ATLANTIC SALMON (*SALMO SALAR*) STOCKING AS A TOOL IN THE RESTORATION TOOLBOX

Summary of a Workshop held:
6 – 8 February, 2009

Antigonish, Nova Scotia, Canada

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Habitat Unlimited
St. Francis Xavier University – Integrated Studies in Aquatic Resources

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EXECUTIVE SUMMARY

It has been recognized that stocking of Atlantic salmon (*Salmo salar*) can be a useful tool for restoration; it is highly controversial and there exist both success stories and documented failures. Many watershed and salmon organizations consider stocking as part of a solution for restoration. Due to the technical nature and the minimal discussion surrounding the issues of stocking, it is difficult for groups to make an informed decision. A workshop took place February 6-8, 2009, at St. Francis Xavier University in Antigonish, Nova Scotia. It was the first event to bring together federal and provincial government officials, First Nations, scientists, non-government organizations (NGO) and people with a general interest in stocking. Information presented was intended to give a well rounded perspective on aspects to be considered prior to stocking. The workshop consisted of a Keynote Address, case studies on the advantages of stocking, and panel presentations on biology, sociology and economics. A break out discussion session followed on the final day.

In the Keynote Address, Dr. I. Fleming (Memorial University of Newfoundland) emphasized the importance of knowing the history of stocking in order to understand the controversy surrounding it. The use of hatcheries has changed over time. Aquaculture was first documented in the 5th Century B.C. with carp. During the Industrial Revolution, people felt hatcheries could repair declining salmon populations; nothing was done to restore the habitat. By the mid 1900s people started rearing salmon for food world wide. In the last ten years people have been turning to hatcheries to assist with salmon conservation. Hatcheries and stocking can be used for conservation, fisheries and livestock fisheries. Stocking alone has not been successful, but can be used as a tool in the restoration toolbox if a clear objective is presented.

Mr. L. Forsyth (Margaree Salmon Association) provided an example of successful stocking. The Margaree River has excellent fish habitat, but during the 1970s to 1980s there was an outbreak of Bacterial Kidney Disease (BKD), which killed many salmon. With the assistance of the Department of Fisheries and Oceans (DFO) and the Margaree Salmon Association, a stocking program was created. Broodstock from the Miramichi and Margaree Rivers were used. Smolt and parr were stocked annually, and the number of adult returns started increasing. The stocking program continues today with the assistance of the Nova Scotia Department of Fisheries and Aquaculture (NSDF&A). The Margaree River has one of the healthiest salmon populations in Nova Scotia.

Mr. W. Regan (Sackville Rivers Association) demonstrated that salmon stocking can be a very powerful tool for educating the public. The Sackville River is located in an urbanized area, where many people are not exposed to nature. Since the 1980s salmon have been stocked in the Sackville River. Initially, the stocking program was supported by DFO, but now NSDFA supports the program. As part of the Sackville River Association's education program, salmon eggs are delivered to classrooms throughout Sackville. The students raise the eggs to fry, and release them back into the Sackville River. Not only do students become involved, but parents too. This gives the community a sense of ownership and restoring the salmon population becomes a personal priority.

Mr. B. Baker (Nepisiguit Salmon Association) discussed the Nepisiguit Salmon Associations (NSA) stocking program, which is very successful. The Nepisiguit River, New Brunswick, has a large falls, which is a natural barrier but the river has over 18 miles of suitable habitat for salmon below the falls. DFO started stocked various stages of juvenile salmon on the Nepisiguit River in the 1970s. Broodstock from Rocky Brook(Miramichi) and the KedgwickRiver(Restigouche) were collected and produced the juveniles.The NSA took over the stocking program in 1981, utilizing broodstock collected at a counting/collection fence on the Nepisiguit River. The Association now stocks both unfed fry(incubation boxes) and fall fingerlings. Eggs are kept in the hatchery over winter, then transferred to incubation boxes on the river in the spring for the unfed fry, thus minimizing time spent in the hatchery.

Mr. M. Hambrook (Miramichi Salmon Conservation Centre) explained that having a hatchery is an excellent tool for restoration and for emergencies. The Miramichi Salmon Conservation Centre was owned and operated by DFO; in 1998 the Miramichi Salmon Association (MSA) took over. The stocking program costs $350,000 annually. The MSA raises funds in different ways. First, the Conservation Centre was converted into a research centre to study wild Atlantic salmon and DFO rents office space for personnel. Second, the government provides funding for hiring students and persons with disabilities. Third, the MSA sells approximately $100,000 of salmon to other conservation groups. Finally, the majority of the Associations revenue comes from trout sales. The MSA sells trout to people with backyard ponds and privately owned lakes, and the private sector. The MSA also has a contract with the Provincial Government, to supply trout to all lakes that are stocked in the province. It is possible, but challenging, for NGOs to financially support a stocking program.

Mr. D. MacLean (Nova Scotia Department of Fisheries and Aquaculture) discussed how salmon fishing has a historical importance for residents of Nova Scotia and that stocking can be used to supplement the fishery. Since the 1980s, salmon and general fishing license sales have declined. In 2005, the total attributable expenditure for the salmon fishery was $3,000,000 in Nova Scotia. In 2006, orders and funding were provided to NSDFA by the province to improve salmon stocks. The NSDFA and DFO cooperatively created a list of rivers to be considered for stocking. The rivers were selected based on the available rearing habitat and broodstock and the stage of salmon required for stocking. The stocking program started in 2008. Broodstock were collected and raised in the Fraser's Mills Hatchery. The province anticipates that the number of salmon and general license sales will increase this year.

Mr. G. Stevens (Department of Fisheries and Oceans) indicated that none of the salmon stocks managed by DFO in the Maritimes Region are meeting or exceeding their conservation requirements, except North River in Cape Breton. The Federal Government does not discourage the Provincial Government, the private sector and First Nation groups to consider salmon enhancement programs. Separate licenses or permission are required from DFO to remove salmon from, or release live salmon into a river. As a general rule licenses are not provided for salmon stocks that are below conservation requirements. Exceptions to this are organizations which may want to preserve or maintain the genetic diversity of species that is endangered. In order for DFO to issue a license three standards must be met: (1) live fish must be free of diseases, (2) not affect the wild stocks size or (3) not affect genetic diversity. Fifteen years ago marine survival was 3%, now it is 0.5%. Even with a salmon enhancement program, only 0.5% of the adults are returning, stocks are still below conservation requirements.

Mr. K. Prosper (Paq'ntkek First Nation) supplied a timeline of the political events that involved Aboriginal groups between the early 1600s to the present. In 1752 the Peace and Friendship Treaty was signed by the British and the Mi'kmaq. Between 1867 and 1985, Aboriginal groups were denied their Treaty Rights. In the last twenty years a series of court events took place to defend Aboriginals rights based on treaty agreements. The court cases covered the right to (i) hunt with modern technology for food, (ii) fish for food, social and ceremonial purposes, (iii) be given priority after conservation for access to fish, (iv) equal standards of living as Non-Aboriginal people and (v) ensure Aboriginal communities survive. Food is a very important part of the Mi'kmaq culture. Food is also very important for all species within an ecosystem. Stocking has the potential to disrupt the natural balance in an ecosystem and many species are affected. When considering stocking, salmon should not be the only species in mind. Consider the smelt, gaspereau, seals, mergansers and fox; everything has to eat. Stocking is not only about improving the recreational fishery. Having a holistic view can help people work together to achieve goals, because each others needs are understood.

Dr. D. Fraser (Dalhousie University) discussed the importance for any species of maintaining genetic diversity in order to respond to environmental change Atlantic salmon have strong links to the local environment and the genetic and phenotypic characteristics of the fish are specific to a location. Salmon can rapidly adapt to the hatchery environment. The genetic organization of a fish placed in the hatchery may be changed in two ways, either (1) relaxation of, or (2) change of, selective pressures. Intentional selection of broodstock may inadvertently lead to these. Fish reintroduced to a natural environment after experiencing these modified selective pressures may be less fit. Multiple traits may be modified by hatchery exposure. There is little research on the effects of hatchery experience on Atlantic salmon, but there is some very good work on steelhead. These studies show a rapid decline in success rate with hatchery exposure. There is concern of the effect on the "effective population size" of the fish, as opposed to the "census population size". The former is usually smaller than the latter, but stocking is generally conducted to increase the census population size. The risk with small effective population size is loss of genetic diversity. Genetic variation within a family should be a consideration in designing a stocking program, as families are frequently better adapted to site-specific conditions. Stocking programs used to boost wild populations have the potential to affect the genetic diversity and effective population size. People concerned with the decline of the Atlantic salmon population are in a dilemma from a genetics standpoint with using stocking as a restoration tool. There is uncertainty in restoration science and the long-term genetic effects of continuous stocking are not well studied. Some key features to consider to minimize genetic issues associated with stocking are: (1) use local broodstock, (2) use a large number of randomly selected breeders, (3) include adults of different body size (MSW and grilse), and (4) minimize the time and number of generations in the hatchery environment. Determining relationships among breeders would be ideal but is financially and logistically difficult. Long-term genetic monitoring programs are essential for hatchery rearing and stocking success.

Mr. B. Rutherford and Ms. A. Weston (Nova Scotia Salmon Association Adopt-a-Stream Program) presented on habitat aspects of stocking. They detailed that for restoration purposes, aspects of the habitat (e.g., water quality, physical habitat, instream cover, etc.) need to be considered at each life stage. Upstream migrating adults should travel as far upstream as possible to ensure seeding of downstream areas by drifting fry and parr. Restoration measures are often used to ensure upstream passage. Frequency of holding pools for adults may be limiting and stocking of adults above impassable river sections may be an option. Suitable spawning habitat is often limiting; stocking adults to increase spawning or fry in suitable habitat may be an option. Where fry habitat is limited, the stocking of late fry or fall fingerlings may be appropriate to circumvent fry mortality/emigration. Under conditions where pre-smolt habitat is limiting, collection of parr and pre-smolt, then holding for release as smolts, may be feasible. One of the differences between successful and unsuccessful stocking programs is the appropriate identification of the limiting habitat factor and stocking as a strategy to circumvent this.

Dr. I. Fleming (Memorial University of Newfoundland) further discussed salmon stocking, following up on his Keynote Address. Under certain conditions stocking may be appropriate, while under other conditions it would not be. In part this is due to potential conflicts in stocking for conservation or for fisheries. The hatchery is an artificial environment and the fish are selectively bred and reared in manners not encountered in nature. The hatchery environment can impose developmental changes in fish, including morphological, behavioural, endocrinological, and brain development alterations relative to wild fish. Some of these are apparent in as little as one generation. In particular, the high density of rearing young salmon and preventing exposure to predators have effects on the developmental processes. The effects of juvenile exposure to the hatchery can be carried through to adulthood, as shown with morphology, behavior and secondary sexual characteristics of coho salmon. Egg size of adult female Atlantic salmon also is linked to experience as a hatchery versus wild juvenile. Interactions in streams between wild and hatchery reared juveniles may be significant and is closely related to habitat quality and quantity. Adding fish to streams with existing wild fish may be counterproductive. Further, stocking may mask an underlying habitat problem limiting production. Stocking programs should be used to enhance the wild production of fish and to improve wild populations. The goal of each stocking program should be clear and specific to a river system. The initiation and completion of a stocking program should be pre-determined. Stocking should not inhibit other action for restoration. Current decision-making with respect to stocking is *ad-hoc* and reactive to public pressures. Norway's example of planning activities by river status may be a useful model for us.

TABLE OF CONTENTS

INTRODUCTION

This report provides a summary of presentations and discussions from a workshop on the efficacy of stocking to restore Atlantic salmon (*Salmo salar*) populations in Atlantic Canada. The workshop was held February 6-8, 2009 at St. Francis Xavier University in Antigonish, Nova Scotia. Speakers from Newfoundland, New Brunswick and Nova Scotia participated in the workshop along with attendees from across the Atlantic Provinces, representing the Federal Department of Fisheries and Oceans (DFO), the Nova Scotia Department of Fisheries and Aquaculture (NSDFA), Paq'ntkek First Nation, four universities (Memorial, Acadia, Dalhousie and St. Francis Xavier), several community salmon associations and Non-Government Organizations (NGOs).

The decline in salmon populations across the Atlantic Provinces has raised concern among all participants. Many groups have considered stocking as a way to improve salmon populations, but the technical nature and controversy surrounding hatcheries and stocking can be overwhelming. Approximately 60 people attended the weekend long workshop (Appendix 1).

The first evening of the workshop included a presentation given by keynote speaker Dr. Ian Fleming from Memorial University of Newfoundland. The following day included discussion panels on: (*i*) the experience with stocking, (*ii*) socio-economic and (*iii*) biological issues surrounding stocking. After each discussion panel and presentations there was an opportunity for the audience to ask questions. On the last day of the workshop, the audience was divided into small groups to further discuss in detail some of the issues surrounding stocking and to record concluding remarks.

It is anticipated that this report will reflect the key points discussed throughout the workshop and that all interested groups will recognize the benefit of sharing information.

WORKSHOP PRESENTATIONS AND DISCUSSIONS

Keynote Speaker: Friday, February 6, 2009

Dr. Ian Fleming of Memorial University of Newfoundland was the keynote speaker for the Workshop. He provided the historical background and set the tone for the panel discussions the following day.

Dr. Ian Fleming
Ocean Sciences Centre
Memorial University of Newfoundland
St. John's, Newfoundland

Knowing the history of stocking is important for understanding the controversy surrounding hatcheries and stocking today. Some of the questions that will be discussed here and throughout this workshop include: (1) under what circumstances is stocking appropriate, (2) when should salmon be transferred into the hatchery, (3) when should they be released, and (4) when should stocking be used for restoration.

Stocking stems from a long history of aquaculture and the controversy surrounding stocking has changed over time, especially in the last ten years. Knowing the roles of hatcheries and what happened in the past is important to be able to provide a context for what is currently happening with hatcheries. Humans have been domesticating animals for over 10,000 years. The first record of aquaculture is documented in Chinese manuscripts from the 5th Century B.C. Aquaculture then involved capturing young wild carp (*Cyprinus carpio*), transporting them into holding ponds, rearing and then harvesting them. In contrast, modern aquaculture is practiced by stripping the eggs from females and sperm from males. The gametes are mixed and the eggs are fertilized and artificially reared. The modern aquaculture process was first documented in 1773. Trout eggs were stripped, mixed with sperm in water and reared in a pond. Aquaculture became popular in the 19th century because people realized they could control reproduction to increase the number of fish. The success led to the idea proclaimed by the US Fish Commission (1876; cited in Lannon 2001) that artificial propagation will make salmon so abundant, that there will be no need to regulate harvest or protect habitat. Hatcheries were viewed as the solution for fixing declining salmon populations. Samuel Wilmot created the first hatchery in North America in the 1860s. In 1896, Atlantic salmon were extirpated from Lake Ontario and the population was not restored. Also, in the late 1800s, California and Maine started producing hatchery reared fish. The Penobscot River in Maine supplied broodstock to other salmon rivers across the United States. During the Industrial Revolution a hatchery model was created in which there were two main ideas; first, that technology can fix anything and that there is no need to repair habitat, and secondly, that all salmon are the same. Broodstock were removed from rivers and transported to other rivers without considering the potential consequences. Brown trout (*Salmo trutta*) are an example of how fish were transported outside their native range. Brown trout are not native to Eastern Canada. They were introduced from Europe in the late 1890s. Brown trout now have a cosmopolitan distribution as they were also introduced to South America, Africa, Australia, and India.

The concept of aquaculture changed when people realized they could rear fish for food. Aquaculture is a very important food industry globally. Norway and Chile are the top aquaculture producers of Atlantic salmon in the world. The wild salmon population is very small compared to farmed salmon. Salmon pen size increased over time from $60m^2$ to the size of a box store. One of the major concerns with aquaculture is the potential implications of escaped farmed salmon mixing with wild salmon.

Hatcheries can be used for three purposes: (1) a livestock fishery, (2) recreational fisheries, and (3) conservation. Hatcheries used in a livestock fishery rear smolts to be sea ranched; that is the fish are released and then harvested for production purposes. Sea ranching has not been successful with Atlantic salmon and is almost non-existent because the salmon did not return in sufficient numbers to make it economically viable. The recreational fishery can be supported and productive in the short term by supplementing reared salmon into an existing population. The fish can also be used to supplement the loss of fish from a native population (e.g. due to dams). Hatcheries for conservation use reared salmon to attempt to assist with restoring self-sustaining wild populations by contributing to natural production.

