating this motive as a very important or extremely important reason for fishing in Southwest Pond. "To meet other people" was rated moderately important and "to get away from other people" was rated as only somewhat important.

Motives related to the natural environment rated the highest among the 21 items in the survey. "To be outdoors" was the single most important reason for fishing in Southwest Pond, rated as very important by 54.4% and extremely important by 46.8% of respondents. "To enjoy or observe nature" was rated as very important and "to be close to the water" was rated as moderately important

There was a great deal of variability in the rated importance of the fishery-related motives. "For the challenge or sport of fishing" and "to catch at least one fish" were rated as very important with 40.1% and 32.9% of respondents rating these motives as very important and 21.3% and 25.3% rating these motives as extremely important reasons for fishing in Southwest Pond. "To obtain fish to eat" and "to catch a trophy fish" were rated as moderately important while "to catch a limit of fish" and "to obtain fish to sell" were rated as relatively unimportant.

Table 4.4. Anglers' suggestions for improving the fishery in Southwest Pond.

Angler's suggestions	Frequency
No answer	42
Enforcement of regulations	23
Discontinue eel fishery	11
Stop illegal netting in estuary	8
Licensed	3
Stop smelt fishery in salt water	2
No pleasure craft on pond	2
Stocking of fish	2
Closed in fall	1
Closed in winter	1
Keep closed seasons	1
Keep the place clean	1
Limit number of anglers	1
Longer seasons	1
Longer smelt season in winter	1
Open on weekends only	1
Open all year	1
Open spring and fall only	1

Motives related to skill and equipment were rated as relatively unimportant by Southwest Pond anglers. "To develop fishing skills" was rated as somewhat important while "to test skills against others" and "to test equipment" were rated as not important reasons for fishing in Southwest Pond.

4.3.4. *Responses Regarding Management Alternatives*

The specific management alternatives and the percentage of respondents who would support each one are given in Table 4.3. Approval ranged from a maximum of 96.2% for a minimum size limit to a minimum of 25.3% for fly fishing only. Anglers were supportive of most management alternatives with only two of the nine alternatives receiving less than 50% support.

Angler's suggestions for improving the fishery in Southwest Pond are listed in Table 4.4. The most common suggestion for improving the fishery was to increase the level of enforcement of regulations on the pond. Other frequent suggestions were to discontinue the eel fishery, which people believe is harmful to juvenile trout, and to stop illegal netting in the estuary.

4.4. Synthesis From the Attitudinal Survey

The results of the survey demonstrate that the Southwest Pond angler population consists mainly of local area residents with a wide range of ages and experience angling in Southwest Pond. Anglers from other areas of the province make up a small percentage of the angler population, but their presence does suggest that the Southwest Pond fishery has the potential to attract anglers from across the province. The Southwest Pond seatrout was the main quarry of most people fishing in Southwest Pond, but both brook trout and smelt were sought by some anglers.

It is important to recognize that management of the Southwest Pond seatrout can have a negative effect on the fisheries for these other species. Informal reports from anglers indicate an extensive recreational smelt fishery that takes place through the ice during winter. Shortening or closing the winter trout fishery would restrict the winter smelt fishery if the pond was closed to all angling during this time. Regulations for managing the Southwest Pond seatrout should be chosen with a close consideration of the effect they will have on the fisheries for the other species that occur there.

The results of the motivational survey are consistent with those from previous studies that support the idea that anglers hold multiple fishing motivations (Hicks *et al.* 1983; Hudgins 1984; Fedler 1984; Siemer and Brown 1994). The results show that Southwest Pond anglers are motivated to fish for a variety of reasons including, but not limited to, being outdoors and enjoying nature, relaxing, escaping everyday pressures and sharing experiences with family or friends. A number of motivations related to the actual catching of fish were also important, however many of the anglers hold stronger motivations related to the natural environment or relaxing with other people.

4.4.1. *Attitudes With Respect to Recreation*

Recreational activities allow people to satisfy desires that cannot be satisfied during their non-recreational times (Knopf *et al.* 1973) and serve as a means of coping with the stresses and strains of everyday life. The relatively high rating of the motives "to relax" (ranked 3rd) and "to escape the daily routine" (ranked 9th) indicate that the fishery in Southwest Pond is a true recreational experience for many of the anglers. The notion of angling as a recreational experience that people use to help cope with the strains of society is not new and studies of various angler populations have consistently found that relaxing and escaping from daily routines are important reasons for participating in recreational fisheries (Driver and Knopf 1976; Hicks *et al.* 1983; Siemer and Brown 1994; references in Fedler and Ditton 1994). Given the high value that Southwest Pond anglers place on fishing as a recreational experience, one of the aims of management should be to provide a fishery resource that best meets recreational needs. The participation rate in recreational fisheries in Newfoundland is nearly 40% (Canadian Wildlife Service 1993) and there is no reason to believe that this rate is any lower for the communities near Southwest Pond. Failure to adequately manage the Southwest Pond seatrout and other fishery resources to truly provide for recognized recreational needs could have a detrimental effect on the quality of life in these communities. Human dimensions research will be an invaluable tool for identifying more precisely what recreational needs and desires anglers hope to fulfil through the fishing experience in Southwest Pond and other recreational fisheries throughout the province of Newfoundland and Labrador.

