Atlantic Salmon Spawning Habitat Enhancement

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December, 2024

Funding provided in part by
Foundation for Conservation of Atlantic Salmon

Introduction

Successful Atlantic salmon management begins with understanding the habitat used by salmon to complete its life cycle. Different population monitoring methods can help identify where productivity is arriving from and if certain habitat areas are limited. For example, conducting redd surveys can be useful for identifying spawning habitat while electrofishing surveys can help identify productive juvenile rearing habitat. Restoration plans should follow a strategic approach that is based on the information collected. Science-based management decisions begin with collecting the appropriate scientific information.

If the correct sequence of restoration techniques are followed, degraded habitat and limiting factors can be successfully addressed. Several techniques will be discussed in the following report to address degraded habitat areas used by Atlantic salmon for spawning. The considerations prior to implementing these techniques (site selection etc) will also be discussed.

The term “spawning bed” is used generally to describe an area created or enhanced for salmon while creating redds. It includes “V” structures installed to create new spawning habitat or raking patches of substrate in specific areas identified from redd surveys. The techniques discussed in the following address the impacts of excessive siltation by reducing substrate embeddedness and the installation of structures that alter stream variables to provide suitable conditions preferred for creating redds.

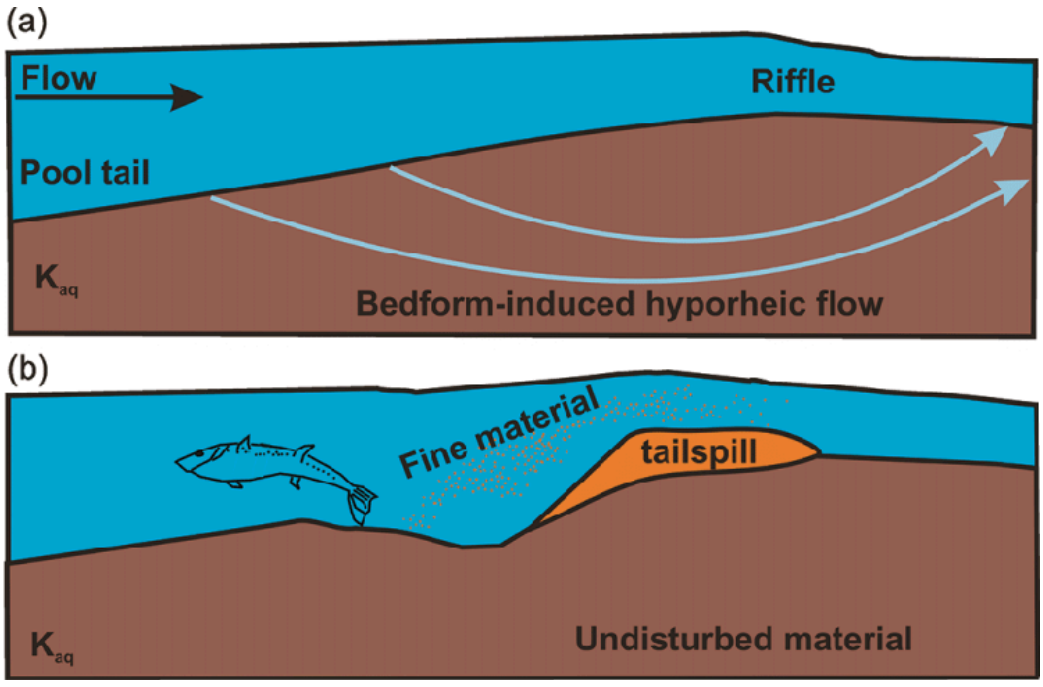
Installing structures that create salmon spawning beds is a precise process and should have sites selected by professionals. Location and stream characteristics are important to understand when planning spawning bed locations. Simply going out and building structures or raking gravel without following the appropriate considerations will not result in the preferred outcome, hence the reason for this report. This technical handout is meant to be used as an aid for placing and creating spawning beds on PEI salmon rivers. This report will describe techniques implemented by the Central Queens Branch of the PEI Wildlife Federation (CQWF) on the West River, PEI. The goal of this report is to share knowledge and expertise with watershed groups on PEI that intend to conduct spawning habitat restoration activities.