Restoration is a focus of conservation efforts and live gene banking is a tool for accomplishing it. Live gene banking involves placing broodstock into a hatchery for the purposes of maintaining the population until the conditions in the wild environment have been restored or recovered to a state where salmon exist self sustainably. Live gene banking is typically the last measure used to assist salmon populations.

Each year there are five to six billion smolts released for fishery and conservation purposes. Most stocking is done in the Pacific Ocean. If people want to stock for both fisheries and conservation purposes, there are potential conflicts. To supplement a commercial or recreational salmon fishery, many fish must be produced and released, and this is unlikely to be conducive with the purpose of conservation, which is to restore self-sustaining the salmon populations.

In the Pacific Ocean, salmon populations are being lost. In southern regions such as California, resources are being used in attempt to restore the Chinook (*Oncorhynchus tshawytsha*), coho (*O. kisutch*) salmon, and steelhead (*O. mykiss*) populations in Central Valley, Oregon and the Columbia River. Climate change, increases in human population size and development appear to be contributing to the losses of salmon populations. Similarly, southern populations of Atlantic salmon in the Northwest Atlantic Ocean, such as those in Maine and Bay of Fundy, have declined to the point of being endangered. In Europe the southern populations of salmon are also at a high risk. Of the salmon that remain in the Columbia River, 70% to 90% are of hatchery origin. The Baltic Sea has a genetically unique salmon population, which is approximately 90% hatchery origin today.

Stocking can be a tool in the restoration toolbox, but will not be effective on its own. Results from a hatchery in Oregon illustrate this. There were large peaks in the production history, but the number of fish being released stayed the same while survivorship declined. Stocking alone did not solve the problem. In another case, the Tornionjoki River in the Baltic was stocked at different locations until 2002 because the salmon population was declining. Some locations were stocked with more fish than others. Based on this research, there was no evidence that stocking is detrimental or that it benefited the stock in areas where more or fewer salmon were stocked. The stocking program ceased in 2002 and natural salmon production increased over time. There was no evidence to support the concept that stocking was benefiting the population. This raises the question why would organizations stock?

The examples above used stocking in a technical production sense, they did not fully consider conservation and captive breeding principals. Captive breeding techniques for conservation have been used successfully to boost other animal populations such as ferrets (*Mustela* spp.) and panda bears (*Ailuropoda melanoleuca)*. Genetics and ecology must be considered. Conservation has changed the purpose and function of hatcheries over time.

In Norway, some salmon populations are faced with low pH (acid rain) and an introduced parasite (*Gariactulus salaris*) originating from the Baltic Sea. The salmon from the Baltic Sea are resistant to *G. salaris*, while those in Norwegian rivers are not. These impacts have created the need for gene banking to preserve the stocks. Gene banking was used in hopes that salmon could be reintroduced once the environment was restored. It is important to not only consider what happens in the hatchery, but what can be done to assist the wild salmon populations.

If watershed and salmon organizations are considering stocking, one should try and maintain the population in a state whereby it can be reintroduced. It is important to maintain genetic variability and avoid domesticating fish by minimizing the time spent in the hatchery because fish adapt genetically and phenotypically to their environment.

There are perceived conflicts between stocking to supplement the recreational fishery and conservation and mitigation objectives. Prior to stocking, one must determine the goals for stocking and constructing a hatchery. Depending on the purpose of stocking, the objectives might be different. The only way stocking will be measurable and effective is if hatchery fish contribute to the salmon stocks by breeding in the wild, without inhibiting the production of wild salmon. If hatchery fish replace wild fish, it is unlikely that the stocking program will be successful. In the past stocking did not assist salmon populations; can it still be used for restoration? The answer is yes, but only with a clear objective.

Discussion

A hatchery fish is one that spends any length of time in a hatchery, including for reproduction. Even if eggs are taken from the hatchery, fertilized and then released into the wild, the fish has experienced artificial selection (i.e. it is the result of artificial breeding, having not been the result of natural mate selection).[1]

In a natural environment wild eggs are fertilized by both male grilse and multi-sea winter (MSW) salmon. Dr. Fleming's video illustrated that a case where a MSW male fertilize a small number of eggs, whereas the male grilse fertilized more eggs because the MSW male spent much of his time chasing away the male grilse[2]; the two mating techniques can increase genetic variability. How salmon spawn in the natural environment is different from what happens in the hatchery environment. In the past hatcheries may have affected the quality of the stock because smaller males were consciously removed, even if the grilse fertilize in the wild.

In the early years of the enhancement effort on the Nepisiguit River, the majority of salmon returning were grilse, with perhaps 20% MSW. As a result of fifteen years of stocking progeny of salmon vs salmon, the current number is now averaging approximately 60% MSW (last ten years). As approximately 70% of MSW fish are females, mate selection is a practical impossibility. With Atlantic salmon, when the female deposits her eggs, any male in the vicinity rush in to fertilize. Males also recuperate to spawn many more times than females. The best way to increase MSW numbers is through use of hatcheries in a stocking program. Considering the impact man has had on most creatures, is what now occurs in nature a "natural" process? Man reduced the percent of MSWs in returns, it is up to man to correct this if possible[3]. Fish should be produced in the hatchery according to the needs of the river system. Selecting MSW males for fertilizing eggs may not be the optimal solution, because the environment has changed (e.g. climate). Fish must be able to respond to their natural environment. The decline in MSW salmon may be partially because of genetic issues and due to the likelihood of mating. If there is low marine survival, perhaps it is advantageous to remain a grilse. Some grilse may not go to the sea at all. An issue with hatcheries is that people decide what is best for salmon stocks; it is not a natural process.

Initially the purpose of the marine hatchery was to increase food production, which has a negative affect. Hatchery managers then started importing and mixing populations. Comparisons between gene pools are possible through DNA analysis, which examines the genetic viability of a population.[4] By 1992, rivers in Maine were constantly being stocked by native species. Foreign fish were not as successful and eventually were not found in the population.

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[1] Question posed by Bob Baker
[2] Comment by Leonard Forsyth
[3] Comment by Bob Baker
[4] Question posed by Larry Bell

Panel 1: Case studies, Saturday February 7, 2009

Representatives from three Environmental Non-Government Organizations (ENGOs) (Margaree Salmon Association, Sackville Rivers Association, and Nepisiguit River Association) discussed their experiences with stocking.

Leonard Forsyth
Margaree Salmon Association
Margaree Centre, Nova Scotia

The Margaree River has the largest Atlantic salmon population in Cape Breton, Nova Scotia, with a summer and fall run. The Margaree is above the conservation requirement and is part of the Gulf Region. The Margaree has been stocked with juvenile salmon since 1882. In 1902, the Margaree hatchery was built and operated by the Federal Government.

The commercial salmon fishery impacted the salmon population during the 1960s to 1970s. Salmon from the Margaree were tagged by Elson from 1961 to 1973. Elson's results indicated that between 32-33% of salmon were being captured off Newfoundland and Greenland. In another tagging study during the 1960s, Elson suggested 42% of 6000 tagged smolts were captured off Greenland. Marshall (1980) suggested that 46% of salmon were captured in Fishing Statistical District 2.

In the recreational salmon fishery, the reported catch went from 1022 salmon in 1923 to 100 salmon in 1975. The salmon stocks in the Margaree were mostly 2SW fish, but by 1970s grilse increased to 35%. The percent of repeat spawners (mostly maiden 2 & 3 sea-winter salmon) declined from 20% to 7%.

Between the 1970s and 1980s the salmon in the Margaree River were affected by Bacterial Kidney Disease (BKD). All juveniles were tested before being stocked from the hatchery. Since 1995, no BKD cases have been found. During the mid 1970s, DFO determined a strategy for enhancing salmon production in the Margaree. Broodstock were collected from Rocky Brook in the Miramichi River, New Brunswick and were used to initially stock the Margaree. Other components of DFOs salmon enhancement strategy were to have different bag limits for the angling season and to monitor the success of the stocking program.

Parr and smolts were stocked in 1977, 1978, 1980, 1981 and 1986 in the Margaree. Broodstock was supplied from Rocky Brook during these years. Due to the outbreak of BKD, salmon eggs were fertilized in the Miramichi Hatchery and transferred to the Cobequid Fish Hatchery in Nova Scotia. From 1987 to 1995, broodstock were collected from the Margaree and parr and smolt were stocked. The Margaree hatchery was turned over to the Aquatic Development Association of Margaree (ADAM). Stocking parr and smolt continued until 2008. The Nova Scotia Department of Fisheries and Aquaculture (NSDF&A) now operates the hatchery.

The seasonal bag limits were changed from two fish per day of any size (June 15 to October 15, 1961 to 1978) to catch and release only for MSW's from June 15 to August 31, for specific locations on the river. After August 31, the seasonal bag limits returned to two fish per day of any size. Fishing on the Northeast Branch of the Margaree above the Big Intervalebridge is sanctuary and closed to salmon angling. After 1985 there was only catch and release and a maximum of four grilse could be hooked and released. In 1985, the commercial salmon fishing was closed.

Prior to stocking the angling catch was recorded as 100, 178, 207, and 184, respectively (grilse and MSW salmon) between 1975 to 1978. After stocking the catch increased to a high of 932 grilse and 141 MSW salmon between 1979 to 1981. The summer angling catch of MSW fish exceeded that of the fall catch in 1969, 1972 and 1973 because early run broodstock were used. There is a correlation with the number of anglers and the catch and fishing effort over time. By the mid 1980s the catch and fishing effort had increased, salmon angling contributed approximately one million dollars to the local economy.

Estuary trap nets were installed and operated by DFO from 1987 to 1996 to measure the success of the stocking program. A total of 5434 salmon were counted during this ten year period. The percent of hatchery origin fish from the summer run was higher (40%) than the percent of hatchery origin fish for the combined summer and fall run (16%).

Stocking in the Margaree illustrated that if the salmon population increases so does the number of anglers. Additionally, stocking resulted in a significant return of adult salmon, which further supports the idea that the stocking program that began in the late 1970's utilizing parr and smolt from early-run broodstock was successful.

Discussion

It is difficult to determine if a program in isolation was successful due to the DFOs experimental design.[5] The elimination of BKD likely contributed to the success of the stocking program. Additionally, the commercial salmon fishery removed salmon, so fewer eggs were being deposited naturally; the river was not producing fish, without the stocking program the angling catch would not have increased.

Walter Regan
Sackville Rivers Association
Sackville, Nova Scotia

The Sackville Rivers Association (SRA) is a not-for-profit community organization, which consists of volunteers concerned with the health of the Sackville River. The goals of the SRA are to protect and restore areas within the watershed, raise awareness about the watershed and establish a greenbelt adjacent to it. The SRA collaborates with other

[5] Question posed by David Garbary

watershed groups and assists with restoring the environment, works to increase environmental awareness and provides training and advice to local community organizations. The SRA fosters sustainable development so that natural resources are available for future generations. The Association feels that clean water and water resource management are the baseline of sustainable development in rivers. We strive to protect the physical environment in the long-term by educating residents surrounding the watershed.

Since 1988, the SRA has accomplished various practical and labour intensive restoration and conservation activities. The Sackville River is approximately 40 km long, starting in Mount Uniake and flowing through several communities including, Sackville, Hammonds Plains, Lucasville, Beaver Bank and Bedford, before emptying into the Bedford Basin. In total the watershed has 17 lakes, wetlands, ponds, streams and brooks. There are over 60,000 people within the watershed and development is continuing.

In 1889, a salmon hatchery was built near the mouth of the Sackville River and it operated until the mid 1900s; salmon stocks were abundant during those times. The hatchery closed because of poor water quality and decreasing returns due to development surrounding the watershed. By 1986, DFO launched a stocking program for the Sackville River. This was created to relieve fishing pressures on traditional salmon rivers, raise public awareness of the importance of freshwater rivers, and to demonstrate that urban areas and the environment can co-exist and be productive. Initially, DFO stocked the Sackville River with salmon from the LaHave River. Since 1992, DFO and the SRA have been collecting approximately 50 salmon from the Sackville River for the stocking program by using a fishway trap and seines.

Collaboration between SRA, DFO and NSDFA has initiated a stocking program to restore salmon populations to the river. The salmon population is starting to restore itself in the watershed, however, habitat and water quality are limiting. There are many reasons to continue the stocking program, including; (i) promoting recreational fishing, (ii) raising public interest in fish and develop a sense of stewardship, (iii) boost local businesses, (iv) introduce new fish species to reduce fishing pressure on native stocks, (v) use of salmon as a biological indicator of river health, (vi) re-establish lost runs, (vii) raising public awareness about river health, (viii) educational tool, (ix), compensate the salmon population for urban development, over-fishing, damming and acid rain, which all likely contribute to population decline and the destruction of habitat, (x) increase the number of volunteers to help with restoration, (xi) gene banking to maintain genetic diversity, (xii) promote tourism, and (xiii) encourage catch and release fisheries.

Negative aspects about stocking programs include; (i) the cost, (ii) possible loss of genetic diversity in native fish, (iii) possible introduction of diseases and parasites, (iv) introduction of invasive species, (v) using stocking to mask the true purpose for starting a stocking program, and (vi) the costs of low marine survival. Regardless of the negative aspects associated with stocking, the experience of the SRA with stocking Atlantic salmon and speckled [brook] trout (*Salvelinus fontinalis*) continues to be positive. Salmon are returning to Sackville River because of the efforts of DFO and volunteers.

Stocking programs are a great educational tool because they encourage the public's interest in salmon and the river. Fishermen, volunteers and the public are keen to observe salmon back in the river. About 315,000 smolts and 320,000 parr have been released in the river in the last twenty years to help restore the salmon population. The stocking program is largely supported by DFO funds and technical support. The cost of the stocking program is approximately $400,000 annually. It costs about $1.00 for each smolt to be reared in the hatchery and there are no cost for unfed fry and parr.

For many years the NSDFA has stocked the Sackville River drainage with speckled and sea-run trout. The purpose for stocking is to give urban residents fishing opportunities. Past records indicate that more then 200,000 speckled trout and 100,000 sea-run speckled trout have been stocked at a cost of $400,000.

By 1996, adult returns of salmon were estimated at 750 by a mark-recapture study. Currently, anglers can catch and release on the river. Many other fish species are targeted in the Sackville River. Without the fishermen and volunteers donating their time, the stocking program would not be possible. The stocking program and presence of salmon in the river has increased the interest and response from fisheries officers. Stocking has caused developers, contractors, and government to improve their siltation prevention practices to protect the salmon and its habitat.

The success of the Sackville River stocking program provides evidence that a watershed with a small or non-existent salmon population can re-establish a stock by a relatively low cost and continuous commitment. The SRA uses the salmon and trout stocking programs as educational tools for River Rangers and Fish Friends Program for children. Since 1994, over 5,000 children, teachers and adults have been introduced to the life-cycle of Atlantic salmon by having their classrooms supplied with an aquarium and salmon eggs.

The stocking program is a necessary tool for the Sackville River and other watersheds organizations. Since the cancellation of federal stocking programs via DFO, salmon in the Sackville River must naturally reproduce. Salmon populations should be maintained and protected.

Discussion

No discussion followed the presentation by Mr. Regan, but see Discussion of Panel 1, following.

Bob Baker
Nepisiguit Salmon Association
Bathurst, New Brunswick

The Nepisiguit River flows 80 miles [130 km] north and east joining a system of lakes and it empties into the Bay of Chaleur at Bathurst. The Nepisiguit River and its tributaries contain over 150 miles [240 km] of suitable water conditions for salmon. There is a 100 ft [30.5 m] natural twin falls approximately 18 miles [28 km] from the mouth of the river which has always limited salmon to the lower river and two smaller tributaries. NB Power owns a hydro-dam below the falls which was built in 1920 by Bathurst Power & Paper.

In the past, part of the river was under private lease, angling catches were approximately 800 fish per year in the 1940s and 1950s, and by the 1960s the angling catches declined to 600 fish per year. The commercial fishery started impacting the recreational fishery. In 1969, the combination of acidic rainfall and waste sulfite from a mining operation created a toxic effluent that eliminated most salmon downstream from the falls. It took five years before the toxic effluent was completely cleared up.