The importance of the Southwest Pond fishery as a recreational experience has implications for future management. A management strategy that attempts to limit the harvest by further reducing the length of the fishing season or limiting access to the resource when other options are available would only unnecessarily restrict people's opportunities for leisure activities and would probably meet with opposition from the anglers. This is evidenced by the fact that the management option that included eliminating the spring fishery received only 55.7% approval and the option for shortening the fishing season received only 28% approval. Although restricting the number of anglers allowed to fish Southwest Pond at any one time was not among the list of potential regulations, the results of the motivational survey suggest that this option would not be accepted by the anglers because it would limit their access to an important recreational activity. Furthermore, the motive "to be with family or friends" was found to be a relatively important reason for fishing in Southwest Pond (ranked 5th) and the motive "to get away from other people" was found to be relatively unimportant (ranked 16th). This demonstrates that anglers place more value on being with other people than being alone and suggests that anglers may tolerate a fairly high level of crowding. Limiting access to Southwest Pond will probably be unnecessary unless there is a dramatic increase in fishing pressure in the future.

4.4.2. *Attitudes With Respect to Environment*

The motives "to be outdoors" and "to enjoy or observe nature" were rated by anglers as the first and second most important reasons for fishing in Southwest Pond. The high importance that anglers place on the natural environment suggests that anglers will not tolerate a decrease in the quality of the environment in the watershed. The sociocultural benefits derived by anglers and any economic benefits that a successful Southwest Pond fishery may bring to the surrounding communities would therefore be maximized by maintaining a healthy ecosystem. As Fedler and Ditton (1994) point out, the high importance that anglers place on the natural environment makes a strong link between recreational fishing and ecosystem health. This shows that a healthy Southwest Pond watershed has value not only for itself as a healthy environment, but also for the recreational benefits it can provide to anglers. The effects of a decrease in environmental quality on the fishery in Southwest Pond will be two-fold. Not only will the trout population be likely to suffer with declining ecosystem health, but the desire anglers have to fish in Southwest Pond will also diminish. Further research is needed to determine what aspects of the natural environment anglers value most and whether any of these aspects (i.e. water quality, amount of development in the watershed) can be controlled by effective management. As exploitation of an ecosystem increases the overall health of the system can be expected to decrease (Malvestuto and Hudgins 1996), highlighting the need for appropriate management of the resource and the need for baseline monitoring of ecosystem health.

4.4.3. *Attitudes With Respect to the Fishery*

Of the six fishery resource-related motives included in the survey, only "for the challenge or sport of fishing" (rated 4th) and "to catch at least one fish" (rated 6th) were found to be relatively important to Southwest Pond anglers. The fact that non-fishery resource-related motives were rated higher than fishery-related motives does not lead to the expectation that some anglers will continue to fish even if the probability of catching a fish becomes very low. This observation, however, does demonstrate that Southwest Pond anglers hold multiple fishing motivations and that providing a quality fishery resource will allow people to simultaneously fulfil desires relating to the relaxation and temporary escape, natural environment and social aspects of fishing. The relatively high importance of these fishery resource-related motives suggests that the satisfaction derived from fishing in Southwest Pond depends on the existence of a quality fish resource without which most anglers will not fish and therefore not receive these additional benefits provided by the angling experience. Catching at least one fish was relatively important to anglers fishing in Southwest Pond, however catching a trophy fish was of much less importance (ranked 12th) as was catching a limit of fish (ranked 18th). Angler opinions about various regulations tended to support this position as anglers tended to favor regulations that would limit the overall catch. There was a lot of variation in importance within a number of motives. For example, the motive "to experience new or different things" had an overall rating of somewhat important, yet nearly 30% of respondents rated this motive as very important. Similar bimodal distributions can be observed with the motives "to develop fishing skills", "to catch a trophy fish", "meet other people", "relive memories", and "get some exercise". Such variability within motives demonstrates that there is no true "average" Southwest Pond angler because the relative importance of various motives varies between individuals. This suggests that a management plan based on angler motivations cannot be expected to satisfy the needs of every angler. This observation does not decrease the value of the motivational research but it does imply that the management of the Southwest Pond seatrout fishery should be geared to providing a variety of experiences that individual anglers can choose from. Furthermore, recognizing that the Southwest Pond angler population consists of various segments with different motivations and desires will aid in predicting angler responses to various management decisions.

