Social–ecological management results in sustained recovery of an imperiled salmon population

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When faced with the loss of a population, resource managers often feel compelled to choose restoration strategies perceived to have low risk, such as the management of the ecological components of the system or the application of regulatory measures. It can be counterintuitive to share decision-making and resource management with those who want to harvest an imperiled population, yet this social–ecological strategy resulted in the recovery of a wild Atlantic salmon population in Newfoundland, Canada. Atlantic salmon supported widespread commercial, subsistence, and recreational fisheries but declines in abundance necessitated closures and other conservation strategies across many areas of Atlantic Canada in the 1990s. Recreational angling for Atlantic salmon was closed in Terra Nova National Park’s Northwest River in 1995 when counts were below expectations based on available habitat. The population continued to decline, even though commercial and recreational fishing mortality had been eliminated, and by 2001, extirpation seemed imminent. Despite pressure to pursue conventional strategies such as catch and release fishing and stocking, public consultation and human dimensions research revealed that illegal fishing was likely contributing to declines and that distrust of resource managers created an environment conducive to poaching. Disrupting this dynamic could not be achieved with conventional strategies, so instead an adaptive management approach was implemented that incorporated local collaboration and improved transparency, and was responsive to positive changes in behavior. Adoption of social–ecological management led to a rapid and sustained recovery of the salmon population in Northwest River, out-performing populations in adjacent rivers managed with conventional management strategies.

Key words: adaptive management, Atlantic salmon, co-management, community engagement, fisheries management, human dimensions

Implications for Practice

- Supporting community values, even when those values appear on the surface to conflict with conservation objectives (e.g. harvest of an imperiled population), can have better restoration outcomes than conventional regulatory or ecosystem-focused strategies.
- Rewarding positive behavior change and addressing mistrust through collaboration and transparency is critical to disrupting destructive behaviors.
- Ecological restoration outcomes will improve when we recognize that all imperiled ecosystems are social–ecological systems.
- Monitoring remains critical to implementing adaptive social–ecological management and limiting risk of negative outcomes.

Introduction

The United Nations have declared 2021–2030 the Decade on Ecosystem Restoration with promises to provide benefits to both humans and nature (https://www.decadeonrestoration.org/). To date, however, many restoration projects have failed to achieve these dual outcomes (Benayas et al. 2009; Gann et al. 2019). Are ecological restoration projects failing because too often social and ecological values conflict (Fernandes 2006)? Although engaging local communities in restoration is widely assumed to be beneficial, ecological evidence that community engagement improves ecosystem recovery has been elusive...
Atlantic salmon (Salmo salar L.) is an important species for commercial, recreational, and subsistence purposes (MacCrimmon & Gots 1979). Indigenous to eastern North America and western Europe, Atlantic salmon have declined in abundance across the North Atlantic (Chaput 2012; Lennert et al. 2019). The total reported nominal catch declined from 10,000 tons in 1970 to 1,000 tons in recent years (Nicola et al. 2018; ICES 2019). In Newfoundland and Labrador (NL), Canada, declines in Atlantic salmon occurred despite mitigation measures in recreational fisheries and a commercial fishing closure since the 1990s (Dempson et al. 2004). Although the commercial fishery closure helped some stocks to increase, most populations continued to decline (Dempson et al. 2004). In 2017, anadromous adults declined in 15 of 19 rivers in NL, with declines of >30% in 12 rivers compared to the previous generation mean (previous 5–6 years for NL; DFO 2018).

Conventional strategies to restore Atlantic salmon include limiting commercial fisheries, stocking to supplement early life stages, and catch and release practices to reduce mortality of adult salmon during recreational fishing (Arlinghaus et al. 2007). Scientists and some conservation groups resist stocking because of negative effects to natural populations (e.g., loss of fitness related to genetic issues; Perrier et al. 2013; O’Sullivan et al. 2020; Hagen et al. 2020). In NL, the retention of Atlantic salmon has been drastically reduced through management measures and as a result catch and release fishing has increased in many parts of the island (ICES 2019). This shift has met resistance in some rural areas of the province where communities oppose catch and release fishing because they value retaining and consuming their catch.

Northwest River in rural NL had a long tradition of retention fishing prior to 1995, when the lower portion of the Northwest River was ceded to Terra Nova National Park (Fig. 1). The park installed a counting fence and discovered that counts of mature adults (798) were well below the 1,726 adult salmon conservation target calculated by Fisheries and Oceans Canada given the available habitat (Cote et al. 2001). To protect the population, the resource’s managers (Fisheries and Oceans Canada and Parks Canada) closed the river to all recreational fishing because it was the only obvious source of human-induced mortality given that the watershed was otherwise relatively undisturbed. The closure of the fishery was contentious because many residents of local communities believed that the salmon population was healthy and that Parks Canada had an overly protectionist mandate. Others suspected that the counting fence itself, which obstructed fish passage until individuals were counted, was causing the decline (see Moores & Ash 1984 for a historic overview of the DFO counting fence program).

The closures were not effective. Despite increased enforcement, the population declined to 152 fish in 2001 (Fig. 2). Illegal fishing with Gill nets was suspected to be the cause of the decline (Cote et al. 2001), which was supported by the high frequency of net-scarred salmon moving through the counting fence (15% and 23% in 2000 and 2001; Cote 2005). However, policing the large areas used by migrating salmon was not feasible. Moreover, law enforcement felt that increased surveillance would be ineffective because some residents alerted poachers of their patrols. With conventional methods unable (i.e. closures and enforcement) or ill-suited (i.e. stocking) to stop the decline (Cote et al. 2001), managers needed alternate approaches to prevent imminent extirpation.

Given that harvested wildlife populations are social–ecological systems (Hunter et al. 2013; Nguyen et al. 2016), to effectively manage the resource, the resource managers sought an understanding of the local communities’ behaviors, beliefs, and motivations. This case study describes a restoration project co-developed by communities and resource managers that uses near real-time incentive-based management to create a more favorable environment for salmon recovery. We report on the status of that imperiled population 20 years later.

**Methods**

This social–ecological approach to resource management was comprised of three elements: (1) understanding perceptions and values of local communities; (2) collaborating with local residents to develop a restoration plan that addressed threats and misperceptions, and incorporated local values; and (3) monitoring, evaluating, and adapting the plan.

**Understanding Perceptions and Values of Local Communities**

Public consultations were initiated in 2001. Experience with poor government consultation erodes trust (Gerwing & Cox 2017) and discourages participation (Davenport et al. 2007). We found that mistrust of government was evident among the local communities of Terra Nova National Park (see below for details). Even though recreational fishing was a sanctioned activity in national parks, residents of local communities accused park staff of intentionally misreporting salmon abundance in order to support protectionist values rather than open Northwest River to fishing. To illustrate that resource managers were willing to listen to the communities’ concerns, a working group open to the public was formed to advise resource managers on potential restoration strategies. To gain an understanding of the cultural, social, and economic values of the local communities, residents also participated in workshops which were facilitated by a human dimensions expert using an approach that has been effective in other controversial wildlife situations around the world (Bath 2009; refer to Supplement S1 for more details on this methodology).

Participants were asked to describe their vision for the river as well as their beliefs around the credibility of different
organizations involved in fisheries management. Perceived threats to salmon were documented and systematically evaluated for their potential scale of effect and the likelihood that they were contributing to population declines. Salmon predators (e.g. birds, seals, etc.), anthropogenic development (e.g. the golf course within the park), and negative effects of monitoring (e.g. counting fences) were considered along with illegal netting. Compared to other seemingly healthy nearby rivers, development, predators, and monitoring were not unique to Northwest River (Cote et al. 2001) and did not explain its poor performance (Cote 2005). Illegal fishing was a more likely threat based on the frequency of observations of net-scarred salmon seen at the counting fence, the vulnerability of salmon migrating in proximity to the communities of Clode Sound, and the resentment many locals felt toward resource managers for “taking away their river.”

In addition to the general views of community members described above, three key focus group results emerged that were important to developing an effective management plan: (1) lack of trust between local communities and resource managers was a major impediment to evidenced-based management; (2) the ability to harvest fish was critical to the communities’...
jurisdictions of NL, fishing quotas and management strategies were based on previous years’ counts. A similar time lag was not desirable for Northwest River since it could decouple the perceived effects of illegal fishing from recreational opportunities. Ideally, access would be permitted only when returns were on track to surpass conservation targets. To do so required projecting year-end totals in real time.

Monitoring Salmon to Evaluate and Adapt the Plan

With input from the working group, ecologically based management targets were developed (interim target of 500 fish and long-term target of 700 fish) and a run-projection model was developed (see Cote 2005). The projection model used the real-time cumulative number of salmon through the counting fence for a given day and estimated the range of possible year-end run totals using the run timing from previous years. A conservative (~20th percentile) year-end estimate was used to decide whether the fishery would open on a day-to-day basis.

This approach risked harvesting a threatened population before conservation targets were realized. However, these risks were mitigated by using conservative projection percentiles and relatively small harvest quotas, as well as maintaining the capacity to quickly shut down the fishery should real-time projections drop below conservation targets. Reporting of catch was mandatory and incentivized through giveaways (e.g., hats, photos of fishers with their catch) and because a second retention tag was not issued until the first retained fish was presented.

The effectiveness of this social–ecological approach (2002–2019) was compared to pre-restoration conditions (1995–2001). Percent change relative to 1995, when the time series started, was calculated by dividing salmon abundance for a given year by the salmon abundance for 1995 and multiplying by 100. To test for an effect of the pre- and post-management plan on salmon abundance in Northwest River, we used a general linear model with a Poisson distribution and management plan on salmon abundance in Northwest River, we used a general linear model with a Poisson distribution and management plan period (pre vs. post) as a fixed effect. We also compared the performance (% change in salmon abundance relative to 1995) of Northwest River to that of other nearby monitored salmon rivers in central Newfoundland (Exploits River, Campbellton River, Salmon Brook, Terra Nova River, and Middle Brook; Fig. 1) using two approaches. First, we applied a linear model to post-management plan improvement with river as a fixed effect. Tukey’s post hoc comparisons (emmeans package) were used to evaluate comparisons between Northwest River and each control river. Second, we evaluated the improvement of post-management plan abundance from the pre-management plan period. This analysis was done with a one-sample t test. All analyses were assessed for significance at p < 0.05 and conducted using R (R Core Team 2020).

Results

Salmon abundance increased significantly following the implementation of the restoration plan for Northwest River (GLM, Zp9.18 = 35.5, p < 0.001; Fig. 2). A 10-fold increase was achieved within 3 years and returns reached 2,551 fish in
2019. We believe these improvements were affected by our social–ecological management approach in part because the frequency of net marks on salmon passing through the counting fence (an index of illegal netting intensity) declined sharply from an average of 19 to 5% once the restoration plan was implemented. Moreover, Northwest River performed better than 4 of 5 nearby monitored rivers relative to the first year of monitoring (the exception being Exploits River, $t_{12} = 1.2, p = 0.85$; Fig. 3) and did significantly better than all rivers when considering improvement from pre-management plan years ($t = -12.2, p < 0.001$; Fig. 3).

In addition to the improvements to the salmon run, the relationships among the resource managers and the local communities also improved. Previously disengaged residents visited the monitoring facility regularly to check on whether returns were sufficient for the fishery to open. The increased transparency associated with sharing data stopped disputes over the validity of monitoring data. The communities observed “their fish” population increasing in abundance because of their conservation efforts. The fishery opened in the second year of the program (2003) with a small retention fishery of 50 fish. Fisheries opened in each subsequent year and the plan was adapted to increase quotas up to 100 fish if more ambitious conservation targets were met.

The social–ecological management of the fishery on Northwest River has created other differences from fisheries on adjacent rivers. The fishery is often truncated (mean: 16 days, range: 2–49 days) relative to adjacent rivers due to the delay associated with assessing the strength of the run and sometimes closing early once harvest limits are reached. The popularity of the fishery can also create crowded conditions, particularly in the first days of the fishery every year. However, the experience remains unique in that there is more access to the best pools since fishers must stop fishing after they catch a fish, which is in contrast to other provincial rivers where catch and release fishers can continue to fish for the duration of the day. Opening day also provides the rare opportunity where fishers can access a river in mid-run that is full of naïve fish, providing ideal fishing conditions. Furthermore, the strength of the returns in Northwest River have permitted fishing under this special management even while other rivers across Newfoundland and Labrador were closed to retention fishing due to concerns of low returns (DFO 2018; Van Leeuwen et al. 2020).

Discussion

This project represents a rare example of sustained ecological recovery achieved through community engagement (Sterling et al. 2017). A novel aspect of this project was the integration of our understanding of local community values, collaboration of community leaders in management plan development, and an adaptive management approach that was responsive to positive changes in behavior. Adaptive capacity (Berkes 2009) among resource managers and local residents was generated through iterative learning, knowledge generation, and effective conflict resolution (Butler et al. 2015). Adaptive capacity continues at multiple levels through dialog and interaction, and by sharing decision-making and responsibility for the recovery of the salmon population. Working group members serve as credible advocates for the restoration of Northwest River salmon within their communities. Through the working group, resource managers also became aware of community issues and were able to respond more quickly, either directly or through public education. The hiring of students from the local communities integrated community members in monitoring activities, which addressed mistrust of data used to guide management. This employment opportunity also provided economic benefit for the local communities.