DFO started a stocking program in the late 1970s, since there were some salmon returning. In 1976, the Nepisiguit Salmon Association (NSA) was formed. The goals of the association were to (i) restore the salmon population in the river, (ii) increase the recreational fishing opportunities and (iii) keep the river clean and improve its condition for future generations. From 1974 until a few years later, DFO provided juveniles derived from broodstock from Rocky Brook (Miramichi) and Kedgwick River (Restigouche) to stock the Nepisiguit River.

In 1981, DFO encouraged the NSA to start an enhancement program. A counting fence was installed seven miles [10 km] from the mouth of the river to monitor the number of returning salmon. Broodstock were also collected at the counting fence. Initially, the program was largely funded by DFO and a job creation program of Canada Employment & Immigration. It was to go on to be funded by various federal and provincial programs, local industry and various fund raising ventures, all secured by the NSA.

When the enhancement program started, stocking was done upstream from the falls in case of another toxic effluent episode. There were few fish above the falls and vacant habitat. Some of the stocked areas were not ideal because the water was too cold, slowing growth and taking longer for the fish to grow to smolt size.

Traditionally in the Nepisiguit River, the salmon run did not reach the pools below the falls until July. By stocking early-run salmon a considerable number of fish were there by early June. Salmon were collected between June and October from the counting fence for broodstock. Fall fingerlings stocked were fin clipped. Of 400,000 stocked fall fingerlings (above the falls), approximately 2,000 adult salmon returned (including grilse). When DFO financially supported the stocking program, smolts were stocked as well. When the NSA took over, mainly fall fingerlings and unfed fry were utilized, first because it made more sense, and second because it was much more economical. In particular, the unfed fry spent no time in the hatchery, and require no feeding.

In 1986, of 72,000 smolts stocked, a total of 26,000 were wire nose tagged and fin clipped.. Over the next several years, a detector was utilized at the counting fence to check all fin clipped returnees. A total of six tagged salmon returned. The NSA's position had always been that it made more sense to stock juveniles as young as possible and let natural selection take its course. In 1985, a team of biologists with Noranda- Brunswick Mining conducted research on the use of streamside incubation boxes in Pavinol Brook, a tributary of the Nepisiguit River. One streamside incubation box contained 25,000 eggs; they had a 95% hatch rate. The next year they used 50,000 eggs and the hatch rate increased by 1%. The following year seven stream side boxes were moved to the Hydro-dam with a total of 350,000 eggs. Over 10 million fish have been stocked into the river, half of those were from the streamside incubation boxes.

Adult salmon are removed from the counting fence and transported to the hatchery where the eggs and sperm are removed. The eggs are kept in the hatchery over the winter. In early May the eggs are loaded into the streamside incubation boxes. Once the eggs have absorbed their yolk sacs, the fry are released into the river. Where only eggs spend time in the hatchery, these salmon are no different from wild salmon. The fry are released from their streamside incubation boxes with the rest of the wild fry.

In the natural environment, fish are most vulnerable at the egg stage. Eggs can get washed away, some are not fertilized, some freeze, some die and grow fungi which kill other eggs surrounding it; this is how fish are lost. Research by Griswold, suggests that 55% of fish are lost during the egg process.

Stocking is a good tool to restore the salmon population. A major benefit to the stocking program is that by breeding salmon in the hatchery, over time the percent of MSW salmon returns increases. Prior to stocking there was approximately 20% MSW salmon, likely because the commercial fishery was harvesting the large salmon. After 15 years of stocking there is approximately 60% MSW salmon. These results have stayed consistent over the last decade.

Approximately 70% of the returning salmon are female. Approximately, 13 to 15% of the female salmon are grilse and they produce fewer and smaller eggs then the MSW females. It is more challenging to boost the salmon population when the majority of returning salmon are grilse.

The Nepisiguit also had a trout stocking program. Over six years, the Nepisiguit Watershed Management Committee and DNR stocked 2.5 million juvenile trout in the upper reaches of the river, greatly increasing the brook trout population and creating more angling opportunities.

If watershed organizations are limited by the number of broodstock available in the river, it is still possible to rebuild the salmon population. Hatcheries can be used to increase the number of salmon. It is important that suitable habitats are available for stocked fish. It is important to minimize the amount of time salmon spend in the hatchery environment. Environmental changes may have impacted the salmon population, but ultimately, man is the cause for the loss of salmon. Bad hatchery practices in the past have discouraged people from considering stocking as a tool for restoration. Salmon are a determined, magnificent fish, and despite man they have survived over the years. Man owes it to salmon to ensure that they do not become extinct.

Discussion

No discussion followed the presentation by Mr. Baker, but see Discussion of Panel 1, following.

Discussion Panel 1 (Case Studies): Leonard Forsyth, Walter Regan and Bob Baker

It would be interesting to conduct a comparison of the number of returns between the Cheticamp and Margaree Rivers, since there has been no stocking on the Cheticamp River for 30 years.[6] One issue is that the run in the Cheticamp River is earlier than the Margaree River. A comparison would be possible if the number of adult returns from the estuary trap in the Cheticamp River were compared to the number of returns on the Margaree River for the last 10 years. Additionally, catch for the overall salmon rearing area, effort and Catch per Unit Effort for zone 18 could be compared.[7] It would be interesting to note if the catches were high in all rivers for 1986 since the returns were high in the Margaree River in that year. By the late 1970s the catch and release numbers in the Cheticamp were low.[8]

This workshop has presented two successful ways of rearing salmon in the hatchery; the first method is to raise eggs until they are fingerlings and then to release them into the river, the second is to raise eggs until the spring and transfer them into incubation boxes in the river. The first program was initially operated by DFO until 1996, then by the non-profit group ADAM until 2008 and is now being operated by the Province of Nova Scotia for stocking the Margaree River and the other program is operated by a community group called Nepisiguit Salmon Association in New Brunswick for the Nepisiguit River.[9] In the Margaree River, releasing smolt and parr instead of fry meant higher smolt production and shorter residency in the river. Initially stocking on the Margaree River was conducted to learn about salmon distribution in the river and to increase adult returns. Hatchery fish were clipped so researchers could determine the hatchery contribution to the returning stocks.[10] In the Nepisiguit River, eggs are placed in incubation boxes, water and food flows through the boxes adapting the eggs to the natural environment. Incubation boxes

[6] Comment by Réne Aucoin
[7] Comment by Leonard Forsyth
[8] Comment by Réne Aucoin
[9] Question posed by Darrel Tingly, answer provided by Leonard Forsyth and Bob Baker
[10] Comment by Leonard Forsyth

cost very little and they last a long time, thereby salmon spend a short period in the hatchery and the majority of their lifecycle in the natural environment.[11]

It is difficult to determine which stocking program is more appropriate, the river systems are different and have different management strategies.[12] The best method depends on the river system and the reason for stocking. Salmon were more abundant when DFO operated the hatcheries.[13] The Provincial government in Western Canada operates the hatcheries because there is still a commercial salmon fishery.[14] Salmon associations and watershed groups need DFO to help with stocking; the ideal salmon budget was in 1992, since then the funding has decreased.[15] The Nova Scotia Salmon Association Adopt-A-Stream Program helps restore fish habitat, but government sources are required to fund the hatcheries; this would benefit the communities by increasing tourism. It is recognized that government departments in Eastern Canada have limited resources; more staff and money are required to assist with scientific surveys throughout the provinces. The provincial governments should be more involved in trying to assist DFO; where DFO in Ottawa is not meeting the community group's needs.[16]

The initiation of aquaculture started to decrease the wild salmon stocks. DFO's mandate should be concerned with wild stocks; DFO should not use federal money to continue funding aquaculture programs.[17]

Without government support it will be difficult to return the salmon stocks to their former glory. Although the Margaree River had greater egg recruitment while stocking, there are still not enough smolts. When DFO was running the hatchery in the 1980s, approximately 40,000 smolts were released; DFO divested itself of the hatchery in 1995 and by 1997 the number of returning salmon declined.[18]

Salmon stocking is not just a tool for restoration; it can be used to increase public awareness as demonstrated by the Sackville Rivers Association.[19] The public feel accountable because they care about salmon and the environment.[20] Public awareness can be raised through education programs; by engaging children interested parents also become involved. In 2002, there was a large pollution event on the Sackville River. Families were calling from across Canada to ask if "their" salmon was still alive. Another program the Sackville Rivers Association initiated is called "River Rangers"; children from the Sackville area are exposed to nature so that they can learn about watersheds and management. These programs are making a difference within the Sackville watershed, and stocking is an important part of the delivery of these programs.

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[11] Comment by Bob Baker
[12] Comment by Leonard Forsyth
[13] Comment by Leonard Forsyth
[14] Question posed by Dr. John Phyne, answer provided by Bob Baker
[15] Comment by Walter Regan
[16] Comment by Walter Regan
[17] Comment by Leonard Forsyth
[18] Question posed by Shane O'Neil, answered by Leonard Forsyth
[19] Comment by Walter Regan
[20] Question posed by David Garbary, answered by Walter Regan

Panel 2: Social-Economic Issues, Saturday February 7, 2009

Mark Hambrook
Miramichi Salmon Association
Miramichi, New Brunswick

The Miramichi Salmon Association (MSA) is an Non-Government Organization (NGO) formed in 1953. The goal of the Association was to conserve and enhance the salmon population within the Miramichi River. The Miramichi River is the second largest river in New Brunswick. There are a few small waterfalls in the watershed, but almost all of he watershed is accessible to salmon.

The Miramichi Salmon Conservation Centre is located at Canada's oldest salmon hatchery. The facility was built by the Federal Government in 1873 and was operated by DFO until 1997. Currently the MSA operates the hatchery. The MSA recognized the importance of having a hatchery as a tool in the restoration toolbox. The Conservation Centre has rectangular ponds, tanks and buildings to incubate eggs and hold juveniles. In addition to the Conservation Centre, DFO had a hatchery with 20 tanks that operated at a local security penitentiary; the MSA now operates these tanks. The stocking program involves collecting wild salmon and breeding them in the hatchery, with juvenile salmon released back into the Miramichi River at different life stages.

The hatchery was important to the community because it attracted tourists. Once aquaculture became popular, interest in the hatchery started to decline. The MSA revamped the hatchery location by creating a "Centre of Excellence for Atlantic Salmon Studies". This project cost 1.7 million dollars and the objective was to create an environment that focused on wild salmon research. Additions to the Conservation Centre included a year-round research facility and protection from predators. Covers were installed over the ponds and an old raceway was converted into an artificial stream, in which water temperature and oxygen levels can be manipulated. There is also a wet lab, research room and accommodations for student researchers and scientists. A U-fish pond was constructed for the community and tourists. The U-fish pond raises awareness about the MSA and it brings the community together.

It costs approximately $350,000 a year to operate the hatchery. DFO does not fund the stocking program, but the MSA has been able to raise the funds to keep the program running. The MSA was fortunate to have members that were good businessmen; these individuals helped raise money for the hatchery. The hatchery is owned by a non-profit watershed committee and operated by a subsidiary company of the MSA called Miramichi Fisheries Management. Salmon and trout are sold from the hatchery with the objective of Miramichi Fisheries Management breaking even each year. The MSA also has a budget of $400,000 a year to conduct work on the river.

There is a total of $100,000 in salmon sales each year. There is a set price for purchasing a salmon or trout with organizations and individuals given the same rate. The market prices of fish were compared in order to determine a fair price to charge customers. The MSA made a commitment that they would buy $50,000 of salmon for stocking annually. Within the Miramichi watershed there are other conservation groups (e.g., Miramichi Headwaters Salmon Federation, Northumberland Salmon Protection Association etc.) that stock salmon. These conservation groups are supported by the New Brunswick Wildlife Trust Fund to help purchase fish. There are also corporate sponsors who purchase fish to stock their private waters, such as International Paper and J.D. Irving Limited. The MSA quickly realized that once fish are released into the river they are available to the public as they migrate back as adults. Some salmon are also stocked outside the Miramichi River to river groups along the Northumberland Strait.

The majority of the Conservation Centre's revenue comes from trout sales. The MSA began selling trout to people for backyard ponds and privately owned lakes. The bulk of the trout sales ($150,000) comes from a contract with the Provincial Government of New Brunswick. The other $50,000 comes from private trout sales. Other income comes from renting office space to DFO. Bringing people together with similar interests is a very positive thing for the community and salmon research and management. The MSA has a priority to hire members from First Nation communities, as well as students and people with disabilities. Government funding is available for hiring students and people with disabilities.

The hatchery is a tool for restoration in case there is an emergency with the salmon stocks in the watershed. The juvenile salmon population in the Miramichi is currently abundant and the demand for stocking salmon has slowed down. Now, more trout are being stocked in lakes by the New Brunswick government and in the river by MSA and JD Irving Ltd. When DFO operated the hatchery, they stocked smolts; the MSA stocks 0+ fingerlings. The MSA believes in minimizing the time salmon spend in the hatchery. The big issue is where to stock the salmon. During summer, the MSA conducts electrofishing throughout the river in order to determine locations where vacant habitat is available for stocking.

One issue on the Miramichi River is with beaver (*Castor canadensis*) dams. In the past some of the highly productive streams have been dammed off by beavers, restricting salmon passage. Electrofishing provides information on which streams require beaver dams to be removed the following year. The MSA has a program with the surrounding Aboriginal groups to temporarily remove beaver dams in the fall to allow adult salmon passage upstream to spawn.

It is challenging for community groups to financially support a stocking program. The MSA is fortunate that it has resources and personnel that are capable of raising funds to continue the stocking program.

Discussion

When stock is purchased, there is no conservation fee, but there is a five dollar stocking fee for brook trout.[21] In New Brunswick a five dollar fee is collected for a license. The MSA rears trout for stocking lakes for the NB Government. In order to sell the trout the MSA went through a bidding process, which determined how much the trout would sell for.

There is also a five dollar fee which is collected by the New Brunswick Wildlife Trust Fund (NBWTF). Some of the conservation groups are capable of accessing some funding to purchase salmon for stocking. The Miramichi River has three to four different NGOs. Initially, the MSA used to receive $40,000 from the NBWTF for salmon stocking, but now only receives half that amount.

Don MacLean
Nova Scotia Department of Fisheries and Aquaculture – Inland Fisheries Division
Pictou, Nova Scotia

Atlantic salmon fishing in Nova Scotia is very important to residents because of the historical and cultural context. The tourism industry has been promoting Atlantic salmon fishing since the 1940s. Anglers fishing in Nova Scotia are fortunate to have the *Angling Act*, which gives them the right to fish. In the late 1940s approximately 5000 salmon were caught in the province each year. Recreational fishing in Nova Scotia was historically based on salmon and trout fishing. Over time the stock sizes have changed due to various pressures (e.g. reduced habitat). In the 1980s the Province sold 10,000 salmon licenses. Since then salmon license sales have dropped by 71%. Also, general fishing license sales dropped from 80,000 to 55,000. The abundance of the resource affects the recreational fishing activity. The NSDFA is dedicated to enhancing fish populations and promoting the recreational fishery. The NSDFA has a management program specifically for trout enhancement. In 2008, license sales were up to 57,000 and it is expected that the number of general licenses will increase slightly again this year [2009].

In addition to low salmon license sales, the water conditions in some of our fall-run rivers are not optimal, which has also impacted the fishery. In 2008, there were approximately 1,500 resident salmon anglers and 400 non-resident anglers. There are dedicated anglers that will purchase a license every year. Resident anglers within Nova Scotia are traveling abroad because they want to fish salmon.

Since 1975 the NSDFA and DFO have participated in a National Survey of Sport Fishing which takes place every five years. This survey provides each province and territory in Canada with a summary report on expenditure and fishing activity. The federal, provincial, and territorial governments learn about angler preferences. The data for the most recent survey are based on individuals that purchase angling licenses in 2005.

[21] Question posed by Larry Bell

Information on the most popular rivers and desired fish species to catch are available. Atlantic salmon and native brook trout have remained among the top five desired species to fish.

In 2005, the direct expenditure of the recreational fishery in Nova Scotia was $55,000,000 and the total attributable expenditure of the salmon fishery was $3,000,000. At this time anglers were spending $150 per day of fishing in Nova Scotia. Based on these data, it costs approximately $680 to catch and release salmon. Many anglers do not retain salmon due to the costs associated with retaining salmon. The $3,000,000 from the total attributable expenditure can be broken down according to county. Inverness County contributed the most, $2,300,000. In 1993, a GTA study determined that the salmon fishery in Inverness County was worth $1,000,000. Examples of values to other counties are $150,000 (Cumberland), $140,000 (Antigonish) and $115,000 (Pictou). A lot of money is being spent in rural parts of Nova Scotia, which is important for the economy and local businesses.

The province owns and operates three hatcheries: (1) Fraser's Mills Hatchery, Antigonish County, (2) McGowan Lake Hatchery, Queen's County, and (3) the Margaree hatchery in Margaree. Fraser's Mills hatchery stores broodstock and adult salmon and trout. McGowan Lake Hatchery supplies brook trout to lakes that have been impacted by acid rain in the southwestern part of Nova Scotia, so that recreational fishing opportunities are available. Initially, these two hatcheries were owned and operated by the Federal Government, but in 1982 they were turned over to the province. The Margaree Hatchery was run between 1982 and 2008 by the Aquatic Development Association of Margaree (ADAM) and turned over to the Province in 2008.

In 2006, the NSDFA gave a presentation on the status of Atlantic salmon in Nova Scotia to the Provincial Cabinet. The province was fortunate to have Dr. John Hamm as the Premier at the time, who was an avid salmon angler. Dr. Hamm recognized the importance of improving the status of salmon. As a result the Cabinet provided marching orders and funding toward researching what the province can do to improve salmon stocks. DFO manages Atlantic salmon. The province is responsible for determining license conditions and distributing licenses throughout Nova Scotia. After the province received funding for improving salmon stocks, the NSDFA and DFO met to discuss those rivers to be considered for stocking. Potential rivers to be stocked included; River Philip, West River Pictou, Mabou River and the Waughs River. St. Francis Harbour River was added to the list later. Aspects that were considered prior to selecting rivers for stocking included examining vacant rearing habitat, determining possible broodstock sources, and identifying what life stage of enhancement should be used for stocking. River Philip was selected because local organizations and employees from the Adopt-A-Stream (AAS) Program created new habitat. Similarly, the West River Pictou was selected because a culvert was repaired to allow fish passage and habitat was made available. There were a number of beaver dams that were removed on the Mabou which opened up fish habitat. No work has been completed on the Waughs River to date. St. Francis Harbour River flows from Goose Harbour Lake, and the lake was dammed in the 1960s to create a water supply for StoraEnso. Once the pulp and paper company changed the way they processed their wood products, the water and habitat was made available to fish. The Mulgrave & Area Lakes Enhancement Project installed a siphon which transferred water from the lake into the river so that more fish habitat was available.

In 2007, 116 salmon from River Philip, West River Pictou, Mabou, St. Francis Harbour River and the Margaree River were collected. Of the 57 salmon from the Margaree, 10 were of hatchery origin. The origin could be determined because the adipose fins were clipped. Salmon were stocked as unfed fry or fall parr, depending on the river. The Margaree stocks both parr and smolt. Last year, 50 fish were collected from the above rivers and 12 were of hatchery origin.

Stocking programs would not be possible without the assistance from many volunteers. It is hoped that salmon fishing will continue and that young anglers will have the opportunity to catch them.

Discussion

The NSDFA responds to community groups by cooperatively working with more than 70 volunteers across the province.[22] Each year the province hosts trout derbies and Learn to Fish Programs. The revenue from purchasing general fishing licenses provides funding for the Learn to Fish Programs.

Greg Stevens
Department of Fisheries and Oceans Canada – Management Division
Dartmouth, Nova Scotia

The information presented is for the Maritimes Region, which includes southern New Brunswick, Bay of Fundy and the Atlantic Coast of Nova Scotia. In the Maritimes Region all salmon stocks managed by DFO are below their conservation requirement, excluding North River, Cape Breton. Salmon stocks are below conservation requirements by 50% to less than 25%. The Inner Bay of Fundy salmon are officially listed as an endangered species.

Hatcheries operated between the 1860s and 1990s to supplement the Atlantic salmon populations and increase economic returns for the commercial and recreational fisheries. DFO ceased salmon enhancement programs in the 1990s. The Federal Government's current position on salmon enhancement is discussed in a draft of the Wild Atlantic Salmon Conservation Policy; the public had the opportunity to review the report and provide feedback. The report has been approved for a second round of consultations. Actions are being taken to preserve and maintain the genetic diversity of Inner Bay of Fundy salmon and Atlantic whitefish (*Coregonus huntsmani*) and other species that may be at risk for extirpation.

[22] Question by Mark Hambrook

The Federal Government does not discourage the Provincial Government, private sector, Aboriginal people or watershed organizations from using salmon enhancement programs for social or economic purposes. However, in order to collect juvenile or adult salmon for broodstock, organizations require a license or written permission from DFO. It is unlikely that permission will be granted if the salmon stock is below the conservation requirement. Having stocks above the conservation requirement was challenging for the NSDFA when they initiated their stocking program in 2006. The collection of broodstock is permitted if groups are trying to prevent the extinction or maintain genetic diversity of fish species. An example of collecting broodstock to maintain genetic diversity is with the Inner Bay of Fundy salmon population because it is at risk of extirpation. DFO along with local organizations are doing preservation work in the Southern Uplands in the Gold, Medway and West St. Mary's Rivers.

In order to release live fish at any life stage (egg, juvenile or adult) back into the river, organizations require a license from DFO. A license is issued based on three determinations, that released fish are (i) free from diseases, and that they will not impact the (ii) size or (iii) genetic characteristics of wild stocks. These standards are outlined in Section 56 of the Fisheries General Regulations. All live fish releases are measured against these standards and everyone, including the Federal Government, must apply for a license.

Before the mid 1990s, a maximum of 3% of stocked smolts would return from sea. Since 1997, that number has decreased to about 0.5% for stocked smolts in many rivers in the Maritime Region. In other words, it now requires six times the dollar investment and number of hatchery produced smolts to obtain the same returns experienced prior to the mid 1990s. About ten years ago, 100,000 smolts were stocked in the LaHave River; now 600,000 smolts would be required to get the same return. If 99.5% of your investment does not return from sea, there is very little gain. Once salmon are released into the river they become a public resource. The few fish that might return are then allocated according to priorities set by government, and recreational use is not the first priority (the first priority is conservation and second is fish for food, social and ceremonial fishing by Aboriginal groups). When marine survival is this low (0.5%), stocks will remain below their conservation requirement and, based on the results presented above, it cannot be expected that you can stock your way out of the situation

If funding was not required by DFO, there is a chance that salmon enhancement programs could be supported. There are some rivers where stock conservation is not a concern, for example the Mersey River, Mushamush River and Sackville River. The Mersey River has been impacted by acid rain and it has seven hydro dams. The Mushamush River probably does not have any Mushamush salmon as it was believed extirpated and received transplanted LaHave River stock. The Sackville River is also stocked with salmon from the LaHave River.

DFO acknowledges that stock enhancement is an issue for salmon anglers, organizations and communities. DFO has been involved in stock enhancement in the past. In May DFO will be hosting an internal workshop to determine its roles and priorities with salmon enhancement.

Discussion

The low return rate can be attributed to poor marine survival because hatchery-reared smolts are released into the river to start their migration.[23] From the egg-to-parr stage salmon are raised in the hatchery, therefore mortality rate is unlikely to happen in freshwater. It is uncertain what causes low marine survival at sea, people want answers and scientist would like to do the research. If scientists can determine what causes low marine survival, perhaps the salmon populations will be restored. It is also possible that salmon are going through a period of low marine survival and that over time, marine survival will increase. Poor marine survival is not the only reason for population decline.[24]

Kerry Prosper
Paq'ntkek First Nation
Afton, Nova Scotia

Atlantic salmon are known as *Lamona* in the Mi'kmaq language. Salmon are fished for food and captured in different ways; traditionally, Mi'kmaq use snares and spears. The following information will focus on the treaty making process, the legal struggles First Nation communities went through to gain the recognition of rights, and the implications of salmon stocking.

During the mid 1750s, the British and French were struggling over who would have control in the Maritime Provinces. First Nation communities had a large role during this period and they mediated between British and French. The British gained control over the French, and signed the Peace and Friendship Treaty with the Mi'kmaq. The treaties were only acknowledged by First Nation communities between 1867 and 1985. Since 1985, there have been treaty litigations to recognize Aboriginal treaty rights.

Four major court cases occurred in the last twenty years, Simon versus the Queen (1985), Sparrow versus the Queen (1990), Marshall versus the Queen (1993), and Badger versus the Queen (1996). Simon's court case aimed at defending the right for hunting practices. These treaties protected Aboriginal people's right to hunt animals for food and to use modern technology to hunt. Sparrows' court case took place on the west coast of Canada, and he aimed at defending the Aboriginal right to fish for food, social and ceremonial purposes. A major concern was the link between allocating priorities for the fisheries and the legal recognition of Aboriginal rights. In the past conflicts occurred because natural resources were limited (e.g., Miramichi and Restigouche River). Agreements between the Federal Government and First Nation communities are necessary to resolve any issues

[23] Question posed by Larry Bell
[24] Question posed by Larry Bell

with allocating resources. If wild stocks are above their conservation requirement then First Nation communities are given priority to fish. Food is an important issue and it relates to the salmon stocking workshop. Badger defended that any Aboriginal rights stated in the treaties (e.g. hunting) must be justified using the Sparrow test. Conservation requirements have to be implemented into the Sparrow test in order to determine allocation priorities. Marshalls' court case discussed and defended the rights for basic needs to live, which includes food, clothing and housing; supplemented by a few amenities. He also discussed how living standards should be equal for Aboriginal people as they are for Non-Aboriginals. The accumulation of wealth has had a large impact on what is happening in the world today.

From these treaty rights and other court cases, if an organization (government, private sector, NGOs) chooses to stock salmon the government has a legal duty to consult Aboriginal groups because this affects that group's interests (food, social and ceremonial purposes). Animals such as the fox (*Vulpes vulpes*), mergansers (*Mergus* spp.) and seals (*Phoca vitulina* and *Halichoerus grypus*) also rely on fish for food and so do the Mi'kmaq. Salmon conservation seems to focus on recreational fishing. If there was an Association for all fish species, there would likely be an argument over which Association should be given priority. Not only are the salmon populations declining, but the smelt (*Osmerus mordax*) and gaspereau (*Alosa pseudoharengus*) runs are smaller. Many rivers provide nursery habitat for juvenile smelt and gaspereau, but salmon and trout also consume these fish. Stocking salmon and trout might affect the smelt and gaspereau populations, possibly contributing to low survival.

Stocking might disrupt the balance in the ecosystem. Smelt and gaspereau are likely a food source for other species. If stocking can impact the health and genetic variability of the wild fish populations, what potential implications does this have for Aboriginal people and their rights. Could stocking impact the availability and quality of food and the livelihood of Aboriginal groups? These impacts must be considered if stocking is a tool in the restoration toolbox.

Aboriginal people's rights are protected to fish and hunt under Section 35 [*Constitution Act*], but how are salmon and fish habitat protected? Is the government obligated to protect the environment in order to protect the Aboriginal rights? If so, will Mi'kmaq become more involved in fish restoration? Is it possible to make the government more accountable for fish restoration? Over time people have been misguided to view the world in a linear fashion. By viewing the world from a holistic approach, people have the opportunity to cooperatively achieve goals.

Discussion

It is evident that stocking salmon has potential ramifications for all species.[25]

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[25] Comment by David Garbary

Discussion Panel 2 (Social-Economic Issues): Mark Hambrook, Don MacLean, Greg Stevens and Kerry Prosper

There is no recreational fishery in the Scotia Fundy part of the Maritimes Region. There is no hook and release or Aboriginal fishery in the south-western part New Brunswick. Since 1990, the Inner Bay of Fundy has been closed to recreational and Aboriginal fisheries for Atlantic salmon. There are some recreational and Aboriginal fisheries on the eastern shores of Nova Scotia. Fish cannot be retained in the recreational fishery.[26]

There will be an internal meeting to examine possible allocations of space within the hatchery.[27] Many people try to sue DFO. It is not believable that the Federal Government would misallocate resources between Aboriginal groups; such as allocating all resources to one Aboriginal group and nothing to other Aboriginal groups.[28]

DFO was wrong to cut off the funding in Ottawa.[29] This did not affect the decisions made for Shubenachadie First Nation.[30] According to Sparrow, DFO does not have to supply salmon to Aboriginal groups.[31] However, DFO cannot mismanage the salmon resources.[32] The Federal Government started collecting salmon from the Inner Bay of Fundy in 1998, prior to the Committee of the Status of Endangered Wildlife in Canada (COSEWIC) listing it as an endangered species. Other fish species such as striped bass (*Morone saxatilis*) can be allocated for food. Conservation is given first priority[33] then Aboriginal food fisheries.

A plan to manage introduced smallmouth bass (*Micropterus dolomieu*) is currently underway.[34] Federal Departments, Miramichi Salmon Association and J.D. Irving worked together to determine the smallmouth bass population size.[35] A barrier was installed between Miramichi Lake and River to prevent further intrusion. A risk assessment was completed and it determined the potential impacts of the bass on the ecosystem. Experts from North America gathered for a workshop aimed at discussing possible interactions between bass and Atlantic salmon and potential solutions. The bass are a high threat to the Miramichi ecosystem and no specific solution was recommended. The report was recently presented to DFO; it is uncertain what the final recommendation will be.

If Atlantic salmon populations continue to decline in Eastern Nova Scotia and salmon are listed under COSEWIC, there are potential impacts on the recreational fishery.[36] COSEWIC listings are complex. First COSEWIC makes a recommendation, which is

[26] Comments by Greg Stevens
[27] Question posed by Walter Regan, answered by Greg Stevens
[28] Question posed by Walter Regan, answered by Greg Stevens
[29] Comment by Walter Regan
[30] Comment by Greg Stevens
[31] Question posed by Walter Regan, answered by Greg Stevens
[32] Comment by Greg Stevens
[33] Comment by Jamie Gibson
[34] Question posed by Larry Bell, answered by Mark Hambrook
[35] Comment by Mark Hambrook
[36] Question by unknown person, answered by Greg Stevens

then given to DFO to make a decision.[37] DFO is responsible for aquatic species and consultations on the potential social-economic impacts are required. If COSEWIC makes a recommendation this does not imply DFO will accept it. The Federal Government has three choices: (1) to accept, (2) don't accept, or (3) send the recommendations back for further consultation. Even if DFO accepts the recommendations, it does not mean that recreational fishing will be closed. The Inner Bay of Fundy salmon are officially listed, but recreational and Aboriginal fisheries still take place for other fish species.

The province has a successful Learn-to-Fish Program, so recreational fishing for trout is promoted.[38] For some individuals the intrinsic value of knowing salmon are present is sufficient. Suggestions on how to appreciate salmon without fishing are welcome.[39] One suggestion would be to have an underwater camera installed in the hatchery.[40] There is evidence from fundraising events that many participants are not interested in angling, people genuinely care about the environment and salmon because they indicate the health of the environment.[41] The Atlantic Salmon Federation's (ASF) Fish Friends Program is a great educational tool and students do fish but the program raises awareness and an appreciation for salmon.

The MSA raises 150,000 to 200,000 fry fingerlings, which are released in the fall. Additionally, the MSA supplies camp owners with 150,000 fry at a cost of $750 for 5000 salmon. The MSA charges by fish. It costs $0.15 per fish to be raised in the tank and $0.40 for fall fingerlings to be released into the river.[42] The MSA charges $0.15 per inch for trout.[43] Funding is one aspect of the satellite rearing program. It costs approximately $350 to transfer salmon into the tanks. Some of the conservation groups apply to the New Brunswick Wildlife Trust Fund for financial support. Private companies such as J.D. Irving pay the full price. The Miramichi Headwaters Salmon Federation has a program where a donation of a dollar purchases a trout to be stocked in the river.[44] A contract of $150,000 purchases 100,000 nine inch [23 cm] trout and 60,000 seven inch [18 cm] trout.[45] A total of 25,000 trout of various sizes were sold to people with backyard ponds, private lakes and fishing clubs.[46] Clubs generally have a budget of $1,500 to $5,000. The MSA learned a business lesson, because in the past the Association raised 200,000 sea-run brook trout and only 15,000 were purchased. It is important to aim to produce what can be sold.