4.4.4. *Attitudes With Respect to Management*

The information about angler motivations and preferences for various types of regulations will be very useful for determining the appropriate management strategy for Southwest Pond. Given the high value most anglers place on the relaxation, natural environment and social aspects of fishing and the lower value they place on some catch-related motives, such as catching their limit, the most appropriate strategy might be to maximize the amount of time people can spend fishing. This could be done by allowing the season to remain open for as long as possible and using various regulations to limit the harvest during the season. Anglers would approve a number of regulations for limiting the harvest such as a minimum size limit, a seasonal bag limit and catch-and-release fishing. A minimum size limit and catch-and-release would be relatively easy to implement; a seasonal bag limit, however, would be more difficult. Such a regulation would require a means of ensuring that anglers did not exceed the seasonal limit and thus would require issuing licences to anglers, something which many indicated they would be willing to pay a small fee to support.

Other methods of restricting the harvest, such as reducing the daily bag limit and a maximum size limit, received less support than did others (although support still exceeded 50%). The objection to a daily bag limit by some anglers is understandable in light of the fact that the provincial daily bag limit for trout (including the Southwest Pond seatrout) was reduced from 24 fish per day to 12 fish per day in 1994. Many anglers may be still getting used to the new bag limit and, while catching their limit is not an important reason for fishing, many anglers may view a further reduction as a severe action. The relatively low approval for a maximum size limit suggests that while catching a trophy fish is not an important reason for fishing, many anglers would like to be allowed to retain a trophy if they caught one. Given the results of the motivational survey, however, it is likely that the approval rate for these two regulations would increase if anglers were given evidence that they were necessary to protect or improve the fishery.

To avoid over-exploitation of the Southwest Pond seatrout population there must be a limit on the number of fish that can be removed during each angling season. If the duration of the fishing season is manipulated there must be a trade-off between the length of the season and the restrictiveness of the regulations used to control the harvest. If an extended angling season is chosen, thus allowing more angling effort to be placed on the fish population, the catch-per-unit-effort must be limited by means such as reduced bag limits, restrictive size limits or catch-and-release. If a short angling season is chosen regulations can be less restrictive, allowing a higher catch-per-unit-effort. In the case of Southwest Pond, where an extended season would best meet the needs of the anglers, the most effective way to proceed would be to go back to the angling public with a number of different options that consist of angling seasons of various lengths and the regulations that would be needed to limit the harvest within each season. This would give the anglers the opportunity to choose the option that they find most acceptable.

The knowledge gathered about the motivations and desires of the angling population in Southwest Pond, as reported in this chapter, should be very useful in the process of selecting regulations to manage the Southwest Pond fishery to maximize the sociocultural benefits to the anglers. Before any regulations are chosen and implemented, however, they must also be evaluated in a biological context. Meeting the desires of anglers will be an important part of successfully managing the Southwest Pond fishery, but care must be taken not to allow the desires of the anglers to override the biological concerns of management.

CHAPTER 5: REBUILDING AND MANAGING THE SOUTHWEST POND SEATROUT FISHERY

5.1. Developing a Management Plan

The goal of managing the Southwest Pond seatrout fishery was initially set as "to provide a sustainable recreational fishery resource that meets the needs and satisfies and sustains the expectations of the people who exploit it" (section 1.3.2). From this goal the two objectives of the present research were developed: 1) to gather information on the range, distribution, life history and ecology of the Southwest Pond seatrout population, and 2) to gather information about the benefits anglers derive from the resource and the attitudes of anglers as related to its management. These two objectives have been accomplished and the data gathered have been presented in Chapters 2-4. The data offer some insight into the Southwest Pond seatrout population and its fishery and show that the population has value both for its unique ecological characteristics and for the socio-cultural benefits provided to anglers in the surrounding communities. The results of both the LEK and the motivational surveys demonstrate that there is a high level of support among local anglers for a new management initiative aimed at protecting the seatrout population and ensuring the sustainability of the fishery.

The remaining two steps in the process of developing a successful recreational fishery as outlined by Krueger and Decker (1993) and presented for the Southwest Pond seatrout fishery in Chapter 1 are: Step 3) to identify problems currently affecting the population and its fishery , and Step 4) to make some recommendations to help improve the current state of affairs in the fishery. Problems will be identified by first evaluating the appropriateness of the two recreational fisheries management plans in use in Newfoundland for managing the Southwest Pond seatrout fishery. This is a useful approach because many of the regulations that have potential for use in managing this fishery are already employed in the existing management plans and may only require minor modifications to be effective in Southwest Pond. These regulations will then be evaluated for their applicability in Southwest Pond based on the biology of the population, the desires and motivations of the anglers, and the logistics of implementing each regulation. Finally, a set of preliminary recommended actions aimed at improving the fishery and protecting this unique salmonid population will be presented.

