WHAT WORKS? A Workshop on Wild Atlantic Salmon Recovery Programs

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ABSTRACTS

The ecology and genetics of salmon recovery: what is success?

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Atlantic salmon populations are becoming increasingly threatened, particularly across the species' southern range. Recovery programs to rebuild these populations have met with varying "success." Success, itself, can come to mean different things in different contexts. Here, I explore recovery in the context of salmon ecology and genetics. Characteristics that make salmon populations resilient to environmental change, whether such change is natural or anthropogenic, can provide a fundamental understanding of what recovery might look like. I look closely at one of the most commonly applied salmon recovery approaches for rebuilding salmon populations that involves artificial culture, i.e. hatcheries and living gene banks. The relationship, both ecological and genetic, between hatchery and wild fish is largely dependent on what occurs during breeding and its subsequent effects on offspring performance. I examine the roles of phenotypic plasticity, non-genetic inheritance and domestication in shaping and dictating the "success" of released hatchery fish and their ecological relationship with wild fish.

Insight from DNA-based parentage assignment analyses on some early indicators of the efficacy of an adult-release stocking program on the Tobique River, New Brunswick

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In 2008, approximately 586 Atlantic Salmon (*Salmo salar*) captured earlier as out-migrating smolt and reared in captivity at the Mactaquac Biodiversity Facility to adulthood, were tissue sampled and released back into natal waters of the Tobique River (above the Tobique Narrows dam) to hopefully spawn and contribute to the next generation of Atlantic salmon. In this same year, approximately 438 sea-run Atlantic salmon, including 348 wild-produced, and 90 hatchery-origin adult males and females, returned to the Tobique Narrows fishway where they were intercepted and tissue sampled before being allowed to continue on their way to waters above the dam. In 2010 and 2011, a large number of out-migrating pre-smolt and smolt collected near the confluence of the Tobique River and Saint John main stem were tissue sampled, as were sea-run adult salmon returning back through the Tobique Narrows fishway in 2012. Scale samples was then then used to estimate age and identify which of the above pre-smolt and smolt collected in 2011 and 2012, and adults collected in 2012, could be considered as candidate offspring of the captive and sea-run adults that spawned in the Tobique River in 2008. A portion (157) of the large number of available sampled candidate offspring, and nearly all of the above adult candidate parents (approximately 1024) have now been genotyped at 12 highly variable microsatellite genetic markers. The 157 candidate offspring were then tested against all of the genotyped candidate adult parents using single parent exclusion analyses. Despite the large number of pairwise comparisons involved (>160,000) and the existence of many non-genotyped candidate parents (unsampled mature male parr), nearly all candidate offspring were assigned unambiguously, and with a high degree of certainty, to single female candidate parents, and many to single male candidate parents. Although only a small portion of the available tissue sampled candidate offspring have been analyzed to date, these results are already providing preliminary information on a) absolute pre-smolt production by the group of released captive adult females, b) pre-smolt production by released captive adult females relative to wild-origin adult females, c) degree of spawning success of released captive and wild returning adult females, d) the mating structure of released captive and wild-origin adult salmon, e) variance in family size, effective number of breeders, and expected rates of loss of genetic variation associated with the captive adult release program, f) the extent of spawning between captive and

wild-origin salmon, and much more. Further insight and increased certainty of many preliminary estimates is expected once the remaining larger group of candidate offspring are analyzed, including many more pre-smolt and smolt collected in 2010 and 2011, adults that returned in 2012, and adults expected to return to the Tobique River in 2013 and 2014.