Spawning Habitat Description

Spawning bed placement must have habitat features to keep the developing embryo's eggs aerated while removing metabolic wastes. Typical redd placement occurs at the crest of a riffle where the water velocity increases as water depth decreases. This creates a hydraulic pressure that forces water into the hyporheic zone which is vital for aerating incubating embryos and removing metabolic waste. Common areas that contain these flow characteristics are within the transition zone between pools and riffles where the water depth decreases and velocity increases.

CQWF produced an Atlantic Salmon Spawning Habitat Characterization report and found that on the West River salmon prefer substrate between 23-64 mm, in areas with water depth ranging from 25-35 cm and water velocities ranging from 1.2 - 2.6 ft/sec (Condon 2023).

These microhabitats have been described by other authors but can vary between rivers. Individual rivers can have unique habitat opportunities and may result in salmon utilizing slightly different microhabitats than previously described. The quality of the habitat used to create redds will influence the ability to satisfy the metabolic demands of developing embryos. Habitat with excessive siltation or poor spawning substrate can result in inadequate dissolved oxygen delivery due to a reduction in interstitial spaces



and reduced oxygen delivery capabilities. Restoration tactics must be aligned with the limiting factor for successful results and the root of the issue must be firstly addressed.

Spawning Habitat Site Selection

The placement chosen for spawning enhancement activities should have extensive planning and consideration before implementation. Redd surveys are useful to identify areas used for spawning and if conducted annually certain areas will be noted to be repeatedly used for redd placement. Data from redd surveys is almost essential in successfully choosing sites for spawning habitat enhancement activities.

Once spawning habitat is identified you can begin associating limiting factors to specific sites. The following are important questions to answer before implementing enhancement tactics.

- Is there high-quality spawning substrate?
    - Smooth, round substrate ranging from 2-6cm
    - If not what is present?
- Is it embedded?
    - What degree of embeddedness?
- If quality substrate is present but no spawning is occurring what is missing?
    - Is the velocity too slow?
    - Is the water depth too deep?
    - Is there a lack of preferred hydraulic conditions?
- Can certain habitat variables be altered to create viable spawning habitat?
    - Ie- creating a pinch point to increase water velocity
    - Installing a “V” structure to alter water depth

Once these questions are considered the process of pairing enhancement tactics can begin. Site selection for enhancement tactics should be consulted by professionals and discussed thoroughly before implementation to ensure a higher likelihood of success. Sites chosen for enhancement should also be monitored for several years post-restoration work to ensure they are used and deemed successful.

Understanding how spawning habitat is being used throughout the entire watershed is important when considering spawning habitat enhancement tactics. For example, why focus restoration work on the upper reaches of small tributaries when the bulk of spawning occurs on the main branch of the river? A strategic approach must be carefully planned in the correct sequence for the best results.

The main goal of installing spawning enhancement structures is to supply a missing component that is needed for the habitat to be viable for spawning. Sometimes habitat is not used because there is one key component missing. Habitat can have ideal flow velocities and water depth but lack suitable spawning substrate. In other cases, there may be suitable spawning substrate and water depth but the velocity is too slow. Spawning habitat enhancement tactics can be paired with certain circumstances to address the issues but it is imperative for successful results that habitat variables are understood and paired accordingly. If the wrong tactic is paired or placed in an unsuitable area then the likelihood of it being successful is reduced significantly. Again site selection should be consulted with salmon experts to ensure placement is well planned and conducted properly.

Table 1. Three spawning habitat restoration techniques with the details regarding the targeted limiting factors and conditions considered for site selection.