5.2. Management under Current Trout Regulations

The Southwest Pond seatrout is not officially recognized as an Atlantic salmon by the government departments responsible for recreational fisheries management in Newfoundland, and therefore, by default, it falls under the trout management plan. Under this plan there are separate summer and winter fisheries which run from approximately February 10 to March 15 and May 6 to August 18. The daily bag limit for each angler is 12 fish or 5 pounds plus one fish. When one of these limits is reached the angler must cease fishing for the day. Prior to 1994 the daily bag limit was 24 fish or 10 pounds plus one fish and there was a single season open continually from January 15 to September 15. Under the trout management plan there is no maximum or minimum size limit on fish kept (although anglers are not permitted to keep juvenile individuals) and there is no seasonal limit of any type to restrict overall harvest each year (Anon. 1995).

The trout management plan is not appropriate for managing the Southwest Pond seatrout fishery. In the past this plan appears to have allowed over-exploitation to a point where the population's size and age structure has been severely impacted. The reduction in the daily bag limit and the shortening of the angling season in 1994 probably did much to reduce the overall harvest, however the current bag limits are probably still too high for this population. Furthermore, the daily bag limits for trout have no underlying scientific basis and, therefore, are probably not even appropriate for many of the brook trout populations in the province for which they are meant.

The trout management plan does not offer adequate protection to the old, large fish which have the potential to make a large contribution of eggs at spawning. The current daily limit of 5 lb plus one fish makes it possible for anglers to remove as many as three large fish during any one fishing trip.

The trout management plan does not provide adequate protection to the population in the spring when it is most vulnerable to fishing. Fishing pressure in the spring is much heavier than at other times and the fish are very easy to catch at this time, probably because they are beginning to feed after overwintering in freshwater. A mechanism to limit the harvest at this season is required so that more fish can survive to spawn the following fall.

In the fall, as the fish return from the ocean, they are much harder to angle because they have spent all summer feeding at sea. Nonetheless, the fall fishery also needs to be managed to ensure that adequate numbers of fish survive to spawn, but under the current management plan the fishing season ends shortly after the run begins, reducing the opportunity that people have to participate in what has the potential to be a productive fishery.

5.3. Should the Southwest Pond Seatrout be Managed as an Atlantic Salmon?

One option for managing the Southwest Pond seatrout fishery would be to designate Southwest Pond and its tributaries a scheduled river system and adopt the standard Department of Fisheries and Oceans (DFO) Atlantic salmon management plan.

Under this management plan a salmon angling license is required to fish scheduled waters which are open to angling usually from late June until early September. Fly-fishing only is permitted and there is a daily bag limit per angler of two salmon retained and four salmon caught and released. There is also a season limit per angler of six salmon retained which is controlled by issuing six non-reusable tags with the license. One tag must be attached to each salmon retained and, on the island of Newfoundland, three of these tags are valid only on or before July 31 and the other three are valid only after July 31. Only salmon measuring between 30 cm and 63 cm in length can be retained except in northern Labrador where anglers are permitted to retain one large (greater than 63cm) salmon per year (Anon. 1995).

Although the Southwest Pond seatrout is actually an Atlantic salmon, the present salmon management plan is no more appropriate for managing this fishery than is the trout management plan. The salmon management plan was designed to limit the overall catch of salmon in the province and was not meant to be applied to any one individual population. While the restrictive daily and seasonal bag limits would significantly reduce the harvest of seatrout, the salmon management plan would transfer most of the effort to the larger fish. There are very few fish greater than 63 cm in the Southwest Pond seatrout population, however a large proportion of the catchable fish are under 30 cm and many of the smaller ones are males (Figure 3.4). The size limits imposed by the salmon management plan would result in protection of the smaller males (which are already more abundant than females) and lack of adequate protection for the larger female spawners, most of which are less than 63 cm in length. Furthermore, as anglers holding a salmon license are permitted only a limited yearly quota of salmon, they would probably be more inclined to keep only the larger fish within the 30 cm to 63 cm range.

Including the seatrout population in the salmon management plan would almost certainly decrease the satisfaction level of many of the anglers who currently fish in Southwest Pond. Under the salmon management plan the Southwest Pond river system would be restricted to fly fishing only. Many of the people observed fishing for the seatrout over the course of the study were not fly fishing, and 74.7% of all anglers surveyed rejected fly fishing as a management alternative for Southwest Pond. Also, most of the people who currently angle for the seatrout do not view the fish as an Atlantic salmon and probably would not be willing to include these fish as part of their already very limited yearly salmon quota. While this would likely reduce the harvest of seatrout, it would also cause many seatrout anglers who also enjoy angling for salmon to cease fishing in Southwest Pond . Furthermore, because the salmon angling season does not begin until June, management under this plan would entirely eliminate the spring fishing season in Southwest Pond, something which 44.3% of all anglers surveyed rejected as a management alternative even if it meant allowing the fall season to remain open longer.

5.4. Evaluation of Potential Regulations for Managing the Southwest Pond Seatrout Fishery

From all the evidence available, the single largest problem facing the Southwest Pond seatrout population appears to be over-exploitation. As the river system became more accessible, mainly due to the construction and subsequent improvement of the road to Greenspond in the 1970's and early 1980's, fishing effort rapidly increased. Unfortunately, the trout management plan, which at that time allowed a bag limit of 24 fish per day, was not adequate to limit the harvest of seatrout to a reasonable level. This resulted in a large decline in the size of the population and the nearly complete removal of larger fish.

There is some evidence that the population has recovered slightly in the past two or three years. A number of the people interviewed in the LEK survey and subsequently contacted again in more informal settings throughout the survey felt that, although the population size was still quite low, there were more fish in the two years of the study than in the five to ten years previous. Furthermore, people interviewed in the general angler survey who had five years or less experience fishing on Southwest Pond tended to report that fishing is better now than when they first began fishing there. If there has been an increase in the population in recent years, it is likely that this is due to the lower bag limit and reduced fishing season implemented in 1994. What all of this suggests is that a further reduction in harvest should lead to further recovery of the population.

If management of the Southwest Pond seatrout fishery is to be successful, it is obvious that the population will require its own management plan. The information gathered thus far suggests that over-exploitation is the main problem currently facing the population, and therefore the initial goal of this management plan should be to reduce the harvest of seatrout to a level that will allow the population to begin the process of recovery. One of the problems contributing to over-exploitation appears to be a lack of enforcement of existing regulations which has allowed a high level of poaching. The simple presence of a fisheries officer in the area would probably do much to deter poaching, however the implementation of a management plan specific to the Southwest Pond river system would, in itself, provide some deterrent because it would demonstrate that the population has value for its unique nature. A new management plan can be based on regulations that are already in use in Newfoundland such as bag limits, size limits, closed seasons etc. These regulations must be tailored to fit the unique characteristics of the population and its fishery must be chosen in such a way as to reduce the harvest while minimizing the impact on angler satisfaction. The acceptability of special regulations is already established in the concept of individual river management which has been supported by DFO and implemented on a number of river systems in the province e.g. Indian Bay River, Gander River, and Main River among others.

Daily bag limits are currently in effect for the Southwest Pond seatrout fishery but, as previously discussed, these bag limits probably do not limit the harvest of seatrout to a level that will allow the population to recover. Ideally, bag limits should be set based on estimates of population size, rates of production, and catch rates from creel surveys. These data are unavailable at the present time and their collection was beyond the scope of the present study. Lack of this information does not mean that bag limits should not be employed, but it does mean that bag limits should be set on the conservative side to avoid over-exploitation. A reduction in the daily bag limit would likely reduce the harvest, especially in the spring when it appears as though the 12 fish per day bag limit is attainable by many anglers. Anglers showed moderate support for a reduction in the daily bag limit and most were not motivated to catch their limit although many reported they would continue to fish for as long as they were allowed. A reduction in the daily bag limit accompanied by the provision that anglers could continue to catch-and-release after the limit was attained would probably be acceptable to a majority of anglers.

One of the problems identified with the current management strategy in Southwest Pond is that the fishing season does not permit exploitation at the appropriate times. In the spring the seatrout are quite vulnerable to angling and are in poor condition, however the same fish caught three or four months later, after spending a summer feeding at sea, will have grown about an additional 8 cm in length and will be in much better condition. The current fishing season encourages anglers to fish in the spring because the lack of a fishing season during the fall migration means that most people only have an opportunity to catch seatrout early in the year. Based on the size, condition, and timing of the run of fall fish, and the popularity of the recreational salmon fishery in Newfoundland (which also intercepts fish returning from the sea), the fall fishery in Southwest Pond has the potential to be a very productive, enjoyable, and unique fishery.