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[37] Comment by Greg Stevens
[38] Comment by Don MacLean
[39] Question posed by Shane O'Neil, answered by Don MacLean
[40] Comment by Leonard Forsyth
[41] Comment by Mark Hambrook
[42] Question posed by Darrel Tingley, answered by Mark Hambrook
[43] Question posed by Larry Bell, answered by Mark Hambrook
[44] Question posed by Larry Bell, answered by Mark Hambrook
[45] Question posed by Larry Bell, answered by Mark Hambrook
[46] Comment by Mark Hambrook

It is uncertain whether HADD [Harmful Alteration, Disruption or Destruction] funding will go towards improving water quality (e.g. liming programs).[47] The Southern Uplands Management Plan is still being developed.[48]

Due to the mixture of privately owned and public waters in New Brunswick, it is uncertain whether the same model can be used to support salmon angling strategies in Nova Scotia.[49] The private sector can participate a lot in the protection of resources and funding when there are private and public individuals involved.[50] The MSA receives financial support from private landowners and the public. The Association charges $100 for the dinner. The bulk of the revenue comes from the auction. Fishing trips are donated by camp owners, and the money from the auction goes directly to the MSA. J.D. Irving owns the headwaters in south-west Miramichi, fish that are stocked migrate to sea and return to public waters, so everyone gets a chance to fish. Fish are not heavily fished in privately owned waters. Often the public views public waters as being the government's responsibility, individuals do not take ownership for issues that are happening in their local environment.

It is difficult to select one species as being more important for a food source than others; salmon, eels (*Anguilla rostrata*), trout and smelt are equally important.[51] Privatizing the river is analogous to privatizing the health care system; resources are available to a select group of people.[52] Aboriginal groups are observing what is being done to the environment and they are becoming more involved. Aboriginal groups are striving to promote a holistic approach to conservation. Aboriginal rights have only been recognized in the last twenty years; prior to that many people did not acknowledge Aboriginal rights. Negotiations on how fish should be managed will be discussed in the future.

Salmon can be sold outside the Miramichi drainage, but in order to purchase salmon, conservation groups must first provide a plan for the stocked salmon.[53] In order to remove, sell and release live fish, the MSA applies for a license from DFO. Conservation groups purchasing salmon from the MSA also require a license.[54] The MSA requires a collection permit for collecting brook trout broodstock; trout are sold throughout the province of New Brunswick. Broodstock collections are done on a tributary by tributary basis.[55] If broodstock is collected from McCain's River, all of the fry and fingerlings are returned to McCain's River.[56] Electrofishing is used to determine locations with low

[47] Question posed by Walter Regan, answered by Greg Stevens
[48] Question posed by Walter Regan, answered by Greg Stevens
[49] Question posed by Dr. John Phyne, answered by Mark Hambrook
[50] Comment by Mark Hambrook
[51] Question posed by Dr. David Garbary, answered by Kerry Prosper
[52] Comment by Kerry Prosper
[53] Question posed by Greg Stevens, answered by Mark Hambrook
[54] Comment by Mark Hambrook
[55] Question posed by Greg Stevens, answered by Mark Hambrook
[56] Comment by Mark Hambrook

juvenile densities. Genetics is being considered when broodstock is collected.[57] Currently, the MSA is stocking fewer fish because juvenile densities are high.[58]

License sales attract a level of fishing activity, which is partially why the province became involved in salmon enhancement; they wanted to improve the recreational sport fishery in Nova Scotia.[59] It is uncertain whether the salmon enhancement program will be as successful as the trout program; they are different species.[60] The success from the Margaree salmon enhancing program encourages NSDFA.

There will be a day when stocking will stop but it is unlikely that there will be a day when organizations give up the use of a hatchery.[61] Hatcheries employee people and provide services for the public and private landowners, they are a necessary tool.

There appears to be a disconnect between the Atlantic salmon policies versus the public policy.[62] It is uncertain whether stocking programs fall under the Atlantic salmon policy, this has caused complications when organizations try to apply for private or public funding. In the Atlantic salmon policy, there is an Atlantic salmon advisory committee and some locations in the province have recreational fishing advisory committees.[63] These committees are brought together by government officials, private sectors and Aboriginal groups to discuss the policies and to determine a communication plan. The Integrated Salmon Management Plan could not be accepted without consultation. These processes may not have been as rigid in the past, but the government follows this process. It should be clear whether a program fits under the Atlantic salmon policy. There have been changes to the Atlantic salmon policy.[64]

One issue with the Atlantic salmon policy is that if you are below conservation requirements, stocking programs are not supported.[65] Secondly, if the hatchery is meeting or exceeding spawning requirements, than the Federal Government supports the stocking program. The MSA funds the stocking program, so there does not appear to be any issues. Hatcheries might be terminated for salmon stock enhancement, but they would not be terminated if the objective was to preserve or maintain genetic diversity.[66] There are more restrictions with hatcheries that use salmon stocks below the conservation requirement. It appears that hatcheries can only be used for gene banking programs; the Atlantic salmon policy did not appear flexible.[67] It seems that the Federal Government has decided that stocking is not a useful tool and that hatcheries should be used for live gene banking programs or to enhance recreational fisheries. Considering that 99.5% of

[57] Question posed by Greg Stevens, answered by Mark Hambrook
[58] Comment by Mark Hambrook
[59] Question posed by Chris Marchand, answered by Don MacLean
[60] Comment by Don MacLean
[61] Comment by Mark Hambrook
[62] Comment by Bob Chaison
[63] Comment by Greg Stevens
[64] Question posed by Bob Chaison, answered by Greg Stevens
[65] Comment by Mark Hambrook
[66] Comment by Greg Stevens
[67] Comment by Mark Hambrook

the stocked salmon do not return from sea, stocking program were not successful.[68] The Miramichi River barely meets its spawning requirements, but there is suitable vacant habitat. The MSA's Mission Statement is to increase the juvenile population, not the number of adult returns; the objective is to maximize river production.[69] Adult returns provide more salmon for the anglers. Stocking unfed fry allows salmon to stay in the river and compete, salmon that survive go to sea and some return. Filling habitats is just as important as preserving salmon in a hatchery.

Rivers can be productive for feeding fish, but stocking poses two impacts for fish communities.[70] Men want fish in the river to use for recreational and Aboriginal fisheries or just to know that they are present.[71] Fish are often indicators for the health of the river. Raising fish in a hatchery and releasing them into a river does not make the river healthy.[72] Knowing fish are in a river makes it healthy.[73] Stocking unfed fry might be the solution for available habitat and low marine survival. Caring only about what goes on in the river is a linear way of thinking, ocean survival should be considered.[74] Marine survival is contributing to the decline of salmon populations, but scientists are not sure exactly how, organizations should do something.[75] If vacant habitat is not used by salmon, other species such rainbow and brown trout will replace the salmon. If you leave habitat vacant it will fill up with chubs and suckers (Cyprinidae and *Catastomus*).[76] Ocean conditions vary and adult returns will vary. By stocking salmon and allowing them to return as adults, it is possible to rebuild a river.

The stocking program started on the Margaree in 1970 and the grilse and MSW salmon population increased.[77] After ten years it was still evident that marine survival was declining. Salmon stocks in the Cheticamp River also increased but not at the same rate as the stocks in the Margaree.[78] Stocked salmon may have strayed into the Cheticamp River, but the stock sizes did not increase like the Margaree.[79] Stocking might cause natural and unnatural events.[80]

Stocking a river will likely result in some salmon returns, but on the Margaree River you are unlikely find Margaree genetics.[81] Stocking has been conducted for over 100 years; it would be difficult to determine if the genetic strains are distinct.[82] Depending on how far

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[68] Comment by Greg Stevens
[69] Comment by Mark Hambrook
[70] Question posed by Kerry Prosper, answered by Mark Hambrook
[71] Comment by Mark Hambrook
[72] Comment by Kerry Prosper
[73] Comment by Mark Hambrook
[74] Comment by Kerry Prosper
[75] Comment by Mark Hambrook
[76] Comment by Bob Baker
[77] Comment by Leonard Forsyth
[78] Question posed by Kerry Prosper, answered by Leonard Forsyth
[79] Question posed by Kerry Prosper, answered by Leonard Forsyth
[80] Comment by Kerry Prosper
[81] Comment by Greg Stevens
[82] Comment by Leonard Forsyth

back the samples go, the genetic strains can be tested; it will be evident if the salmon stocks are all the same.[83]

Panel 3: Biological Issues, Saturday February 7, 2009

Dr. Dylan Fraser:
Department of Biology, Dalhousie University,
Halifax, Nova Scotia

Maintaining genetic diversity is important within any species. Natural selection can act on the genotypes or individuals within a population to favour those individuals if there are changes in that environment. With climate change certain individuals will be favoured, depending on how the environmental variable changes and the genetic organization of that population. Genetic diversity can also be thought of as insurance, important for when times are tough. The genetic diversity and variability within a species are interrelated. Maintaining genetic diversity is important for salmon so that they can respond to environmental change. Stocking programs should incorporate studies on the genetic diversity of a population, in order to understand the measures to rehabilitate wild salmon populations. Salmon have strong links to their local environment and the genetic and phenotypic characteristics of the fish are specific to a location. For example the body morphology of Atlantic salmon are often associated with the following characteristics: migration, complexity of migration, prey, life history characteristics, age-at-maturity (itself associated with changes in the environment), behaviour, genetic differentiation and associations with the habitat. Strong links between the genetic characteristics and environment suggest that fish locally adapt to their environment. Differentiation has largely arisen since glaciation of 8,000 to 15,000 year ago. However, adaptation can also occur quickly, within a few generations.

Genetic and phenotypic differentiation of Atlantic salmon, within and between populations, are important for adaptation. Salmon can rapidly adapt to hatchery environments. The hatchery and natural environments are different in many ways. In the hatchery salmon are fed automatically, there are no predators and the water flow in the tank does not mimic natural riverine currents. Densities of fish are greater in the hatchery than those in the wild. There are a number of studies that suggest the behaviour of hatchery fish at high densities is not what would be observed in the wild. Hatchery environments also differ from natural in terms of water temperature, chemistry, pH and conductivity. The temperatures in a hatchery will likely remain constant, whereas in the wild the temperatures are more variable. Dr. Fleming previously mentioned that mates are artificially selected in the hatchery, whereas in the wild males and females select their own mates. Where fish are locally adapted to their environment, this mate selection may be important to ensure the survival of their offspring.

In the past decade, there has been growing concern that hatchery reared salmon might cause rapid genetic changes within a popualtion, which could be detrimental to survival

[83] Comment by Greg Stevens

in the wild. Wild fish typically have a lot of genetic diversity. Once fish are placed in the hatchery their genetic organization can change by two main mechanisms: (1) relaxing of, and (2) changing of the selective pressures. Relaxing natural selective pressure refers to removing individuals from the wild that would have normally been selected against, and placing them into the hatchery. Individuals that cannot deal with the variable environmental conditions in the wild would not survive. The hatchery environment relaxes these selective pressures. The second mechanism involves changing those selective pressures, intentionally or unintentionally. Intentional selection could involve selecting all multi-sea-winter fish for broodstock collection. Intentional selection of individuals may cause inadvertent selective changes which may arise due of environmental changes within the hatchery; this might favour specific genotypes over others which would normally be selected against in the wild.

The return of hatchery fish back into the natural environment after they have undergone relaxing and changing selective pressures has potential consequences. Initially, the population size in the wild might be large, but the hatchery fish would have experienced genetic changes that allowed them to adapt to the hatchery environment. Survival or successful breeding of hatchery fish returned to the wild may be difficult because they are not adapted for that environment and they would not be favoured. In an extreme case, there could be fewer fish and less genetic diversity than when the population size was originally determined.

Hatchery related genetic changes are not limited to specific traits. Research has shown that genetic changes occur to many traits. Various aspects of the salmon's life history have been changed or are potentially changed through the hatchery rearing process. Multiple traits which are associated with survival and optimal growth have been changed through the hatchery process. Reproductive behaviours have also changed in adult salmon this might be attributed to the hatchery process.

There are concerns about genetic changes of hatchery fish and implications for mixing of hatchery and wild fish. Rehabilitation of a wild population requires hatchery fish to contribute to the wild fish population, particularly since the depleted wild population would have faced many threats. There are no solid studies that have examined how hatchery reared Atlantic salmon individuals perform compared to wild individuals. However, there are a couple of studies which have used Pacific salmon to examine this matter. Hatchery reared fish are defined here as fish that have spent any proportion of their lifecycle in an artificial environment with human manipulation.

Araki et al. (2007) investigated whether the performance of hatchery reared and wild steelhead offspring are similar. The hatchery and wild fish were of the same origin. Steelhead have a similar life history to Atlantic salmon, therefore are comparable. Wild steelhead were removed from the river and raised in the hatchery until age one and then were released back to the wild. The remainder of the life history of the hatchery reared fish was spent in the natural environment. During the release of the hatchery fish Araki et al. took several steps to improve the chances that the hatchery fish may have performed better in the wild environment. When the hatchery and wild steelhead returned from sea, researchers compared the number of offspring produced by the hatchery versus wild fish. The study compared three crosses of fish. The first cross examined the lifetime success of wild crossed with wild fish. DNA analysis was used to confirm these fish had no hatchery influence. From the DNA samples, it was possible to assign offspring to parents with higher confidence. The second cross also involved wild fish but after returning to the river these fish were removed and placed in a hatchery. The offspring were raised in the hatchery for one year and then released to the wild. The third cross involved one parent that experienced hatchery rearing from a previous generation and the other parent having been raised in the wild. The offspring of this cross were also raised in a hatchery for a year and then released. If the hatchery environment, rearing process and hatchery fish cause genetic changes which could be detrimental to survival, the following predictions could be made: first, it would be expected that the pure wild fish would produce more offspring and have greater survival than individuals with any hatchery background. Secondly, the offspring who's parents were pure wild, of which one spent a year in a hatchery (Cross 2) would produce more offspring and have higher survival than those individuals who had one wild parent and one parent in the hatchery, and who had spent the first year in the hatchery environment (Cross 3).

Results from this study indicate the second cross had a success rate of 60% compared to the pure wild fish from the first cross. The success rate of the offspring from the third cross declined even more; these fish had approximately 31% of the success rate from the pure wild cross. Fish from cross two and three had similar environments, except cross three had an extra year in the hatchery; from this the overall success rate was halved. There was a general trend that these hatchery fish were influenced by how long they were in the hatchery. A monitoring program should be undertaken when fish are released back into the wild environment to determine how the offspring perform over several generations.

Another study examined steelhead from Lake Superior. Broodstock were used. Hatchery reared fish were raised to the fry or smolt stage, and then placed into the wild. The offspring of parents raised to fry or smolt were compared, by examining the relative hatchery performance of the fish over two generations. The parents were also compared. It was predicted that fish that had parents in the hatchery for a shorter time would do better than fish with parents in the hatchery for a longer time. The predictions were correct; fewer offspring were produced from parents who were released as smolts than those released as fry. Within a generation the hatchery seems to reduce the overall survival of fish when they are released to the wild. This study suggested that the survival of hatchery reared fish tends to decrease when the length of the hatchery rearing process increases. The two studies presented above required a large commitment of resources and time to complete, and were labor, financial and time–intensive; this is a limitation on our understanding of genetic effects of hatcheries.

Another major concern with stocking is that it might have an impact on the genetic diversity of wild fish populations. Geneticists use the term 'effective population size' to refer to the genetic population; this is in contrast to total number of fish in the population of 'census population size'. An example of a census population size may be a count of

50 fish. The effective population size refers to the number of males and females that are mating. If there are 50 mature fish, with 10 being female and 40 male, not all males will have a chance to mate. Some males will be outcompeted for access to females; they will not pass their genes on to the next generation. Therefore, effective population size does not behave as 50 individuals it might be closer to 20 individuals. The effective genetic population size does not always behave as the census population size. Typically, the effective population size is much smaller. Effective population size can change by gene flow which introduces new genetic diversity to the population; this mechanism may be very important. It has been recognized that smaller census populations often have smaller effective population sizes with low genetic diversity. This situation presents the risk of losing genetic diversity more quickly through random genetic processes than larger census populations with higher genetic diversity and larger effective population sizes. Smaller effective population sizes, with lower genetic diversity, may not be able to respond to environmental change in the future. This may result in conservation concerns.

Wild Atlantic salmon populations vary in terms of their mating systems and the number of precocious parr both over time and within and among rivers. River systems can have varying proportions of MSW and grilse producing offspring. The abundance of Atlantic salmon can fluctuate within and among rivers for different populations, but the effective genetic population size will also vary and the genetic consequences of those differences are important.

When investigating a population, another aspect to consider is the variation within a family. A spawning run might have 50 individuals, with the assumption that these 50 individuals randomly mate. In many situations of small population size this may not be true. Certain families may be better adapted to an environment or environmental change, which increases their survivorship and causes an increased representation of this family within the population. Fluctuations within a population have important implications for genetic diversity. If there are 50 fish with different genotypes in a population, intense environmental change (e.g., high temperature or fishing pressure) could greatly impact the survival of that population. In this situation the population could experience a “bottleneck effect”, where the population abundance declines so that the number of individuals is low and genotypes are lost. If the abundance was still 50 fish, one might be inclined to say the population has not changed, but the genetic population may have lost diversity and abundance. Over time, if there are still rapid changes in the environment, it could be more challenging for this population with fewer genotypes to persist. Genetically that population has changed from the previous generation.

Stocking programs used to boost wild populations have the potential to affect the genetic diversity and effective population size. Declining Atlantic salmon populations can have high genetic diversity. However, some hatchery programs are designed to intentionally select a small number of breeders, which may not genetically represent that population. The small number of breeders could be genetically similar. Hatchery fish are mass produced, the abundance of a population may be initially increased, but the genetic diversity may not correspondingly increase due to the low number of breeders.

Initial boosts in population abundance after stocking raises concerns because the ratio between the effective population size and the census population size can be reduced. There are concerns that over successive generations increased variation in family size, limited representation of families, artificial mating and genetically homogenous hatchery fish will lead to inbreeding. A measure that could be taken to prevent inbreeding would be to select individuals from a larger effective population. Genetically homogenous hatchery fish are released into the wild and those fish are competing with the genetically diverse wild fish. If there are environmental changes to which the hatchery fish cannot accommodate the wild fish could have an advantage. In this situation, from a genetic point of view, there could be "less fish" (i.e., smaller effective population size) than the original initial wild population if the hatchery fish affected some wild fishbefore they were eliminated by the environmental change.

Through a series of studies in the United States, Hedrick et al. (2000) researched whether stocking large numbers of Arctic char (*Salvelinus alpinus*) might impact effective population size and census population size. This study can be applied to Atlantic salmon. Wild char were removed from a local river and used for broodstock. The offspring were reared to the smolt stage and release back into the river. Pedigree analysis was used to examine the DNA samples from returning adults in the following generation. DNA analysis allowed researchers to discriminate hatchery from wild fish. Results indicated that by quantifying the effective population (wild and hatchery fish), the size of the stock increased. Hedrick et al. also determined that there was a slight difference between the ratio of the effective population size and the census population size with stocking.

The experimental design and hatchery practices from these studies are important. A large number of breeders were used to produce the hatchery fish. There were equal contributions of each family from the wild placed in the hatchery. One family was not over-represented compared to others, which helped to maintain the effective population size and the genetic diversity. Males and females were spawned equally, so eah individuals genes had a chance to be passed on, this does not happen in all hatchery programs.

People are concerned with the decline of salmon populations and in a dilemna from a genetics standpoint with using stocking as a restoration tool. Without stocking, the declining populations may not have a chance to recover, which would increase the chance of that population being extirpated. Genetic diversity can decline quickly in hatchery reared fish, which decreases their chance for survival and increases their chance for extirpation.

Restoration science contains uncertainty as stocking can boost a population in the short term, but that may not always be true. The long term-genetic effects of continuously stocking over several generations are not well studied. Cumulative effects on the genetic diversity of the population could hinder, rather than enhance, the population in the long term. There are actions that can be taken to reduce the overall potential impacts of rearing fish and releasing them into the wild.

Some of the changes that have been implemented in hatchery programs have good intentions but might actually be more harmful to the fish populations. A key point mentioned in various sources indicates hatchery practices should use local broodstock. Salmon adapt to their local environment, and their traits might be specific to their native stream. Stocking non-local fish automatically puts them at a disadvantage because the optimal phenotypic and genotypic expressions are not suited for that river system. If non-local hatchery fish mix with wild fish, they could produce offspring that are also not locally adapted. Using local broodstock increases the chances that the offspring will adapt and survive in the wild.

To minimize genetic impacts in a hatchery rearing program, use a large number of randomly selected breeders. It might be unrealistic to assume every watershed could provide more than 50 breeders. Measurements can be made to ensure that the genetic diversity of smaller populations is well represented. In order to design a hatchery rearing program, the local population within the river system must be well understood. A random selection of the breeding population should include adults that mature and spawn early and late and of different body sizes (i.e., MSW and grilse). If a random sample of breeders are used from the local population, the selective changes that arise within the hatchery are likely reduced; genetic diversity will likely be maintained where intentional selection of individuals was avoided.

In an ideal situation, determining the relationships between the breeders is desirable to ensure, for example, half or full siblings are not being crossed with each other. In order to determine the relationship between the breeders, DNA analysis is required. By knowing this information, each family can be equally represented reducing the chance of losing rare families. Similarly, an equal representation of the sex ratio ensures that one sex is not over-represented compared to the other and that all genes have an opportunity to be passed on. Overall, these measures would help to reduce the loss of genetic diversity in the hatchery.

Research has demonstrated that hatchery rearing does genetically change fish. The amount of time within a generation and the number of generations spent in the hatchery should be minimized. If the hatchery environment mimicked the wild environment, perhaps the genetic changes would not be as drastic, and there would be less chance of favouring certain individuals in the hatchery relative to those adapted in the wild.

By taking the precautions mentioned above, the chances of hatchery fish surviving in the wild would improve as they would be better adapted to the wild environment. When releasing stocked fish, they should be of the same size as the wild fish. Long term genetic monitoring programs are essential for hatchery rearing and stocking success. Monitoring the population would allow for adjustments to be made to the stocking program to best suit that population. Various aspects of salmon ecology and habitat play an important role in stocking. Regardless, if genetic effects are reduced habitat must be available to support a stocking program.

Discussion

Researchers would not know how many wild fish are produced at a particular stage, because they are looking at the lifetime success and only adults were sampled.[84] They would know how many adults were returning to the river and the number of adults that produced recruits, because a counting fence was used.[85] Information on whether the salmon were wild or if they had some hatchery influenced could be determined.[86]

Studies on DNA are becoming more financially feasible; however, long-term studies would require a lot of more resources.[87] In order to effectively monitor the wild fish populations, extensive resources must be invested. It is challenging to assess a stocking program in terms of the number of hatchery fish that are contributing to each successive generation if DNA research is not applied. If there are only a couple hundred wild fish left in a river system and a stocking program is applied in hopes to boost the population; a university or government lab could be hired to determine the population's characteristics, if the necessary resources are provided.[88]

Bob Rutherford and Amy Weston
Nova Scotia Salmon Association, Adopt-A-Stream Program
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Habitat restoration is conducted to improve conditions for all species within the ecosystem, not only Atlantic salmon. However, when a stream is being assessed to improve salmon populations, aspects of habitat (e.g., water quality, physical habitat, instream cover, etc.) at each life stage are considered. The majority of habitat restoration work in Nova Scotia focuses on preventing ice formation and break-up as these factors can hinder natural fish productivity. Habitat restoration work also includes studying algae production and the biodiversity of insect and fish populations in the watersheds.

Migrating adult fish should be able to access the upper reach of a river so all habitats are used, which also distributes the densities of juvenile fish. Fishways are built around dams to permit fish passage. Falls and culverts can obstruct the passage of migrating fish. Regulations dictate how culverts should be installed; however, without resting locations in deep pools, and suitable water flow and levels, it is difficult for fish to reach upper parts of the stream. Prior to habitat restoration in Brierly Brook, fish stayed downstream because there were no resting locations in pools. Therefore not many fish were spawning in this brook.

[84] Question posed by Bob Baker, answered by Dylan Fraser
[85] Question posed by Bob Baker, answered by Dylan Fraser
[86] Comment by Dylan Fraser
[87] Question by Leslie Buckland-Nicks, answered by Dylan Fraser
[88] Comment by Dylan Fraser

Salmon returning to the river travel upstream, while the river current travels downstream. Salmon prefer traveling approximately 100 m before resting in a holding pool. If there are kilometer-long stretches within a river with no holding pools, salmon may not continue upstream. Habitat can be repaired by creating more holding pools. Another possible solution is to trap and transport the migrating adults to suitable vacant habitats in the upper reaches of the watershed. Stocking programs can be used to boost the population in locations with suitable vacant habitat. Once migratory routes are restored for fish passage, fish can travel throughout the watershed.

Restoration is also critical for spawning habitat. Spawning salmon require holding pools with cover next to the spawning beds. Females will remain at a spawning bed for a few days constructing redds in a gravel substrate, while several males attempt to fertilize the eggs. Water flowing over the spawning habitats should be well oxygenated and clean. Many rivers in Nova Scotia have limited gravel spawning habitats. On the south shore of Nova Scotia there is plenty of boulder and cobble habitat. Stocking salmon in areas where there is gravel spawning habitat might be worth investigating, if there is little naturally occurring spawning activity. Limited gravel spawning habitat can be bypassed by collecting adults and stocking fry. Additional water conditions for spawning habitats include a low sand/silt content, so that eggs can hatch and the young fish progress through alevin to fry swim-up stage.

Fry remain near stream edges where the water is shallow, velocity low and there is cover. Fry habitat is disappearing, which is problematic because in order to survive fry need to disperse. Due to limited spawning habitat, adults are constructing redds in close proximity and within small areas of the stream, resulting in high fry densities. If fry densities are high and there is limited fry habitat and food low survival will result (i.e., density dependent mortality). Stocking late fry or fall fingerlings is a possible solution for limited fry habitat.

Parr densities are highest near riffles and runs approximately 40 cm in depth. As the water level in the riffles and runs decreases the parr density also decreases. Many larger parr living in smaller streams will stay in pools year round. Deep pools with instream cover are important for parr during low water periods in the summer and to hide from predators.

Limited rearing habitat is a major issue because the entire freshwater aspect of a salmon's life cycle is not supported. Under this condition only smolts could be stocked. Sampling has shown that many rivers have high numbers of parr, but low numbers of smolts. Pre-smolts will overwinter in pools that are ice covered and feed in extremely cold water, but they require good instream cover. If ice freezes to the bottom of the pool, it is possible for the ice to scour in the spring, impacting the survival of pre-smolts. If pre-smolt overwintering habitat is limited, one strategy could be to collect parr and smolts in the spring and raise them in the hatchery over the followingwinter or until they are ready to spawn.

There are many successful stocking stories in watersheds with abundance of quality spawning and rearing habitat. The unsuccessful stocking stories have missed identifying one of the limiting habitats. It is very common to have fragmented habitat where resting locations and pools are not available to migrating adults. It is also common to lack pre-smolt overwintering habitat.

Discussion

No discussion followed the presentation by Mr. Rutherford and Ms. Weston.

Dr. Ian Fleming
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St. John's, Newfoundland

Based on the information presented and the discussions, there are costs and benefits to stocking; under certain conditions stocking may be appropriate,while under other conditions it would not be. This presentation is aimed at discussing potential conflicts between stocking for conservation and fisheries.

The wild and hatchery environments are different. In the wild parr have different densities and levels of predation, and salmon have to spawn naturally. Humans can try to make the hatchery environment as similar as possible to the natural, but it is challenging. When salmon are placed into the hatchery, they are reared at higher densities than in the wild, altering their behaviour. There are also no predators in the hatchery. The higher densities are required to produce an abundance of fish, which is in conflict with producing fish with a near-natural behaviour repertoire. Another conflict is with mating. In the wild, males compete for access to females to spawn and females choose their mates. In the hatchery, the fish are spawned through human selection; we choose which male and female gametes will be crossed.

Fish that are removed from the wild and placed in the hatchery go through a number of developmental changes as a consequence of the environment and this can be observed after one generation. The environment, genetic organization, origin, human selection for mating, and the random effects of selecting a proportion of the wild population for the hatchery contribute to changes from a wild to hatchery fish. Hatchery fish tend to be less streamlined and have rounded fins compared to wild. The quality of the fish can be improved by decreasing fish densities, but the trade-off is that fewer fish will be produced for stocking. A profound developmental change was illustrated by a study at the University of California which examined fish brain development according to the complexity of the hatchery environment. Fish were placed in either tanks with no substrate or tanks with gravel substrate on the bottom. Brain development was reduced in fish which were kept in a tank without substrate. It is uncertain whether these differences in brain development would persist over time.

There are also behavioural differences between wild and hatchery parr. The hatchery parr have been raised from egg in the hatchery and tend to be more aggressive than wild parr. There is, hwoever, conflicting evidence as one study has reported no differences in aggression and another reported hatchery parr to be less aggressive. Wild and hatchery fish react differently to potential predators. By waving a hand over a tankto mimic an avian or terrestrial predator, wild fish will react quickly by swimming away, whereas hatchery fish will come closer to the surface, because they associate a shadow over their tank to feeding.

There are indirect consequences of rearing salmon in the hatchery. Many hatchery managers want to also increase salmon growth, which alters the production of hormones. Hormonal changes not only affect growth but also juvenile behaviour. A study examined the changes in endocrine regulation and actions with responses to predators. Fish were placed in an experimental chamber where an artificial heron was placed in a tank. Behaviours were observed and heart rates monitored by a wire mesh inside the tank. The results indicated there was a strong correlation between changes in endocrine regulation of wild and hatchery fish and responses towards predators.

My M.Sc. research examined the breeding characteristics between hatchery and wild coho salmon. I sampled adult coho from five to six hatcheries raising young to smolts and ten to twelve wild populations in southern British Columbia and compared adult development of secondary sexual characteristics, including morphology, body shape, colour and kype size. The hatchery males had less developed secondary sexual characteristics than wild males. The hatchery and wild salmon spent the same amount of time in the ocean, as hatchery fish were released as smolts. The wild male coho developed more prominent secondary sexual characteristics for breeding and competing for mates. The colour of hatchery coho was different from wild, due to genetic and/or environmental changes. The effects occurred early in the juvenile stage (prior to smolting) and were potentially carried over to the adult stage.

There are many differences of breeding behavior between wild and hatchery salmon. Male hatchery coho salmon have reduced competitive ability towards other males, court less frequently and are ranked lower when competing for access to females. Females have higher egg retention on the spawning grounds and guard the nests less than wild females.

Research in Norway compared hatchery and wild Atlantic salmon body size and associated egg size. The hatchery and wild salmon were of the same river origin. The hatchery and wild salmon offspring came back to the river as adults to spawn. Regardless of adult body size, hatchery reared salmon produced smaller eggs than wild salmon; this was a response to their environment after one generation. Small egg size appears to be related to growth rate during the juvenile stage.

It is also important to consider how hatchery and wild fish interact in the natural environment. If the number of returning adult fish is increased by augmenting with hatchery fish, there may still be reasonable recruitment. If there is habitat loss, adding hatchery fish to the returning wild adult fish could supplement a population or it could displace the wild fish with hatchery fish due to interactions. Displacement of wild fish could occur if the hatchery fish are more aggressive or are released at larger body size than naturally occurring wild fish. In 1986, a study in Oregon focused on the differences between stocked and non-stocked rivers. Thirty rivers were sampled in that study with half of these rivers being stocked with hatchery fish. After one generation, the number of hatchery and wild fish for the stocked and non-stocked rivers were compared. If stocking had a positive effect, the number of fish should be higher in the stocked than unstocked rivers. A negative effect meant fewer stocked fish returned compared to wild fish. If there was no effect on the wild population, the stocked fish would have disappeared. In the first generation, the stocked rivers had higher returns than the rivers with only wild fish in that environment. The offspring of the stocked fish that spawned in the natural environment represent the second generation. The returns of the second generation in stocked rivers were poorer than those in the unstocked rivers. The stocked fish and wild fish were of the same origin. The study suggests that stocking had a potentially negative effect on the production of wild fish in the rivers whenmore than a single generation is considered.