Despite the success, the approach had detractors, primarily from advocates for catch and release fishing who asserted that “catch and kill” fishing could not be a credible strategy for stewardship of an imperiled population. However, the evidence supports a working group that has managed a sustainable fishery for almost two decades. For example, once fisheries on this river became commonplace, the working group resisted external requests to expand harvest quotas too quickly for fear of losing the population gains. Certainly consumptive resource users (e.g. Indigenous peoples) have been shown to be effective stewards of resources elsewhere (Armitage et al. 2009; Campbell & Butler 2010).

Broader adoption of this approach has been limited due to the perceived cost and challenge of river-specific social–ecological management across large jurisdictions. Accurate data on adult salmon returns provide crucial information for the program; however, most salmon populations in the province’s rivers are not currently monitored with counting fences. Intensive monitoring, as well as building and maintaining relationships, takes time and financial support (operation budgets for this project were ~$30–35 thousand CAD per annum). Even in Northwest River, monitoring was interrupted from 2012 to 2016 due to resource managers being required to reallocate funds to other priorities, despite broad support by local communities to
continue. However, incorporating a social–ecological approach added minimal cost to the monitoring program that was previously only documenting the decline of the salmon population. Thus we consider this approach cost-effective considering the positive recovery of the salmon population and the improved working relationship between local communities and resource managers. Recognizing the benefits of a social–ecological approach, Terra Nova National Park has more recently applied social–ecological management to restore forest health through moose harvests.

Even though most resource managers appreciate the value of engaging local communities in restoration, it may be tempting to resist social–ecological management approaches when values and beliefs appear to be in conflict (Madden & McQuinn 2014). To avoid risk to the resource, resource managers may choose to exert regulatory measures or manage the ecological components of the system rather than share decision-making and management with others. In this case, the social–ecological process identified perceptions of stressors, sources of mistrust, and values that needed to be addressed by the management approach. This information was jointly used by community members and managers to build a management plan over which local communities took ownership and maximized the initiative’s chances of success. Population recoveries of this magnitude are rare, particularly considering that restoration action did not alter any ecological processes (i.e. habitat enhancement, stocking, etc.). Instead, the human environment in which the ecosystem operated changed to the benefit of the salmon population, and to the benefit of the humans that interacted with it.

Dealing with human interactions with ecosystems can be complex. Our project’s success undoubtedly benefitted from the fact that there was broad consensus on community values, the issues addressed were occurring at local scales, and the management approach did not negatively affect many competing interests. As resource management issues become more complex, consensus and collaboration will become more difficult. Nevertheless, positive outcomes will be more likely achieved when a management approach is structured around shared ecological understanding of the system in need of restoration (Fischer et al. 2021).

Acknowledgments

The success of this project was heavily reliant on Larry Spracklin, Ray Chatman (co-leads), and other members of the Northwest River Atlantic Salmon Conservation Working Group who invested their volunteer time and social capital in working with authorities to restore an important community resource. Rex Porter, Chuck Bourgeois, and Leon Slaney (DFO) played a critical role in establishing the Working Group and also contributed to the development of the management plan. We also acknowledge the importance of DFO and Parks Canada managers (Peter Deering, Bill Brake, Jim Baird, and Wayne Follett) who took on reputational risk to sanction this unconventional approach. Gratitude is extended to the dozens of Parks Canada and DFO staff, students, and local residents who collected monitoring data on Northwest River, community residents who provided important feedback in public meetings and workshops, and the Town of Port Blandford for hiring and administering counting fence staff. Law enforcement staff of Terra Nova National Park and the Clarenville detachment of DFO’s fisheries officers also provided important support to the restoration program. We are also grateful to Mervin Langdon (Parks Canada) for collating records of net scars and for the maps provided by Christina Pretty. Four anonymous reviewers also provided insightful comments on an earlier draft of the manuscript.

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Supporting Information

The following information may be found in the online version of this article:

Supplement S1. Human Dimensions in Salmon Fisheries Management: an Approach to Listening and Learning From Local Residents

Figure S1. Total returns of Atlantic salmon through counting fences installed at Northwest River (A), Terra Nova River (B), Middle Brook (C), Salmon Brook (D), Exploits River (E) and Campbellton River (F).