Given the short duration of the saltwater phase and the apparently high survival afforded by this strategy, it is likely that the number of fish removed by anglers in the spring reduces the number of fish returning to freshwater in the fall. If enhancing the fall fishery is an objective (and many anglers suggest that it should be), it will be necessary to reduce the number of fish removed from the population in the spring. Any action to reduce the impact of the spring fishery is likely to result in reduced satisfaction of many anglers, however, as the spring fishery is quite popular and well established. Moreover, 44.7% of anglers interviewed in the general survey were against closing the spring fishery even if it meant extending the fall fishery. Support for reducing or even closing the spring fishery may be increased if the benefits of doing so were communicated to anglers in terms of trade-offs between the number and size of fish caught in the spring and the resultant number and size of fish available in the fall. Given the popularity of the spring fishery and the only moderate level of support for closing it entirely, however, this is one area where conflicts can be anticipated. Nevertheless, if the population is to recover the harvest in the spring will have to be reduced. One possible solution is to shorten the spring fishery without eliminating it entirely. The fishery in the spring opens around May 6 and lasts three to four weeks, until the fish have migrated to the ocean. If the opening of the fishery was delayed for two weeks, this would give anglers who enjoy fishing in the spring the chance to fish, but it would also allow many of the fish to migrate to sea before the season opened.

The option of shortening the fishing season was rejected by 72.2% of anglers, therefore any reduction in the spring fishery should be accompanied by a lengthening of the fishery in the fall. Because the spawning run in the fall extends through September, the full potential of this fishery would be realized by allowing it to remain open at least until the end of September. This extension could initially be a catch-and-release fishery only, at least until the effects of the other regulation changes can be assessed. Allowing the fishery to remain open longer in the fall has the extra advantage of allowing anglers to observe first-hand the effects of the reduced harvest in the spring and may be one way of reducing the conflicts that are bound to arise if changes are made to the spring fishery.

Size limits are a type of regulation employed in the salmon management plan that may be useful in Southwest Pond. Three types of size limits are commonly used in managing recreational fisheries: minimum size limits which are used to protect juvenile fish, maximum size limits which are used to protect large, highly fecund individuals, and slot limits which are used to protect fish in an intermediate size range. Both maximum and minimum size limits are already employed as part of the salmon management plan in Newfoundland.

One of the effects of over-exploitation currently being experienced in Southwest Pond is a reduction in the number of large fish. For the purpose of this discussion large fish will be defined as those making up the upper 15% of the length frequency distribution. By this definition a Southwest Pond seatrout is considered large if it is greater than 42 cm in length. Eighty-four percent of all fish analyzed greater than 42 cm were female and these large fish have high fecundity (up to 2226 eggs in a 42-cm individual). As these individuals obviously have the potential to make a large contribution of eggs at spawning, protecting these large fish is one way to aid in the recovery of the population. Catching a trophy fish was not very important to the majority of anglers fishing on Southwest Pond although nearly 37% of anglers surveyed rated this motive as either very or extremely important. As a management option a maximum size limit received moderate approval from anglers (54%). One solution that would help protect large fish but still allow anglers the opportunity to fish for large fish would be to limit the proportion of the daily bag limit that can be above a given size.

Although a minimum size limit was the regulation that received the most support from seatrout anglers, the usefulness of such a regulation in Southwest Pond is questionable. All of the fish caught by anglers in the spring had been to sea at least once and most had probably matured and spawned the previous fall. In the fall, many of the catchable size fish were maturing for the first time and the presence of immature fish of the same age suggests that some of the larger individuals making the second migration were also maturing for the first time. Furthermore, almost all of the individuals less than 28 cm present in the fall are males. Protecting first time spawners of both sexes would therefore require a minimum size limit in the range of 35 cm to 40 cm which would result in a transfer of effort only to the larger fish, many of which are highly fecund females. A minimum size of 35 cm is undoubtably larger than what anglers had in mind when asked about a minimum size and, because such a regulation would reduce angler's access to many catchable size fish, its imposition would likely result in reduced angler satisfaction.

Two other management options that received a high level of support from seatrout anglers were the establishment of an angling license to fish in Southwest Pond and a seasonal bag limit per angler similar to that in effect under the salmon management plan. A seasonal bag limit would be an effective way of ensuring that the resource was equitably divided among all anglers and, if based on knowledge of fishing effort and rate of production within the population, could be a very effective method of limiting the harvest to a level that the population can sustain. To be effective a seasonal bag limit would require a mechanism to limit the total number of fish per angler but, unfortunately, such a mechanism is unavailable at this time. The establishment of a license to fish in Southwest Pond would provide a mechanism for implementing a seasonal bag limit and would also provide a means of generating revenue to support the cost of local management. The establishment of a license to fish in Southwest Pond is probably premature at this time, however this idea was supported by 73.4% of seatrout anglers and should be a consideration in the future after the population has shown strong signs of recovery.

The following is a list of specific recommendations aimed at reducing the harvest and beginning the process of building a successful Southwest Pond seatrout fishery:

Recommendation 1: Do not include the Southwest Pond seatrout population in the Atlantic salmon management plan.

Recommendation 2: Implement a bag limit of at most 6 seatrout per angler per day.

Recommendation 3: Restrict the harvest of large fish by allowing anglers to take only one fish greater than 42cm in length per day.

Recommendation 4: Delay the opening of the fishery in the spring until at least the third Saturday in May.