Maine's experience with captive reared adult Atlantic salmon outplants

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Stocking strategies to restore endangered populations of Atlantic salmon (*Salmo salar*) within the Gulf of Maine DPS have used all hatchery life stages available; eggs, fry, parr, smolt, and gravid adults. Management focusing on fry stocking has not resulted in significant adult returns and natural reproduction. Stocked smolts produce large returns but the long term benefits are unknown. Adult stocking circumvents much of the hatchery influence on mate selection and potentially results in progeny that are more likely to survive and reproduce in the wild. However, stocking adults sacrifices numerical production advantages achieved by traditional hatchery methods. In 2005 an adaptive management project began in selected streams in which river-specific Atlantic salmon adults, reared to maturity from large parr captured in the rivers, were stocked in the autumn. This work has expanded to other streams and includes investigations into movements, redd construction rates, site fidelity, and vital rates. Stocked adults successfully spawned producing juvenile Atlantic salmon. Using acoustic telemetry, we found high fidelity to the release location at spawning. Juvenile assessments documented that 0+ and 1+ parr densities were similar to densities in fry stocked areas. Managers need to consider lifetime fitness in evaluating large scale gravid adult outplanting projects.

Atlantic salmon *(Salmo salar)* eyed ova planting and streamside incubation in the Sandy River

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The Maine Department of Marine Resource (formerly the Atlantic Salmon Commission) in 2003 began experimenting with streamside incubators and egg planting to reintroduce Atlantic salmon into vacant habitat in the Sandy River. The Sandy River watershed is approximately 1,536 km^2 and has more than 25,000 units of Atlantic salmon rearing habitat. The streamside incubators, constructed from discarded refrigerators, were operated from 2003 to 2007 and resulted in 146,000 fry being stocked. While streamside incubators were successful in introducing fry into the drainage, they were difficult to maintain and the number of eggs that could be incubated was not sufficient to achieve recovery of a large watershed. In contrast, a hydraulic planter allowed for large number of eyed eggs to be planted annually, 590,000, 860,000 and 920,000 in 2010, 2011, and 2012. Juvenile assessments conducted using emergent fry traps and Catch Per Unit Effort (CPUE) electrofishing surveys of planting sites documented successful emergence and dispersal from planting sites in the first year of growth. In addition, 30 randomly chosen (Generalized Random-Tessellation Stratified Design) sites sampled by CPUE methodology resulted in 73% and 67% of the sites containing salmon in 2011 and 2012. Based on juvenile size at age 0+, we determined that less than 50,000 eyed eggs should be distributed among sites that were with greater than 1 kilometer apart. The egg planting project has allowed for a large scale re-introduction of salmon to the Sandy River watershed.

Assessing the effectiveness of "on river" hatchery reared 0+ "fall parr" to increase juvenile abundance and adult returns on the East Machias River

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For the past 20 years the Atlantic salmon (*Salmo salar*) stocking program in the Downeast Maine has been focused on "unfed" fry and limited smolt stocking, but success has been limited. Research suggests that unnatural rearing conditions in hatcheries inhibit the ability of stocked fish to transition to the wild, resulting in high mortality. To address the limited success of the stocking program, Downeast Salmon Federation, in collaboration with federal, state, and NGO partners, is implementing a project to assess the effectiveness of rearing 0+ "fall parr" in an on-river hatchery to increase juvenile abundance and adult returns in the East Machias River. The 0+ parr are being reared in an "enhanced" rearing setting. Utilizing unfiltered river water, substrate incubators, dark colored tanks, natural feed, and water velocity manipulation, the DSF is producing a more natural, physically fit, and more cryptic 0+ parr. All parr were stocked in the fall after river temperatures were below 7^{o}C. Stocking densities have been increased to well above historic stocking levels. The project includes rigorous assessment of all life stages. Along with changes in rearing techniques, age at stocking, and stocking densities, there is a collaborative focus on addressing connectivity, adding large woody debris, and low pH mitigation in the East Machias watershed. This project is a new model for salmon recovery in the Downeast region.

Evaluation of migration performance of hatchery restoration products (Age 1 smolts) using acoustic telemetry

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The Dennys River Atlantic salmon stock is at the northern extent of the endangered Gulf of Maine Distinct Population Segment's range. Although the stock once supported a prominent US salmon rod fishery, the population has since collapsed as a result of dams, pollution from an EPA superfund site, overfishing, and poor marine survival. Since 1875 hatchery supplementation has been the primary restoration tool used for the Dennys River salmon. From 1990 to 2000 fry were the primary hatchery product stocked. In 2001, managers decided to begin stocking Dennys origin river-specific 1+ smolts. Based on regional hatchery smolt marine survival it was estimated that stocking 32,000 to 50,000 smolts had a 75% probability of producing 67-117 2SW returns. Approximately 50,000 smolts were stocked annually from 2001 to 2005. To evaluate and describe estuarine and coastal migration performance of these hatchery smolts, we acoustically tagged a subset of smolts (n=70-150) each of the five years. We observed a significant number of reversals in the estuary and bay environments and losses (>50%) that were higher than those documented in many other systems. Reversal behavior, while potentially normal for smolts when transitioning into the marine environment, may suggest underlying issues of smolt quality. With few post-smolts making it to the Gulf of Maine or Bay of Fundy, recovery of this stock will be challenging.

Impacts on fitness due to captive exposure depend on life-stage in captivity for Inner Bay of Fundy Atlantic salmon

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The number of populations assessed at some level of risk of extinction continues to increase. As a result, programs to captive rear and release wild-origin individuals are increasing in number and scope in attempts to lower risks of extinction. Atlantic salmon (*Salmo salar*) populations across much of their North American range characterize this situation well. Despite considerable efforts in the development and implementation of various combinations of captive rearing and re-introduction programs, undesirable effects of domestication are cited amongst the factors most limiting the realization of program objectives. Using a long-standing Parks Canada recovery program, we quantified the effects of two common juvenile release strategies (unfed fry and 5 month feeding parr) on important measures of natural fitness for this animal. We followed individuals from release as juveniles through to eyed-egg stage of the next generation. Results show those released as fry exhibited higher levels of fitness later in life and into the next generation. Our results are useful for managers of conservation programs considering which life stage to captive rear when natural fitness and re-generation of wild populations are program objectives.

Where you are raised does matter: The use of semi-natural rearing ponds as an Atlantic salmon conservation tool

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The study of phenotypic plasticity is important in determining how species react to differential environmental pressures, and ultimately understand the processes leading to local adaptation and specialization. Under these optics, a shift into a new habitat may induce plastic responses in a variety of traits, creating opportunities for habitat-dependent pressures to select individuals that are better adapted to the new environment. Conventional and semi-natural rearing conditions for Atlantic salmon (*Salmo salar*) parr provide an exceptional system to study plastic responses because they offer contrasting habitats (uniform versus complex). These contrasting habitats are expected to promote differential pressures on key phenotypic traits, thus promoting plasticity and local adaptation. In this study, we investigated how fish morphology and fin condition responded to conventional or semi-natural rearing conditions under different stocking densities. We found that variations in morphology can be linked to habitat differences, with fish reared in semi-natural ponds converging to a wild-like shape and fish reared in conventional ponds diverging from this "optimal" form. In addition, we found profound differences in fin condition between semi-natural and conventionally reared fish. These results indicate that rearing fish under semi-natural conditions produces a more morphologically wild-like fish, which is important because it allows individuals to survive under changing environmental conditions.

The Exploits River stocking program: river of dreams

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In the early 1980's a group of local businessmen and the Department of Fisheries and Oceans were asking themselves similar questions: could the largest River in insular Newfoundland that was 90% inaccessible to Atlantic salmon become a major producer? Would adult fish return to newly established habitat? Could this development be completed in conjunction with a significant pulp and paper industry, who were the sole users of the river's resources for almost a century? And the big one... could the Department of Fisheries and Oceans work as equal partners with a local conservation group to even attempt this feat.

With determination and hard work by all involved the answers to these questions would result in the Exploits River joining the ranks of top producers of Atlantic salmon in North America. From construction of a large and innovative fish passages to a major stocking program of over 50 million salmon fry in the middle and upper areas of the watershed, what some called a "Pipe Dream" is now a reality with annual returns approaching 50,000 adults.

The rise and fall of Atlantic salmon restoration on the St. Croix River (ME/NB)

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For reasons common to many rivers, Atlantic salmon runs on the St. Croix River declined in the 1800s and 1900s. Improvements to fish passage and pollution treatment led to significant and innovative international restoration efforts in 1981-2006 but these ultimately failed. This rise and fall will be reviewed, with possible lessons for others.

One step forward, two steps back: obstacles to Atlantic salmon recovery in the Magaguadavic River

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The wild Atlantic salmon (*Salmo salar*) population in the Magaguadavic River decreased from about 1000 returning adults in the 1980s to fewer than 100 by the mid-1990s. A live gene bank program was established in 1998 and several population enhancement strategies have since been employed, including stocking of: unfed fry, first feeding fry, parr, smolt, and adults. These techniques have failed to provide a positive recovery response. Several limiting factors have hindered the recovery effort in this river such as exotic fish species, salmon aquaculture practices, fish passage obstructions, low marine survival, and even the stocking program itself. The main purpose of hatchery programs should be to preserve the genetic diversity of the wild population until the primary limiting factors are identified and addressed.

An overview of historical enhancement and recovery initiatives for southern upland Atlantic salmon

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Abundance of Atlantic salmon (*Salmo salar*) in Canada's Maritimes Region has been in decline for more than two decades. Substantial and ongoing declines in Nova Scotia's Southern Upland region have been observed, recent electrofishing surveys have provided evidence for river specific extirpations, and remaining salmon populations are considered to be at critically low abundance. The Southern Upland population of Atlantic salmon was evaluated as Endangered by the Committee on the Status of Endangered Wildlife in Canada in 2010, and Fisheries and Oceans Canada has begun the formal process to determine if it will be protected under the Federal Species at Risk Act. Population supplementation through artificial breeding and rearing has been used to enhance salmon fisheries for over a century. Increased reliance on supplementation programs for Southern Upland salmon arose due to the impacts of acidification. These programs appeared to be viable throughout the 1980's; however, they were discontinued in the 1990's and mid-2000's, as they could not offset the downturn in marine survival, which included economic considerations, and wild populations were not large enough to ensure genetic risks were low. Other enhancement and recovery measures for Southern Upland salmon have included fish passage and population enhancement to establish populations above natural barriers, efforts to restore populations that had been virtually extirpated, closure of commercial fisheries, increasingly restrictive management measures for recreational fisheries, and supportive rearing programs to augment declining populations. This presentation will provide an overview of enhancement and recovery initiatives undertaken within the Southern Upland and considerations for recovery.

A brief history of Old Stream: how doing nothing can be the best strategy

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Old Stream is a highly productive cold water tributary to the Machias River located in Washington County, Maine. The Machias River is within the Gulf of Maine Distinct Population Segment for endangered populations of Atlantic salmon (*Salmo salar*) listed under the US Endangered Species Act. Among these drainages, Old Stream is a bright point. Annual escapement to Old Stream has been high; around 30 adults annually. Juvenile densities are among the highest in the Downeast SHRU and there is strong evidence suggesting that juvenile production is positively related to natural escapement rather than through hatchery related strategies such as fry stocking. Since 2008 there has been no enhancement from any hatchery product. The implications of this are many but two key points are highlighted: first, that natural rearing is more likely to produce returning adults than artificial enhancements, especially in years that marine survival is low among other strategies. Second, that habitat in Old Stream is functioning well thanks to projects improving access to stream reaches and helping to maintain stream functions.

Successful partnerships in the use of high technology to protect and restore salmon habitat in the Restigouche Watershed

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This presentation will demonstrate how partnerships between stakeholder groups were the basis for the successful completion of various projects by the Restigouche River Watershed Management Council (RRWMC). I will cover the different technologies used by the RRWMC to improve knowledge and the management of Atlantic salmon habitat in harmonization with other activities while providing aquatic habitat protection. The four project to be presented will cover: aerial surveys to search for sources of siltation run-off; habitat characterization and location of thermal refuges through the use of high precision imaging; the use of LIDAR (Light detection and ranging) imagery to reduce the impact of agriculture and other activities on salmon habitat; the equivalent cut area calculation used to integrate protection of watersheds in forestry planning.

Geomorphic approach to salmon habitat restoration

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Restoration and enhancement of salmon habitat is a common goal for many not-for profit and governmental organizations. This work often takes the form of modifying the flow of water and sediment by installing in-stream structures constructed of either rock or wood or a combination of both.

In-stream structures are popular because they are relatively inexpensive when compared to other means of modifying flow such as re-shaping the channel geometry or changing the planform, i.e. the way the channel meanders across the floodplain. As the popularity of these structures grew between the 1970s and 1990s so did the need for regulatory review and approval, resulting in the publication of various standards for their design and installation. These standards provided design methodologies that were necessarily simplified, if they presented any design criteria at all. The template approach was necessary because water and sediment dynamics in natural systems are inherently complex and take a combination of many fields of study and experience to understand and predict. The template approach lead to the inappropriate installation of many structures or their use in a riverine setting that would not support the desired outcome. As a result, the success rate of in-stream structures has been poor and well documented in the last decade, causing many funding and regulatory agencies across North America to be skeptical, and in a few regions a near blanket ban on their use has been implemented. This talk will summarize the history and development of a few of the most common structures and highlight their benefits, their weaknesses, and focus on the physical setting that lends itself best to the intended goal of each structure, ultimately being salmon habitat restoration and enhancement.

A River Runs Through It: How Culverts Disrupt Salmonid Habitat Connectivity in Rivers

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Because culverts are the most economical type of stream crossings, they are found in large numbers in several Atlantic salmon (*Salmo salar*) river systems. Such culverts often form barriers that reduce or interrupt connectivity between habitats critical for the completion of the life-cycle of a fish, thereby significantly impacting productive capacity. This presentation reports the results of various field research projects conducted in Québec on the impact of culverts on brook trout (*Salvelinus fontinalis*) and describe similar work currently being initiated on Atlantic salmon. The salient results of the brook trout studies indicate that 1) a large proportion of culverts are impassable to brook trout, 2) predictive models often underestimate fish passage success, especially for small fish in corrugated culverts 3) fish behavior inside culverts maybe the key to improving fish passage predictions 4) habitat fragmentation affects the genetic structure of trout populations. Similar studies of salmon passage success within culverts will be conducted in order to develop models that help identify problematic crossings and prioritize those to be rehabilitated in order to maximize positive returns.

Evaluating the ecological effects of the Penobscot River Restoration Project

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The Penobscot River Restoration Project (PRRP) is a unique and innovative aquatic restoration project that aims to increase connectivity by removing two mainstem dams and bypassing a third dam on an upstream tributary without a subsequent loss in hydro-electric generating capacity. Given the large investments being made nationally in the field of aquatic restoration, as exemplified by the PRRP, the lack of rigorous monitoring and research to support the assertions of the beneficial effects of dam removal is surprising. Investments from a number of partners including the Nature Conservancy, the Penobscot River Restoration Trust, NOAA's Northeast Salmon Team, and over $1.3M in NOAA Restoration Center support through the American Recovery and Reinvestment Act of 2009 are now supporting rigorous ecosystem monitoring of physical, chemical, and biological parameters. Thus, the PRRP provides an important opportunity for fisheries agencies, academia, and the general public to begin to learn and understand the true ecological effects of large scale dam removals. These investments in monitoring and research will allow the public to make informed decisions regarding the costs and benefits of large scale restoration projects well into the future.

Using the Dam Impact Analysis Model to assess the recovery potential of Atlantic salmon

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Dams are a major contributor to the historic decline and current low abundance of diadromous species, including endangered Gulf of Maine Atlantic salmon. We developed a population viability analysis to quantitatively evaluate the impact of fifteen federally licensed hydroelectric dams on Atlantic salmon (*Salmo salar*) population dynamics in the Penobscot River, Maine. We used a life stage-specific model to compare a salmon population under the current state of downstream dam passage success to scenarios with increased dam passage success and increased marine and freshwater survival rates. Performance metrics for the scenarios included adult abundance, distribution of adults throughout the watershed, and number and proportion of smolts killed by dam-induced mortality. Dams located on the mainstem of the Penobscot River had a greater impact on the Atlantic salmon population than dams located on tributaries, but all mainstem dams and all tributary dams did not affect the population equally. The combination of spatial location and passage success is important to the impact of each dam. This model will provide support for regulatory processes, will help prioritize future passage improvement efforts to maximize the benefits to the Penobscot River Atlantic salmon population, and is adaptable for use with other diadromous species and river systems.

Marine-derived nutrients in natural and model systems in eastern North America: How nutrient subsidies benefit resident and anadromous fishes

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Returns of anadromous fish have declined dramatically in the past century throughout eastern North America, reducing the delivery of marine-derived nutrients (MDN) to rivers. The role of MDN transport in coastal rivers in the region is a function of net nutrients transferred by all anadromous fish and collectively may result in MDN subsidies equivalent to those delivered by salmon on the Pacific coast. Temporal variation in MDN occurs because of variation in species composition, abundance, spawning strategy, and life history of anadromous fishes. The current scarcity of these fishes may have profound effects on aquatic production, particularly in nutrient-poor systems. Artificial nutrient addition to river systems is an environmental management strategy to subsidize for nutrient shortages in streams resulting from population declines. With multiple species spawning in the same rivers in a given year, it is important to understand how different timing and spawning strategies of anadromous fish affect nutrient and productivity dynamics for proper implementation of nutrient additions. Drawing from results from parallel MDN studies carried out in the maritime provinces of Canada and Maine, we will compare and contrast effects of natural and simulated anadromous fish runs on stream productivity. We will address how effective nutrient additions are in simulating natural conditions and the ways that nutrient additions may be most effective in anadromous fisheries management.

Movement and distribution of juvenile Atlantic salmon (*Salmo salar*) during periods of thermal stress in two Eastern Canadian rivers

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Juvenile Atlantic salmon (*Salmo salar*) demonstrate a physiological stress response when water temperatures exceed 23ºC. Once temperatures approach the upper lethal limit (~28ºC), juvenile salmon manage their metabolism via behavioural thermoregulation. Territorial behaviour is abandoned in favour of an aggregated response in areas of cooler water (thermal refugia). The objectives of this study were to examine how the incidence of temperature stress affects the movement and distribution of juvenile salmon in two eastern Canadian rivers, the Little Southwest Miramichi (LSWM; NB), and the Ouelle (OU; QC). Passive Integrated Transponder (PIT) tags were utilized over two summers (2009/2010 LSWM; 2011/2012 OU) to monitor the temperature-related movements of 635 and 332- 1+ and 2+ parr, respectively. In 2009 (LSWM) and 2011 (OU), no juvenile salmon aggregations were observed despite maximum temperatures exceeding 24ºC for 7-consecutive days (max 26.1ºC; LSWM) and 8-consecutive days (max 28.2ºC; OU), respectively. In 2010, 33.6% of tagged parr were observed aggregating, when hourly temperatures remained >23ºC for 4-consecutive days (max 31.0ºC). Some parr traveled >10km to locate refugia during this period. Concurrent wide scale mortality was observed in all age-classes. In 2012, juvenile abundance in areas proximal to thermal refugia was 43.5% greater than in areas lacking refugia. Preliminary analysis suggests that cumulative high-temperature exposure may stimulate aggregations. With future climate change scenarios predicting these temperature thresholds will be surpassed more frequently, it is important that the behavioural and physiological responses of parr be considered to ensure species conservation and sound management.

Buffering acid and providing hope: Early results of the West River (Sheet Harbour, NS) acid mitigation project.

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The issue of acid rain has led to the extirpation of many Atlantic salmon (*Salmo salar*) populations within Nova Scotia's Southern Upland region. To address the issue of river acidification, the Nova Scotia Salmon Association, the Atlantic Salmon Federation, and partners initiated an acid mitigation program in 2005 on the West River, Sheet Harbour. A fully-automated lime doser now buffers the river's water by releasing precise dosages of powdered dolomite lime.

An ongoing monitoring program has documented the efficacy of lime dosing and its impacts on the river's water quality and aquatic ecosystem. Following installation of the lime doser, the river's pH increased above the target of 5.5 along the entire 30 km treated reach, and in some locations, liming raised the average pH by 2.5 units. In response to this increased pH, aquatic invertebrate biomass has increased, there has been a shift in dominant invertebrate taxa, and acid-sensitive invertebrate species are now more common. Similarly, there is some evidence that the salmon population has responded to liming. For example, electrofishing-based estimates of juvenile densities generally increased in treated sections. Further, annual estimates of smolt production suggest that juvenile abundance has increased in treated areas which contrasts control (not limed) sections of the watershed. Further, given the declining smolt production trends in nearby salmon index rivers, liming in the West River appears to have increased the quality of freshwater rearing habitat and subsequently increased egg-to-smolt survival.

Although these results are preliminary, should our observations reflect the actual ecosystem response, liming in Eastern Canada appears to be a viable and effective restoration strategy for acidified salmon rivers.

POSTER PRESENTATIONS

Contribution of different live gene banking strategies to the production of smolt and returning adult Atlantic Salmon on the Big Salmon River

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Abstract: Evaluation of two different Live Gene Bank (LGB) release strategies has been possible because of ongoing collaborative monitoring projects in conjunction with genetic analysis or parentage assignment. The in-river LGB, i.e. progeny released as unfed fry and fall parr, has essentially increased the number of smolts emigrating from the Big Salmon River from 2004 to 2011 by three-fold. Progeny released as fall parr have an average in-river survival to the smolt stage that is four times greater (7.1 vs 1.7%) than progeny released as unfed fry although the return rate to 1SW salmon for smolts produced from the unfed fry is double that of the fall parr releases. In the past decade, progeny from the LGB have contributed to about 20% of the returning adults on the Big Salmon River.

Poor marine survival of summer fed hatchery fry compared to wild fish

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Monitoring of seaward migrating salmon smolt is conducted by DFO using rotary fish wheels annually near Durham Bridge on the lower Nashwaak River near Fredericton, NB. Approximately 10% of the fish captured during the springs of 2008 and 2009 had been Adipose Fin Clipped (ADC) indicating that they had been tank reared during their first fresh water summer. DFO operates a fish counting fence in the same location each summer to estimate the population of returning adult salmon. Grilse (1 Sea Winter fish) that originated from ADC smolt, migrating seaward in 2008, made up 5.53% of the total grilse returns in the 2009 season, while grilse originating from seaward migrating ADC smolt in 2009 made up 2.34% of total grilse returns in 2010.Although we had already ascertained that summer rearing hatchery fry in tanks decreased their survival and growth in fresh water compared to fish stocked in June, it is now evident that summer feeding hatchery fry to increase their size and supposedly enhance their success in the wild also compromises their survival in the sea.

Extended tank rearing of salmon fry decreases success in fresh water

Peter Salonius

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Half of 12,000 six week feeding hatchery fry were distributed, unmarked in June, 2006 above an impassable falls near Fredericton, New Brunswick. The other 6,000 were reared (summer fed) in cold spring water fed tanks until September, 2006 when they were similarly distributed (adipose fin clipped / ADC) into the same sites. The ADC summer fed, cold water reared fry were somewhat larger than their counterparts than their more wild counterparts when they were distributed in September, 2006; however, electrofishing of pre smolt in late summer 2007showed that the unmarked fish were much more numerous and considerably larger than their summer fed ADC counterparts. The trial comparison (this time rearing ADC fish in tanks fed by much warmer stream water) was repeated in 2008. When the ADC summer fed, warmer water reared fry were stocked into the stream in September, 2008, they were much longer and more than twice as heavy as their counterparts that had spent the summer in the wild, however electrofishing of pre smolt in late summer 2009 showed unmarked June distributed fish to be much more numerous and somewhat heavier than their summer fed ADC counterparts.

Rationale for Treating the Entire Southern Maritimes as a Single Bay Management Area

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Single bay management areas for sea cage aquaculture were established to decrease the cross transmission of salmon diseases and parasites between sites whose stocking, grow out, harvest and fallow periods were staggered in time. Research in Norway has shown that both eggs and the planktonic stages of salmon lice (*Lepeophtheirus salmonis*) remain infective for long periods of times in cold sea water and can be transported long distances on ocean currents. Damage to seaward migrating smolt by cold-water-transported aquaculture origin sea lice probably played a major role in the drastic decline of Outer Bay of Fundy and collapse of Inner Bay of Fundy salmon stocks in the 1990s, before the parasiticide *Emamectin benzoate* (SLICE) offered effective control of sea lice on farms. The correspondence between increasing loss of sea lice control from 2010 onward and the drastic reduction of adult salmon returns in the southern Maritimes and Maine suggests that sea lice are again major agents in wild salmon population dynamics. Establishing the entirety of the southern Maritimes as a single bay management area would allow wild smolt to migrate through farm-origin-sea-lice-free sea water during some years.

Fisheries and aquatic habitat management at 5th Canadian Division Support Base Gagetown

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5 CDSB Gagetown (formally known as CFB Gagetown) is home to several military units as well as the Army's Combat Training Centre and the Canadian Forces School for Military Engineering. Training activities include mounted and dismounted manoeuvres, small arms, artillery, demolition, bombing, urban operations and helicopter support.
Approximately 110 000 ha in size, the base contains over 3200 km of watercourses, 156 ponds or lakes and 6487 ha of wetlands. These water-bodies support Atlantic salmon, a locally important brook trout fishery among other fish species. Environmental stewardship, compliance, and sustainable ranges and training areas are key goals of the Army's Strategic Environmental Direction. Strategies to meet these goals with respect to the conservation of fisheries and aquatic habitats include: environmental planning, protection and compliance; resource mapping; environmental monitoring; information and education; stream and wetland enhancement; and water crossing improvements.

Evaluation of a recovery strategy for Atlantic salmon: The effects of stocking hatchery raised juveniles on top of wild populations

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Faced with diminishing adult Atlantic salmon (*Salmo salar*) returns and mysteries surrounding at-sea survival of out-migrating smolts, it is important to maximize in-stream production of the species. Stocking of juvenile Atlantic salmon is a commonly used recovery and enhancement strategy; however, its effectiveness in increasing juvenile salmon densities and production has never been fully investigated. The purpose of this project is to determine if stocking has increased the overall production of juvenile salmon in the Miramichi River watershed. In order to accomplish this goal, historical electrofishing data has been obtained, allowing for the creation of a geographical model of salmon parr densities through time. This model will allow us to determine which landscape level variables (i.e. slope, upstream catchment area, distance to ocean etc.) best predict salmon parr densities across the watershed. The data will be examined in relation to stocking records (locations and rates) to determine how effective stocking has been in improving salmon production on the Miramichi River over the past 30+ years. The results of this ongoing investigation will lead to an improved understanding of stocking dynamics in the Miramichi watershed and may lead to the development of best management practices in relation to Atlantic salmon stocking programs.