A study in Sweden used brown trout, a close relative of the Atlantic salmon, to determine the effect of adding wild fish compared to adding hatchery fish in the same environment, and to compare productivity in terms of growth and survival. The study examined two rivers and within each river two experimental blocks were discriminated. In each stream the blocks were split into three sections and were distant from each other. The first section was a control section, which had existing wild brown trout. Electrofishing was used to count the fish and to ensure the densities of fish for each section were the same. The second section consisted of introduced wild brown trout and hatchery brown trout. The hatchery fish had returned to the river the year before. When the fish returned, researchers reared them in the hatchery and then placed them in the river during spring with the wild fish. In the third section, half of the wild fish were removed and replaced with wild fish. In each of the three sections, the fish were compared three months prior to the manipulation. After the manipulation, the results were compared at two and four months. Initially, the growth rate of the fish was similar between the three sections. After adding hatchery fish to the wild fish production (Section 2), the growth rate decreased, due to intense competition. Wild fish competing with wild fish (Section 3) was the most intense competition and growth rate decreased. Over time the control section with only wild fish and no manipulation (Section 1) had the highest growth rates. In the sections where fish were added to the population, the population increased, which decreased production in terms of growth of the fish. From this it is clear that it is important to consider density-dependent interactions when adding fish to an already existing population. It is also important to stock in habitats with low densities of fish. Stocking success does not just refer to the number of fish that return as adults, but also to the number of offspring that the adults produce. When stocking does not displace wild salmon and adds to total production, it is successful. There are few studies that provide scientific evidence for successful stocking programs.

Removing wild fish from a river prevents them from spawning in their natural environment. In order for stocking to be successful, more hatchery fish have to be produced than wild fish removed. Fish will adapt to the hatchery environment over time. If hatchery reared fish are released into the wild, it is unlikely that they will respond well to the natural environment because of changed selection pressures. By adding hatchery reared fish to the natural environment, potential problems could be disguised. If the rivers are being stocked and there are good returns of fish, it may not be evident what problems do exist within the environment. For example, even if fish are put into a hatchery they will not necessarily return to the river, many fish die at sea. It might appear that the freshwater environment is the problem and stocking would be a potential solution. However, stocking may not add to the production of the wild population, so the underlying problem would be disguised.

Another potential problem is the response by predator populations, such as birds and trout, if large numbers of hatchery fish are released. Stocking might also increase human exploitation, especially with Pacific salmon where a commercial fishery still exists and wild and hatchery Pacific salmon are harvested.

The goal of stocking programs should be to enhance the wild production of fish and to improve the wild populations. In order to achieve this goal, there are significant ecological and genetic risks and benefits that must be recognized and considered prior to stocking. It is important to understand what constrains wild populations. If wild fish populations are healthy and breeding successfully, it would not be beneficial to the wild populations to stock or place them into a hatchery environment. The goals of each stocking program should be clear and specific to a river system. The initiation and completion of a stocking program should be pre-determined.

Stocking can be used to enhance fisheries. There are a couple of caveats however. First, depending on how hatchery fish are raised and when they are released, they potentially will have reduced fitness compared to wild fish. Secondly, by raising fish in the hatchery environment, potential negative ecological interactions can occur upon release between hatchery and wild fish. Stocking can also be used for conservation. It has not scientifically been demonstrated that stocking benefits conservation, but as a temporary tool it could be useful to boost populations. Stocking should not inhibit other actions for restoration. Habitat must be available in order for stocking to be useful.

It has not been discussed whether certain rivers should be selected for stocking in order to ensure that other rivers remain wild. Norway has identified a series of rivers and fjords that are considered National Rivers. These rivers and their tributaries are protected from aquaculture and further development. Fishing is permitted, but the rivers are naturally productive. Other (non-National) rivers are selected for stocking or to allow aquaculture nearby. This type of planning has been applied in agriculture, urban development and industrial parks in Canada, however, has not been applied to the aquatic environments.

Currently, the decision making with respect to stocking has been random and applied when pressure develops. Humans respond to change rather than identifying the change beforehand and making an informed decision based on what is best for the river system and wild fish that live within it.

Discussion

The studies presented were ones that were known in the literature.[89] These studies were scientifically controlled; there was controlled situations and manipulated situations, which allowed for a comparison. Dylan [Dr. Fraser] mentioned a few recent studies on steelhead, where there were ecological and genetic affects.[90]

Before considering stocking there are many factors that have potential positive and negative consequences that should be considered.[91] One key point was that there are few studies which have quantified if stocking has contributed to the long-term success of a population. Robin Waples (2007) did a review concentrating on Pacific salmon in locations where stocking was discontinued. He examined populations before and after stocking. There was evidence that stocking had some positive, negative and neutral effects. However, the majority of the cases have suggested that stocking has no effect.[92]

If you have no fish in your river, then you should consider stocking.[93] There is not enough information on the population of fish within that river system, but it would be interested to learn more.[94] It is most important to identify the purpose of stocking.[95]

[89] Question posed by Bob Baker, answered by Ian Fleming
[90] Comment by Ian Fleming
[91] Question posed by unidentified speaker, answered by Ian Fleming
[92] Comment by Ian Fleming
[93] Question posed by unidentified speaker, answered by Ian Fleming
[94] Question posed by unidentified speaker, answered by Ian Fleming
[95] Question posed by John Phyne, answered by Dylan Fraser

Discussion Panel 3 (Biological Issues): Dr. Dylan Fraser, Bob Rutherford, Amy Weston and Dr. Ian Fleming

Unfortunately all documentation on this discussion panel (video, audio and notes) were either not recorded or subsequently lost. There is no official record of the discussion following Panel 3.

<u>Guest Speaker</u>: <u>The Honourable Geoff Regan, M.P. (Halifax-West)</u>.

Many participants that attended this weekend long workshop have dedicated time in their lives to improving the salmon stocks and the health of rivers. Future scientific studies should aim at answering more questions about genetics and the ecological interactions between hatchery and wild salmon and why mortality rates are low after returning from the ocean. Future research should also focus on further ideas of how salmon populations can be restored. A quote by Henry David Thoreau reads "*many men go fishing all of their lives without knowing that it is not the fish that they are after*"; which explains why participants attended the salmon stocking workshop. The stewardship, protection of rivers and biological research, does not mean that all efforts are concentrated on fish or fishing. It is about mans connection to nature. Life should be about dedicating your time to events that reflect your values. Individuals such as Walter Regan from the Sackville Rivers Association along with his co-workers have done a considerable amount of work.

There are many issues related to fish throughout Canada, but it has become more obvious how water is important to our society and necessary for life. When people consider the big picture, there are many issues related to water. Three examples include: (1) every year the ice caps in the Rockies melt, that water flows into the Fraser River and sockeye salmon rely on the waters levels to be high. (2) For every one million people in the prairies they are the same number of cattle. An abundance of nutrients are being deposited into Lake Winnipeg resulting in algae blooms. (3) Summers in the past few years have been really dry in the centre of the continent and when water levels are low there are higher risks of Walkerton.

Learning to fly fish teaches patience and the love for the sport. Generations in the future should have the opportunity to experience the peace and perspective fly fishing can offer. Current restoration efforts keep the vision to continue fishing alive. Canadians in the future should recognize and appreciate what great things salmon organizations have accomplished by being ambitious in order to preserve the countries natural heritage.

Breakout Group Discussion, Sunday February 8, 2009

In the breakout session participants were allocated to three groups. There were three rooms designated with the three themes of the conference, (1) Case Studies, (2) Socio-economic Considerations, and (3) Biological Considerations. Each group spent a period of time in each room, rotating through all rooms so that all participants could voice opinions/concerns within each theme. To guide discussion, within each room (theme) were four previously developed questions. The text from this section of the workshop is more "rambling" than previously, reflecting the nature of the discussions which took place.

Room #1: Case Studies

Question 1: What do you think are the three key factors which provide for success of stocking Atlantic salmon in rivers?

Habitat, water quality and a stocking plan are the three key factors for a successful stocking program. The key factors will vary according to the watershed. A large number of breeding adults, low stocking densities, knowledge of the genetic diversity and minimal time in the hatchery would be optimal. Additionally, educating the public on a stocking program and user group needs will get people more involved to develop a stronger sense of community. Stocking programs could be developed by university students or the work could be contracted out. The Department of Fisheries and Oceans cannot be everywhere, but students are more flexible.

Question #2: How do you define a "success" or a "failure"?

The first task prior to stocking should be to examine the problems caused by humans and to solve these problems. In order to stop river degradation and have a successful stocking program, the regulations should be examined and changed to make improvements.

Success would be determined by establishing a sustainable population and retaining a healthy watershed to the point that stocking does not have to continue. When stocks are released and the adults return and reproduce, that would be a measurement for success. If fish do not return, then it would be a failure. If enough salmon return that angling opportunities can be re-opened that would be fantastic; participants were divided on whether this should be considered a measurement of success. Success could be defined by species diversity and their ecological success. Success and failure are on a timeline, it would depend on if the purpose was for restoration or to support a recreational fishery.

Salmon should not be the only fish species monitored to determine the success of a stocking program. If there were large runs of smelt, trout, gaspereaux and sea trout, does this constitute a success if the only intervention was stocking? By increasing species diversity, the number of predators could increase as well, which would be a failure. Associations would have different goals, which would vary the levels of success depending in the river system.

Question #3: What are the commonalities and lessons we might learn from the three successful examples we have heard?

Rivers cannot be restored to their past pristine environments. When species are extirpated, you cannot get them back. Extinction can be viewed as a natural process. Species that become extinct are replaced by other species. Species diversity in ecosystems varies. It has been suggested that the extinction rate has increased over time and that climate change impacts the extinction rate. One prediction is that within four years the extinction rate will be higher.

If historically well known salmon rivers do not now have salmon, it does not necessarily mean the river is in worse condition. On the contrary, it was also felt by others that if salmon were historically in a river, then they should be in the river now.

Question #4: The three case studies reviewed on Saturday morning were stories of success. Are you aware of unsuccessful stocking attempts? Why might they have failed?

DFO started stocking rivers in the Southern Upland Region that had been affected by acid rain. The process was delayed and this resulted in failure. Another example of stocking programs that failed would have been in East River, Chester, where pH levels increased and eventually dropped. It would not be possible to compare the rivers in the Southern Upland with the rivers on the North Shores. The rivers in the North Shore have good water quality. West River Sheet Harbour should have been a case study since the water quality improved and the salmon have been spawning in the river.

There are many examples where population estimates have been assessed poorly. The public has been misled by reports indicating that there are so many different species of fish in the river and their abundances. A lot of resources were put into West River Sheet Harbour to improve the poor habitat conditions and stocking was used to try and augment the salmon population, but it failed.

In the past stocking has failed because the objectives and goals were too high for the rivers salmon population and habitat conditions. Habitat improvements were not taken into consideration when there was a salmon population decline on the Nepisiquit River in New Brunswick. Participants argued that the three case studies presented on Saturday morning were not successful; it depended on each individual definition of success. All three cases had salmon that spent different amounts of time in the hatchery. Some stocking attempts have failed potentially based on the stage of life the salmon were placed in the hatchery. However the salmon in the Nepisiguit River spent the least amount of time in the hatchery. The Nepisiguit Salmon Association stocks unfed fry, a program that seemed the most successful. No other known river associations have stocked with unfed fry.

None of the case studies presented considered the importance of population genetics. Bad hatchery practices are potentially harmful to wild fish populations; which gives people the perception that hatcheries are bad. Community involvement in fundraising and education brings the community together. Knowing the origin of broodstock allows studies to be completed on the genetic variability, so that hatchery fish can be kept close to their wild counterparts. Broodstock should be a representative of fish in the river of origin and guidelines should be developed for removing fish from the rivers for broodstock collection.

The Sackville River has been stocked and continues to be stocked, mostly for an educational program with students. Juvenile salmon from the Sackville River were taken to Ontario for genetic studies. It had been noted that the salmon were a completely different stock from the migratory adults. The Sackville River was once prime salmon spawning habitat, now it resembles a gravel pit. The number of wild salmon returning was approximately 3%, whereas the hatchery returns were approximately 0.5%.

Consider all tools for restoration before making a decision because hatcheries are expensive and they are a commitment not to be taken lightly. It has been discouraging for organizations that have tried to stock and have received low numbers of returns. There are complex issues surrounding stocking, which can be improved by taking into consideration the information that has been shared. Experience and knowledge are the keys to discriminating poor science as opposed to science with few errors. Science should be used for gaining information for stocking programs. Studies on what happens to salmon while they are at sea are important for associations and organizations considering stocking as a restoration tool. The case studies allowed the audience to learn about the successes and failures and where and how these groups made mistakes are important for the future.

Salmon associations and organizations need financial back-up from the Government. Laws need to be enforced to regulate the people that fish illegally. Communities surrounding watershed have started policing the rivers themselves to ensure people are not fishing illegally.

When participants were asked which rivers should be improved in terms of habitat the Medway River was mentioned, but that might require extensive habitat improvements. Another river that was mentioned was the Musqudoboit. A lot of rivers in southern Nova Scotia are affected by acid rain. DFO indicated that approximately 0.5% of the hatchery salmon returns, but if there was good water quality, perhaps more salmon would return. Studying rivers with small or no salmon populations are equally as important as studying rivers with salmon because they offer researchers a chance to compare and learn preventative measures.

Room #2: Socio-economic considerations

Question #1: Is there good evidence that stocking of salmon into rivers translates into greater "social value" (e.g., more anglers, greater economic income, etc.)? Given the expense of stocking, is it the best tool to provide maximum "bang for the buck" in terms of restoring Atlantic salmon to abundance?

Overall, participants agreed that stocking would create stronger social values. The community economically benefits from stocking because it attracts tourists. The stocking program for the Sackville River was initiated to raise awareness and education amongst an urban community. Stocking programs can work with various sized community groups and volunteers are extremely valuable. The economic gain from stocking may not be large, but community involvement would be invaluable. The social value of fish is greater than the total expenditure for stocking, even if only a small percentage of adults return. Stocking does not have to exclusively focus on the ecological impacts but may focus on maintaining a healthy river. Information about stocking should be passed down to younger generations who may benefit economically from stocking in the future. By transferring knowledge, the community becomes more empowered by their decisions.

Some rivers are beyond the point of being restored due to their low abundance. Economically, it does not make sense to continue stocking in a river that does not have the conditions to support the stock, especially since hatchery programs are publicly funded.

Stocking has positively affected angling on the Margaree River. A natural healthy river system can support a stocking program and a recreational fishery for anglers. Climate change may affect the recreational fishery. For example, snow used to remain in the Cape Breton Highlands until July. Currently snow melts by May which increases the water flow. Stocking should first be used for recreational fisheries and it can also be used as a social tool.

Searching for funding for publicly owned water can be difficult. Stocking could be used as a tool for restoration, especially if the provincial government releases hatchery reared fish into a river. Habitat restoration is effective but it requires a community’s long-term commitment to make a difference. Habitat restoration may not be the first tool, but it is an option. Hatcheries should not let the government off from protection. There has to be a balance between river health, fish and people. An example of a balanced river would be the Margaree. The river provides First Nation groups with fish for food and ceremonial purposes. First Nation groups have a quota and there are only a few rivers in Nova Scotia where they can be filled. Excellent fishing spots are targeted by all anglers and First Nation groups.

Question #2: How do we accommodate multiple users with equal rights to the fish (e.g., First Nations and recreational anglers)?

Fishing rights are not quite equal to start with, because user groups place different values on salmon. First Nations, anglers and the industry should come together and discuss issues with the government to find a balance. Stocking programs should aim to meet all user groups needs, whether it would be for food or recreation. All people should have a more holistic approach. Progress has been made, but DFO does not contribute financially to stocking programs.

Recreational angling license holders in Nova Scotia have the right to fish but this does not apply for all Maritime Provinces. The First Nation groups have agreed to not harvest in rivers, such as in Southern Nova Scotia where the stocks are below their conservation requirements. First Nations benefit from stocking programs, where hatchery fish are provided instead of fishing wild salmon. The government tries to separate the First Nation groups, commercial fishermen and anglers. The regulations that the DFO and First Nation groups negotiate are confidential so they are not available to the public. There should not be any separation between people who share a common interest in natural resources, such as fishing.

It appears that DFO wants salmon organizations or angler groups to communicate through DFO about First Nation rights. If First Nation groups discuss matters directly with DFO, then they are bound by Government. There was a period after Sparrow when First Nation groups had their own mitigation coalition. The Government decided that First Nation groups should co-manage the fisheries. The Government funded the First Nation group's coalition for a while, but then stopped. This same situation happened with stocking programs. DFO also came out with an Aboriginal fishing strategy to educate First Nation groups under a set of regulations and to ignore Aboriginal treaties. The social value of salmon has been lost for some First Nation groups and anglers.

First Nation groups and anglers share many common concerns. By working around the Government, perhaps more can be accomplished. Conflicts between user groups are what keep people in the Government employed. There are thirteen Chiefs in Nova Scotia, they should be talking more about these issues so that questions can be discussed and everyone can move forward. Anglers fish salmon for recreational purposes, but First Nation groups fish salmon for food and ceremonial purposes. It might be difficult for anglers to understand why First Nation groups use salmon for ceremonial purposes. Colonial Laws do not apply to Mi'kmaq. Raising awareness about the challenges that the Mi'kmaq culture faced and still faces would likely clarify why enforcement efforts were needed, but how they were enforced. There are no issues with First Nation groups having access to salmon or any other fish provided conservation requirements are met. The main issue identified is that anglers do not know the regulations. Lists of the regulations and explanations should be available to the public for educational purposes. Anglers have come a long way with understanding First Nations and the relationships are improving.

An issue in New Brunswick was that some Aboriginal individuals were using gillnets to fish and it was believed that too many mature females were being captured. Mature females are important for breeding and producing recruits. Also, it was believed that some Aboriginal families were selling salmon for personal profit. This became a social issue between First Nation groups and anglers. Through negotiations between First Nations, anglers and other user groups issues such as the above can be solved.

Question #3: Is there a perception of difference in value between "wild" salmon and hatchery reared salmon? Do we need to consider this in thinking about stocking a river?

All people who grow up fishing have a special social connection to older generations. It is important to preserve that bond people share over fishing. Everyone values catching a wild salmon and people take ownership of rivers that they are connected too. For First Nations wild and hatchery reared salmon taste different. Further, capturing salmon in the natural environment has a stronger traditional community value.

Anglers have mixed feelings about catching hatchery salmon. Anglers that catch and release tend to keep a record of the number of wild or hatchery fish they catch out of curiosity. If hatchery fish are clipped, fishermen can tell the difference, otherwise there are no visible differences between hatchery and wild fish. Capturing a wild fish feels better because it gives a "good vibe" about the river and its habitat. Wild fish also fight more on the line than hatchery fish. Anglers are out fishing for the experience and their primary concerns are habitat protection, enforcement and stocking.

Question #4: If an increased sport fishery brings in economic value to a community, will that value exceed the cost of the stocking program (i.e., is the program sustainable?)

The government does not fund stocking programs. Organizations, volunteers and surrounding communities support and make stocking programs possible. The more volunteers the less expensive the stocking program will be. Stocking programs also create employment opportunities. The stocking program for the Margaree River is sustainable. It has good returns of adult salmon, which attracts anglers. The cost of stocking would be trivial compared to the economic benefit. If the cost to stock fish was too cheap, the rivers would be overstocked.

Room #3: Biological considerations

Question #:1 Is the biological risk worth the potential sociological and economic benefit? How do you quantify that biological risk and measure that against sociological benefits?

The biological risks will fluctuate depending on the river system, salmon population size, maximizing the health of the river and the effects from stocking. Population genetics is a relatively new research field. There might be biological risks, but the socio-economic return might be worth those risks, particularly for rural communities such as the Margaree.

Biological risks such as disease transfer and competition increase with stocking. If stocking was applied at low abundance, populations are still at risk of extinction. Salmon in the Southern Uplands Region of Nova Scotia are at a biological risk due to acid rain. The Medway River has been impacted by acid rain, this river was stocked in order to increase the viability of the population, but eggs may not be able to survive in waters with low pH.

Biological risks also depend on the geology of the river. Little research has been completed on the impacts of stocking a river in the long term. Stocking on the Sackville River was appropriate because of the geology and the program restored the salmon population in the river. However, wild populations are more stressed when stocking occurs, which can result in lower biological diversity, putting the wild population at higher risk.

Cancelling the salmon recreational fishery would result in economic losses in many rural parts of the Maritime Provinces. It was suggested that salmon are capable of telling what habitats have the best water chemistry and quality. Fish populations tend to replenish themselves over time; this can be a long cycle, which might support reasons for why stocking was initiated.

Mistakes were made by using unfit fish and in many cases they escaped into the wild. Survival rates have changed within the ocean, possibly due to the changes in the environment. Nature has a way of changing the gene pool. Animals have been introduced and have flourished such as whitetailed deer, brown and rainbow trout. Maintaining the ecosystem as close to natural is important for the species within that environment. Salmon are at the top of the food chain. By manipulating one of the top predators this might cause a disruption in the balance of the ecosystem. The biological risks are high and are always measured against the benefits. Further studies on why few adult salmon return to the rivers after migrating to the ocean should be conducted; the ocean controls everything.

Question #2: How can we minimize the known biological risk if we do decide to stock? What other tools should be considered concomitant with a stocking program?

Few scientific studies have been conducted on Atlantic salmon. Now researchers want to study the genetic loss, but no one has indicated what the genetic loss would be from stocking. Studying population genetics in Atlantic salmon would be a long term monitoring program. Norway spends over $25,000 on acid rain mitigation each year. The Canadian Government does not do enough. For every river the habitats should be assessed in order to determine whether or not stocking would be an appropriate restoration tool. Stocking has biological risks and there are social and economic costs and benefits.

Stocking enhances the sport-fishery which economically benefits the local communities. It creates a fishery and allows people to benefit from angling. The assessment of biological risks has not been done as often as it should. However, scientifically and technically we are still on a learning curve.

Participants agreed that stocking programs should aim at keeping hatchery fish as similar to their wild counterparts as possible. In order for a population to adapt to environmental change, the population must be genetically diverse. Use the best available science to create a stocking program. Take into consideration not only freshwater habitat but the ocean habitat as well when designing a stocking program. Hatchery managers are not interested in the short-term goals for stocking. They want to achieve the long-term goal of improving the population abundance. There have not been any fish populations driven to extinction because of stocking. Hatcheries and stocking have a potential to do good for fish abundance.

For the last century stocking programs have been implemented in various river systems throughout the Maritime Provinces. Hatchery reared fish have been transported from various rivers to stock other rivers; once released the hatchery fish mix and interact with wild fish. Salmon populations in the Maritime Provinces have a mixed background. However, it was felt that the Medway River might have no altered genetics.

Issues with stocking programs being successful seem to be linked with fish migrating to the ocean and retuning to the rivers to spawn. Salmon have low marine survival. This may be due to decreased genetic viability while living in the ocean. Fish may not return to the river because of poor water quality, such as low pH. Additionally, salmon can have long migratory routes. Salmon have been tagged and released in England and captured in the waters off of Newfoundland. However, man-made barriers, such as dams, block migrating routes to spawning grounds, which force salmon to spawn in other locations or not at all; this may change the river dynamics.

If stocking continues for populations at low abundance, the wild populations are at risk. Interestingly, DFO and the NSA started a stocking program with a salmon population at very low abundance and the population started increasing until the population became sustainable and the program stopped. The Nepisiguit River had good water quality and available habitat. Knowing the genetic diversity of a population provides insight to what steps should be taken to ensure that population is not detrimentally affected by stocking.

Question #3: Should we seriously consider the effects of our stocking on existing fish and fish-eating bird and mammal communities? That is, do our desires for salmon trump the current structure of ecological communities?

There are mixed views on whether or not focusing the restoration efforts on salmon will cause a shift in the ecosystem, some participants felt it would and others disagreed. The ecological community should be examined and taken into consideration. Watersheds are common grounds for both wildlife and communities. Everyone needs a holistic approach. However, some communities will continue to focus on salmon.

By focusing restoration efforts on salmon, it would not shift the balance in the ecosystem seriously. By removing a top predator, other predators at lower levels might be affected. Walrus and killer whales used to eat seals. Perhaps it would make a difference for the seals and seabirds. Cormorants used to feed in the ocean, but they have moved upstream to feed on juveniles and smolts. Predators are out of balance in the ocean and some rivers and stocking might attract more predators. In order to restore salmon populations, some predator populations such as cormorants might have to be reduced. Controlling predators can often benefit the species greatly. Controlling the predators would not be the answer because nature has a way of bringing the numbers back. Predators are just as much a part of the community as the fish. People should learn from past mistakes.

Salmon feed a lot of species and humans should not be left out. Watersheds are a common ground for people with similar interests. Salmon attract other species, which in return attracts more people. Some rivers could be reserved just for salmon, but rivers such as the Margaree are economically important for the surrounding rural communities. Could stocking cause more problems than good?; this question has yet to be answered.

Question #4: If a detrimental genetic effect was not likely to show up for 20 years, but we could increase returns in 5 years, would it be worth stocking

It would be worth stocking if the population was going to go extinct. Sometimes we need to focus on a short-term goal in order to create a sustainable long-term goal. Short-term benefits do not outweigh the long-term benefits. Ignorance is bliss. If we do nothing, the stocks will not benefit and neither will humans, if we do too much humans again will not benefit, therefore it would be desirable to determine a balance where conservation comes in. Sometimes a focus should be on one thing, so that mistakes in the past can be learned from.

Hatchery systems have evolved over the years. In the past, goals have been mixed up. It would be difficult to stock for a fishery and for the benefit of the population. Fisheries are important, but if you want to increase the population abundance, than the focus should be on restoration. It would be more challenging for the population to come back with a fishery and anglers.

Summary and Conclusions from Workshop

To summarize the weekend's discussion is difficult as it was broad-based and far-ranging. The text below attempts to encapsulate the important features discussed in this workshop. To begin, a stocking program should address four primary questions: (1) under what circumstances is stocking appropriate, (2) when should salmon be transferred into the hatchery, (3) when should they be released, and (4) when should stocking be used for restoration. Clear goals must be established for why the stocking is required and when it will be terminated. There are two purposes to stocking in the Nova Scotia context – for conservation or for a recreational fishery. Such stocking can be a tool in the restoration toolbox but will not be effective on its own; habitat and appropriate water quality must also be available to accept stocked fish. Stocking needs to be considered in terms of limiting habitat. The choice of life stage to stock depends upon the habitat constraint to be circumvented.

It is vital to maintain the genetic viability and avoid domesticating salmon and an important way of doing this is to minimize the time spent in the hatchery environment. The hatchery experience may detrimentally affect fish genetics in as little as one generation. Intentional selection by humans for spawning may decrease genetic variability. Re-introduced (hatchery fish may show reduced fitness and lower survival, and mixing of hatchery and wild fish is a concern due to genetic dilution of site-specific genetic uniqueness. Genetically, the effective population size is less than the census population size which has implications for the ability to deal with a changing environment. Key factors to consider to minimize genetic issues are (1) use local broodstock, (2) use a large number of randomly selected breeders, (3) include adults of different body sizes (MSW and grilse), and (4) minimize the time and number of generations in the hatchery environment. Long-term genetic monitoring programs are essential for hatchery rearing and stocking success.

The hatchery experience differs from the wild; densities are many times higher than natural and predation pressure much reduced. This can affect developmental, behavioural, morphological, and endocrinological processes. There is a fundamental conflict in trying to maximize growth or numbers yet retain ”natural” experience for fish. The hatchery experience of a juvenile can affect adult body size and behavior, and also the egg size of the mature female fish. Interactions of hatchery and wild fish in streams may impair natural ”wild” production if care is not taken to release young in vacant habitat. The efficacy of stocking is questionable based on published reviews of studies.

Stocking of fish is beneficial to the recreational fishery and the economics associated with it. Involvement of the NSDFA in salmon stocking has been recent and is based upon there being vacant rearing habitat (either newly created or made accessible), possible broodstock sources, and identification of the appropriate life stage to stock. The Federal Government does not discourage groups wishing to stock, but it is unlikely to grant permission if the salmon population is below conservation requirements. Collection of broodstock may be permitted if trying to prevent extinction or maintain genetic diversity. At-sea mortality currently makes stocking of rivers of questionable value due to the very low returns.

Stocking, apart from conservation and augmenting the recreational fishery may also be important in education and stewardship programs. Creating a self-sustaining hatchery program requires a diversity of activities (e.g., selling fish, renting office space, fundraising, etc.).

Under legal obligations First Nations have a right to salmon stocked in the rivers. These people need to be consulted and “at the table” in discussions of salmon stocking. Further, people should look more holistically at the issues surrounding stocking; how does such activity affect other species and the ecosystem in addition to “favoured” species.

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Appendix 1: Workshop Attendees

Name	Organization
Al McNeil	NS Department of Fisheries and Aquaculture
Aleasha Boudreau	Université Sainte-Anne
Allison	Aquatic Resources – St. FX (Student)
Amy Weston	Adopt-A-Stream
Andrew Breen	Bluenose Coastal Action Foundation
Ashley Giovinazzo	Aquatic Resources – St. FX (Student)
Bev Davison	Mersey Biodiversity Facility
Blair Bernard	Unama'ki Institute of Natural Resources
Bob MacDonald	Mulgrave and Area Lakes Enhancement
Bob Rutherford	Adopt-A-Stream
Carl Purcell	Nova Scotia Salmon Association
Chris Marchand	Antigonish Town and County Anglers Association
Colin O'Neil	Sackville Rivers Association
Corey Fitzgerald	Aquatic Resources – St. FX (Student)
Courtney Watt	Biology -St. FX
Dale Archibald	St. Mary's River Association
Danielle Murray	St. Mary's River Association
Darryl Murrant	NS Department of Fisheries and Aquaculture
Darryl Tingley	Medway River Salmon Association
David Garbary	Aquatic Resources – St. FX
Don MacLean	NS Department of Fisheries and Aquaculture
Dr. John Hamm	
Dylan Fraser	Dalhousie University
Geoff Regan	Government of Canada
George Ferguson	Nova Scotia Salmon Association
Graham Daborn	University of Acadia
Greg Stevens	Department of Fisheries and Oceans
Heather Mayhew	Antigonish Harbour Watershed Association / The Fresh Air Society
Ian Fleming	Memorial University of Newfoundland
Jamie Gibson	Department of Fisheries and Oceans
Jennifer Ross	Aquatic Resources – St. FX (Student)
Joel Camus	Cheticamp River Association
Joel Goodfellow	Aquatic Resources – St. FX (Student)
John Cameron	St. Mary's River Association
John Phyne	Sociology – St. FX
John Whitelaw	Medway River Salmon Association
Karen Seymour	Aquatic Resources – St. FX
Kelly Meagher	Aquatic Resources – St. FX (Student)

Appendix 1: Workshop Attendees (cont'd)

Name	Organization
Ken MacAulay	Antigonish Town and County Anglers Association
Kerry Prosper	Pak'tenkek First Nation
Kris Hunter	Habitat Unlimited
Larry Bell	Sackville Rivers Association
Larry Short	Sackville Rivers Association
Laura Smit	Aquatic Resources – St. FX (Student)
Lauren Allen	Nova Scotia Nature Trust
Leonard Decoste	Richmond Wildlife Association
Leonard Forsyth	
Leonard MacDonald	Mulgrave and Area Lakes Enhancement
Leslie Buckland-Nicks	Antigonish Harbour Watershed Association
Lewis Hinks	Atlantic Salmon Federation
Mark Hambrook	Miramichi Salmon Association
Mark Pulsifer	St. Mary's River Association
Matt MacVicar	Aquatic Resources – St. FX (Student)
Melissa Dorey	Richmond Wildlife Association
Nathalie Nadeau	Aquatic Resources – St. FX (Student)
Nick MacInnis	Aquatic Resources – St. FX
Norma Prosper	The Confederacy of Mainland Mi'kmaq
Patrick O'Reilly	Department of Fisheries and Oceans
Raymond Prosper	Eskasoni Fish & Wildlife Commission
Rene Aucoin	Cheticamp River Association
Robert Baker	Nepisiguit Salmon Association
Robert Chiasson	Charlo Salmonid Enhancement Center
Sam Marshall	Aquatic Resources – St. FX
Sarah Hett	Aquatic Resources – St. FX
Sarah Turkeli	Aquatic Resources – St. FX
Sean Mitchell	St. Mary's River Association
Sean Neary	NS Department of Fisheries and Aquaculture
Seth Rutner	Aquatic Resources – St. FX (Student)
Shane O'Neil	Department of Fisheries and Oceans
Stephen Caines	Sackville Rivers Association
Stephen Cole	Biology -St. FX
Walter Regan	Sackville Rivers Association