Recommendation 5: Extend the fishery until the end of September. This extension should be on a catch-and-release basis at least until the population has recovered sufficiently to permit increasing the harvest.

Recommendation 6: Increase the level of enforcement of regulations in both freshwater and saltwater.

Recommendation 7: Apply the bag limits and size limits to both the freshwater and saltwater fisheries.

5.5. Implementing Regulations and Direction of Future Research

The first step in implementing new regulations for the Southwest Pond seatrout fishery should be to go back to the anglers to get their input and opinion about the recommended regulations. Data were collected on anglers' responses to general changes in fishing regulations, but at no time were anglers presented with any specific regulations such as those recommended here. It is possible that anglers may find some of the proposed regulations too restrictive, however it is also possible that the anglers will support more restrictive regulations in some areas. Angler desires cannot be allowed to override biological concerns, but if anglers are presented with proposed regulation changes before they are implemented, along with the biological rationale and expected outcome, any serious objections can be dealt with prior to implementation.

Part of any future consultation process should be a presentation of the data gathered here about the seatrout population and about the anglers themselves. This will allow anglers to understand the scientific basis for implementing new regulations and will also allow them to assess the possible affects of new regulations based on their own knowledge of the seatrout population and its fishery. Furthermore, if anglers understand the scientific basis for the new regulations (and the results of the LEK survey suggest that they will) and are involved in the decision making process, the probability of successfully implementing a new management plan will be greatly increased. Perhaps the most efficient method of accomplishing all of this would be to hold a public meeting in one of the surrounding communities. Such a meeting would include a presentation of all available data and the rationale behind the proposed changes followed by an input session where anglers could present their own opinions and ideas. Such a format has proven useful for selecting new regulations to manage the Indian Bay River brook trout fishery located 20 km to the south of the Southwest Pond river system.

If the management process in Southwest Pond is to continue to evolve, i.e. to follow the principles of adaptive management, the database presented here must be continually updated and expanded. Future work should include studies of abundance, recruitment and mortality rates, feeding habits and habitat requirements of the fish, and catch and effort of the fishery. One of the main objectives of future research should be to obtain an estimate of the number of fish that can be sustainably removed by the fishery each year. This information will provide a better basis for setting bag limits, size limits and open seasons than is currently available. Future work should also include monitoring of the fishery for changes resulting from implementation of new regulations. This includes monitoring not only changes in the fish population but also changes in angler satisfaction and motivations and changes observed by anglers in the fish or fishery. As new information is added, management of the fishery can be advanced toward providing the optimum sustainable yield (interpreted in the broadest possible sense) from a unique Newfoundland salmonid, the Southwest Pond seatrout.

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Appendix 1: The questionnaire used to gather the Local Ecological Knowledge of Southwest Pond seatrout anglers.

The Southwest Pond Trout Questionnaire

Hello, may I speak with __________ please. Hello Mr/Mrs. __________ . My name is Steve Sutton and I am a biology student at Memorial University. I am doing a study on a particular fish that is reported to live in the Southwest pond area. Right now I am gathering data on this fish from local anglers in order to determine how much information I can get about this fish from the people who are the most familiar with it. I was wondering if I could ask you a few questions.

Yes__ Continue.
No__ Thank and terminate.

If you do not know the answer to a question or would rather not answer a question, just say so.

1. Some people say there is a special fish that lives in the Southwest Pond area. Are you familiar with this fish?

   No. __ Thank you, goodbye.
   Yes. __ Continue.

2. What names do you use for this fish?

3. What characteristics do you use to identify (use name interviewee suggests) and distinguish it from other fish.

4. When did you first learn about (use name interviewee suggests)?

5. Where do they live?
   Do they enter any rivers that flow into Southwest Pond?
   Do they live in any other river systems?

6. Do they go to sea?

No. __ Go to question 20.
Yes.__ Continue.

7. What time of the year do they go to sea?

8. What size are they when they first go to sea?

Length_______ (Record the one
Weight_______ answered first)

What would that be in (ask other category)?
How old would you say a fish of this size is?

9. How far do they go in the sea?

10. What do they eat when they are in the sea?

11. Do people fish for them in the sea?

No. __ Go the question 16.
Yes. __ Continue.

12. Where do people fish for them in the sea?

13. When is the best time to fish for them in the sea?

14. What type of gear is used to fish for them in the sea?

15. What is the size of (use name interviewee suggests) that people catch most often in the sea?

Length_______ (Record the one
Weight_______ answered first)

What would that be in (ask other category)?
How old would you say a fish of this size is?

16. How long do they spend in the sea before they return to freshwater?

17. Do they grow much during the time at sea?

18. What time of the year do they return to freshwater?

19. Where do they spend most of their time?

    Sea___ Estuary___ Fresh

20. What do they eat in freshwater?

21. Do people fish for them in freshwater?

    No __ Go to question 26.
    Yes __ Continue.