Restoration Technique	Limiting Factor Addressed	Site Selection
Gravel Raking	Spawning substrate embeddedness	Areas frequently used for spawning with suitable flow characteristics
“V” Spawning Bed Structure	Lack of desired hydraulic conditions	Areas with ideal flow velocity but lack ideal hydraulic conditions with decreasing water depth/increasing velocity
Flow Pinching Structure	Lack of desired hydraulic condition (flow velocity too slow)	Areas that have slower flow velocities but have high-quality spawning substrate present. Can be created while notching blockages and log jams

Spawning Habitat Restoration Techniques

The following will describe three techniques implemented on the West River that improve spawning habitat qualities and conditions. The three techniques discussed in the following area are gravel bed raking, installing spawning bed “V” structures, and creating pinch points.

Gravel Bed Raking

The purpose behind raking gravel beds is to address substrate embeddedness in areas that contain ideal spawning substrate. The end result will remove fine sediments from the spawning substrate, increase permeability and oxygen delivery effectiveness. Having suitable sized substrate free of fine sediments will provide high quality habitat for incubating embryos which will result in an increase in survival and ultimately an increase in local juvenile populations.

The first step in gravel bed raking is identifying spawning areas frequently used by salmon to create redds. It is essential to choose sites that are regularly used by salmon to create their redds to ensure sites selected for raking have a higher probability of being utilized. Raking gravel beds does not attract salmon to spawn so areas must be thoroughly understood to ensure raked areas are correctly placed. This activity occurs on a micro-scale so if raking is off by a few meters it will essentially be rendered useless as it must occur directly in areas used by salmon to create their redds or else it has no purpose. Using physical markers (flagging tape or stakes on the stream bank) during redd surveys can be useful to mark locations for future raking activities.

Gravel raking is a simple process that involves thoroughly raking stream substrate to ensure fine sediment is carried away from the desired spawning area. The substrate should be pulled aside until you have reached a desired depth (~30cm), once the spawning substrate has been sufficiently unembedded the substrate can be evenly spread back out. The substrate must be evenly spread back into the area it was pulled from or else the final product may have a net negative impact as the spawning habitat can be impaired rather than enhanced. Large areas should be raked (minimum 2x2m) to increase the likelihood of salmon using a portion of it to create their redds and will account for varying water levels. Additional substrate can be imported to ensure there

are ample amounts of high quality substrate to create redds. Smooth fish-sized Island stone is preferred but can be difficult to obtain. Using non-native Nova Scotia river rock is also an option though is more costly and requires extensive manual labour importing it to the site.

Gravel raking should be conducted later in the field season (August) to ensure gravel is raked as close to spawning season as possible ensuring spawning success. It should never occur in June as the young of the year salmon will have just emerged from their redds and will still be nearby in high densities.

The left photo demonstrates an area raked with the substrate pulled to either side and down to the desired 30cm depth. The photo on the right displays the final product with the desired substrate pulled back into spawning area.

“V’ Spawning Bed Structure

In many circumstances, habitat areas can have high quality spawning substrate but are missing variables that result in habitat not being utilized for spawning. In certain cases, the water velocity and depth may be suitable but the streambed lacks structure that promotes hyporheic flow. Artificial spawning beds that use the “V” structure style create hydraulic conditions that mimic the crest of the riffle (transition zone between the tail of the pool and riffle) and creates the conditions that produce hyporheic flow and an increase in water velocity. Site selection for these structures occur in areas with no history of redds and aim to create new viable spawning habitat that attract salmon to utilize.

Site selection is the first step in the process and choosing sites for artificial spawning beds requires in depth expertise and knowledge. Professionals must be consulted before installation to ensure the habitat is not negatively impacted and site selection is in the correct location. “V’ styled spawning beds typically occur in sections of rivers with ideal water velocity and depth but lack characteristics that promote hyporheic flow. Water depths should be 25 to 50 cm deep with water velocities >1 ft per second.

Once sites have been selected either two pieces of lumber or large cobble or boulders can be used to create a “V”. If using lumber, 6-10” diameter logs are preferred. Depending on the stream width the length of logs can range from 5-10ft. The logs are secured using three pieces of rebar and used to pin the logs in a “V” position formation with the opening pointing upstream. The opening of the structure is then filled with locally sourced spawning substrate or Nova Scotia river rock. The preferred-sized is smooth rounded substrate should range from 2 - 8 cm mixed with an assortment of smaller-sized gravel. A similar process using boulders can be followed to create a “V’ structure and then infilled with spawning substrate. Typically the tactic that utilizes natural materials is preferred.

Photo on left displays an installed “V” spawning bed structure on the main West River with an Atlantic salmon redd. The photo on the right displays a “V” spawning bed structure on the upper main West River installed in 2023 and in 2024 it also had an Atlantic salmon redd utilizing it.

Flow Pinching Structure

Similar to the “V” spawning bed structures other mechanisms can be used to encourage the water flow to accelerate and attract salmon to spawn over areas with suitable spawning substrate. The first tactic to increase water velocity can be achieved when managing woody material within the stream channel. Woody material can have notches created in the middle (or to either side) which promotes flow acceleration within the notched area. The general rule of thumb, the notched area should be ⅓ of the stream width (10m stream width so the notched area should be 3m). Individuals managing large wood within the watercourse channel should have ample experience, knowledge and an understanding of what the desired outcomes are for decisions made. For instance, many cases large log jams can create suitable spawning conditions if the water flow is pushed in a certain manner or it may require a level of removal to also create favorable spawning conditions. It is important to understand the hydraulic conditions, sediment regime, and general water course conditions you are working within for optimum results.

An additional benefit to the notching technique is the importance of woody material for other forms of habitat. Woody material can act as cover for varying sizes of salmonids and invertebrates and it also plays an important role in shaping our stream morphology. However, if excessive woody material is accumulated in the reach of the river the spawning habitat can be compromised by a reduction in stream velocity which ultimately encourages sediment deposition. By notching accumulated woody material a balance can be achieved that satisfies a well balanced aquatic environment.

Structures can be installed that mimic the previously mentioned notching technique. Full logs can be positioned (typically pointing upriver) to help direct water over suitable spawning substrate and increase water velocity. Boulders can also be positioned to achieve the same result. The main goal is to focus the water flow over an area with suitable spawning substrate, increase water velocity, and promote hyporheic flow. Other tactics noted to have achieved similar results are digger logs, wing deflectors, and other forms of deflector structures. Using soft-engineered structures (full log placement) is preferred due to the lower physical labor involved, lower cost when compared to constructing deflectors, and is a more natural technique.

Photo left displays a notched tree that created a pinch point and an Atlantic salmon redd position within the notched area. The photo on the right is a soft engineered structure that aimed to created a pinch point over imported Nova Scotia river rock for a spawning area.

Conclusion

Managed sites should be monitored during spawning season to document usage and redd prevalence in nearby areas. Documenting results is an important component for adaptive management and incorporated into future management decisions. Spawning habitat variables should be studied and understood on managed rivers as the implementation of the discussed techniques may vary from river to river.

It is strongly encouraged that watersheds with ongoing salmon restoration activities conduct extensive redd surveys. The information gathered from redd surveys is the foundation for guiding restoration plans. It is important to document productive spawning habitat areas within individual watersheds as these areas should not be disturbed as they are likely already functioning as they should. Other reaches of the river will be noted to not be reaching their ful spawningl productivity which should then be paired with restoration tactics that tackle specific limiting factors. Redd surveys play a critical role in CQWF's annual planning and plays an important role in forming watershed management plans/strategies (Condon 2022).

The process of aligning management techniques and limiting factors is vital for achieving restoration success. If management techniques are deployed without aligning with limiting factors and careful consideration of site placement the end results will likely not be successful. