Restoring connectivity in coastal wetland habitats via channel creation in a large regulated river

Restauration de la connectivité dans les habitats des zones humides côtières par la création de chenaux dans un grand fleuve régulé

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RÉSUMÉ

La perte récente d'habitats et de connectivité dans le système du Saint-Laurent est attribuable à la régulation des eaux, ainsi qu'à la prolifération et à la dominance de la massette glauque invasive (*T. X glauca*). Le manque d'accès et la modification des milieux humides ont influencé l'habitat de frai pour les poissons potamodromes, tels que le grand brochet (*Esox lucius*), un superprédateur du littoral. Nous examinons l'opportunité de l'utilisation d'une excavatrice amphibie (EA) pour reconnecter les habitats par la création de chenaux pour relier les chenaux principaux aux zones connexes, les prairies humides, et ainsi améliorer l'habitat de frai des poissons. Les réponses au niveau des poissons et des milieux de frai rivulaires, et notamment des critères tels que la végétation des zones humides, la réponse de la banque de graines, les macroinvertébrés prédateurs, la température (°C), l'oxygène dissous (mg / L) et l'accès des poissons par rapport aux niveaux d'eau (m) ont été comparées entre les sites ayant bénéficié d'améliorations de connectivité et les sites de référence naturels. Les sédiments des plaines inondables exposés par les travaux ont montré une réponse positive des plantes indigènes bénéfiques, indiquant la viabilité de la banque de graines. L'utilisation par 13 espèces de poissons a été documentée dans les chenaux nouvellement créés et on a démontré une production plus réussie du grand brochet pendant les périodes du printemps caractérisés par des niveaux d'eau plus élevés. Si nous concluons que les améliorations de connectivité ont été une réussite initiale pour les poissons et leurs habitats critiques, les projets sont limités par l'effet de la régulation du niveau d'eau sur le système dans son ensemble. Des études supplémentaires seront nécessaires pour aborder la succession de la végétation sur le long terme et les réponses au niveau des populations de poissons.

ABSTRACT

Recent habitat and connectivity loss in the St. Lawrence River system is primarily attributed to water level regulation and the spread and dominance of invasive hybrid cattail (*T. X glauca*). Lack of access and wetland changes have influenced spawning habitat for potadromous fishes such as northern pike (*Esox lucius*), a top littoral predator in the system. We examine if an amphibious excavator (AE) can be used to reconnect habitats via channel creation by linking main channels with their remnant meadow marsh areas to enhance fish spawning habitat. The response of fish and riparian spawning habitat including wetland vegetation and seed bank response, predatory macroinvertebrates, temperature (ºC), dissolved oxygen (mg/L) and fish access given water levels (mASL) were compared among sites with connectivity enhancements to natural reference sites. Exposed floodplain sediments following excavation showed a positive response of beneficial native plants indicating seed bank viability. Use by 13 fish species was documented in created channels and northern pike production was demonstrated with greatest success during periods of higher spring water levels. We conclude that connectivity enhancements show a positive initial success for fish and their critical habitat but projects are constrained by the system-wide effect of water level regulation. Continued investigation is needed to address longer-term vegetation succession and fish population-level responses.

KEYWORDS

Channel excavation, coastal wetland, habitat restoration, invasive cattail, northern pike.

1 INTRODUCTION

The St. Lawrence River is the sole natural outlet to the Laurentian Great Lakes that contain nearly 1/5th of global fresh surface water and is a major drainage of the North American continent. Lake Ontario and the upper St. Lawrence represent a distinct hydrologic unit where flows and levels are under management authority of the bi-national US and Canadian International Joint Commission (IJC) formed by treaty in 1909. Water regulation occurs under US Army Corps of Engineers Plan 1958D at the Robert Moses Saunders Power Dam ~160 river km downstream. The international section of the St. Lawrence contains a heterogeneous mix of freshwater habitats and extensive coastal wetlands that have been regulated for over 50 years. The IJC is investigating new approaches to hydrologic regulation that incorporate environmental function in addition to traditional considerations of shipping, hydropower, riparian and public interests, municipalities and coastal processes.

Loss of connectivity among habitats within freshwater coastal wetlands is often associated with nutrient enrichment, sedimentation, accelerated accretion, invasive plant dominance and interruption of natural flow regimes. Recent studies have documented significant changes within coastal wetlands that include expansion of invasive robust emergent *Typha* x *glauca* (cattail), a hybrid of a native *T. latifolia* and the European invasive *T. angustifolia,* that have encroached on native wet meadow habitats important for fish spawning (Rippke et al. 2010, Farrell et al. 2010). These plant types along with the effects of suppression of natural water levels have led to a reduction of habitat connectivity within wetlands and are hypothesized to have altered patterns of fish spawning, especially for northern pike that has affected their reproductive success and population levels (Farrell et al. 2006)

1.1 Channel excavation as a restoration tool

Restoration of connectivity within coastal wetlands is focused on where invasive cattail has filled spawning channels for northern pike and has been proposed as a technique to help remediate wetlands and benefit fish populations. An aquatic excavator creates/restores open channels to reconnect sedge meadows to the main channel and re-open fish access to spawning habitat. The excavator also creates a floodplain bench covered with a thick layer of underlying peat substrate and may affect riparian vegetated habitat. Restoration goals for the project are to enhance spawning habitat and facilitate its access by northern pike and other native species. Research is needed to evaluate efficacy of the technique through a comparison of excavated sites to natural reference sites.

2 METHODS

2.1 Study Design

Sampling sites	Channel length (linear meters)	Age of channel (years)	Fish community	Macroinvertebrate community	Vegetation community	Temperature (°C)	Dissolved oxygen (mg/L)
Excavation S1	181	3	x	x	x	x	x
Excavation N1	165	3	x	x	x	x	x
Excavation N2	122	2	x	x	x	x	x
Excavation I	273	2	x	x		x	x
Excavation L	449	1	x	x		x	x
Reference 1	154	n/a	x	x	x	x	x
Reference 2	111	n/a	x	x	x	x	x

Table 1. There were 7 sampling locations in 2011, including 5 excavation sites and 2 reference sites. Response variables collected at each location are denoted by an x.

2.2 Fish and macroinvertebrate response

To evaluate the fish response, we deployed emigration traps designed to capture fish as they move downstream to the main channels. Traps were set at excavation and reference channels following the northern pike spawning period (June 1), checked daily, and collected later in the summer (July 15). All fish were identified to species. Total lengths of northern pike were measured (mm). Macroinvertebrates present in traps were counted and identified to genus-level.

2.3 Habitat response and access

Differences among treatment and reference sites were tested (ANOVA) for (surface, mid-water column and bottom) mean daily water temperature (°C) and dissolved oxygen (mg/L) levels. Water temperatures were also compared among Onset loggers set to take measurements every 2 hours April through October. Water level data was obtained from the NOAA ABAN6 gauging station on the St. Lawrence and compared to periodic staff gauge readings taken from French Creek.

To monitor the riparian vegetation following excavation, permanent sampling plots were established at both excavation and reference sites. Transects were set perpendicular to the channels at consistent increments based upon original channel length. Five vegetation plots ($1m^2$) were located long each transect, with the first being located centrally in the middle of the channel, one each at the periphery of the channel bank, and two more positioned 'inland' (5ft from the bank). Total number of transects established for all sites was 23 (115 plots). Within each $1m^2$ plot, the percent cover for all plant species was ranked via visual inspection using a modified Braun-Blanquet scale. Categories recorded for *Typha* exclusively included maximum plant height, stem number, and number of flowers.

Channel elevation cross sectional profiles and digital elevation models were used to quantify the water level habitat access relationships and determine flooded area among habitat types for the past 25 years to determine regulation plan effect on fish access in restored vs. natural channels.

3 RESULTS/DISCUSSION

3.1 Fish and macroinvertebrates

There were 200 northern pike caught across all excavation sites yielding a mean catch per unit effort (CPUE) of 0.89 fish/net night and 45 northern pike caught across all reference sites yielding a CPUE of 0.68 fish/net night. Mean species richness appears to be higher at excavation sites (9.2) compared to reference sites (6.0). Metrics including mean northern pike abundance, density, and size, as well as mean overall fish abundance, density, species richness, diversity (Simpson's), percent composition of predatory fish, and predatory macroinvertebrate densities will be statistically compared between treatment and reference sites.

3.2 Habitat response

Physical data have been collected and analytical procedures have yet to be completed to compare treatment and reference sites. Sedge meadow community representatives in the genera *Carex, Juncus, Eleocharis*, and *Cyperus* were more highly represented in excavation sites. Beneficial natives such as *Zizania aquatica* (annual wild rice) and *Sparganium eurycarpum* (broad fruit bur-reed) were noted in both excavation channels and at neither of the two reference sites. Metrics such as per-plot diversity, relative cover, importance value, Floristic Quality Index (FQI), and *Typha* spp. stem density will be statistically compared between treatments. Profile and DEM data have been collected but models remain to be created. Water levels data show a strong association of the St. Lawrence River gauging station to measurements taken at the French Creek study site indicating an effect of regulation at the dam on the local scale study area.

4 CONCLUSION

Connectivity enhancements show a positive initial response for fish and their critical habitat, but efficacy is likely constrained by system-wide effects of water level regulation. An assessment of new regulation plans by IJC relative to USACE 1958D will provide inferences towards impacts on restoration outcomes related to site access by spawning fish. Further investigation is needed to address longer-term vegetation succession and fish population-level responses.

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