22. Where do people fish for them in freshwater?

23. When is the best time to fish for them in freshwater?

24. What type of gear do people use to fish for them in fresh water?

25. What is the size of (use name interviewee suggests) that people catch most often in freshwater?

    Length_______ (Record the one
    Weight_______ answered first)

    What would that be in (ask other category)?
    How old would you say a fish of this size is?

26. Have you ever seen or heard about them spawning?

    No__ Go to question 32.
    Yes__ Continue.

27. Where do they spawn?

28. How deep is the water there?

29. How fast does the water flow?

30. What is the bottom like?

31. What time of the year do they spawn?

32. At what size do they first spawn/mature?

Length_______ (Record the one
Weight_______ answered first)

What would that be in (ask other category)?
How old would you say a fish of this size is?

33. What other fish are found in the Southwest Pond river system?
(Check the ones answered)

Atlantic salmon___	Brook trout___
Brown trout___	Rainbow trout___
Smelt___	Eels___
Arctic char___	Other_____________

34. What is the most abundant fish there?

35. Do you think (use name interviewee suggests) interbreeds with any of these?

Yes__ Which ones?

Atlantic salmon___	Brook trout___
Brown trout___	Rainbow trout___
Smelt___	Eels___
Arctic char___	Other_____________

No___	Don't know___

36. Does (use name interviewee suggests) spawn in the same place at the same time as any of these?

Yes__ Which ones?

Atlantic salmon___	Brook trout___
Brown trout___	Rainbow trout___
Smelt___	Eels___
Arctic char___	Other__________
No__	Don't know___

37. What do you think (use name interviewee suggests) is most like?

Atlantic salmon___	Brook trout___
Brown trout___	Rainbow trout___
Smelt___	Eels___
Arctic char___	Other__________-

38. Do you fish for the (use name interviewee suggests).

No__ Why not? Go to question 45.
Yes__ Continue.

39. Where do you fish most?

40. When do you fish most?

41. How do you fish most?

42. Have you seen any changes in the quality of fishing over time?

No__ Go to question 44.
Yes__ What are these changes?

43. What do you think may have caused these changes?
(Check the ones answered)

______Winter fishing
______Net fishing
______Habitat destruction
______Number of anglers fishing in the area
______Lack of adequate management
______Poaching
______Other____________
______Don't know

44. What would you consider to be a good days catch?

Number_____ (Record the one
Weight_____ answered first)

What would that be in (ask other category)?

45. How many (use name interviewee suggests) would you say there are now?

46. What would you consider to be a large (use name interviewee suggests)?

Length_______ (Record the one
Weight_______ answered first)

What would that be in (ask other category)?
How old would you say a fish of this size is?

47. Have you ever caught one this large?

Yes___
Where?
When?
How?
No___

48. Do you fish for any other species of fish?

Yes_ Which ones?

Atlantic salmon___	Brook trout___
Brown trout___	Rainbow trout___
Smelt___	Eels___
Arctic char___	Other___

No_ Go to question 50.

49. Which fish would you most prefer to catch?

Atlantic salmon___	Brook trout___
Brown trout___	Rainbow trout___
Smelt___	Eels___
Arctic char___	Other___
Southwest Pond trout___	

50. Have you noticed any changes in the fishing for the other fish in the places where you fish?

51. Do you think there should be any special regulations for this fishery?

Yes___What should they be?
No___

52. Is there anything that you can tell me about (use name interviewee suggests) that I have not asked?

53. Do you know of anybody else who I might be able to get information on (use name interviewee suggests) from?

Yes___
Name______
Phone #_____
No___

54. May I contact you again in the future?

Yes___
No____

55. Would you like me to send you a copy of the results of this study?

Yes___
Address__________
No____

Interviewee name__________ Date of interview

Appendix 2: A sample calculation of the two-step scoring procedure to place motivational items into categories. From Gilbert (1977).

Step 1. Establish ranges of values

79 respondents in survey x 4 (value of extremely important) = 316 (highest possible score for any item)

316 / 5 (number of possible responses for each item) = 63.2 (size of interval between min. and max . value for each category)

Not important	= 0 to 63.2
Somewhat important	= 63.2 to 126.4
Moderately important	= 126.4 to 189.6
Very important	= 189.6 to 252.8
Extremely important	= 252.8 to 316

Step 2. Calculate importance score of each item and determine item importance.

For item A ("To escape the daily routine"):

11 (not important) x 0	0
9 (somewhat important) x 1	9
28 (moderately important) x 2	56
25 (very important) x 3	75
6 (extremely important) x 4	+ 24

Score = 164 = moderately important overall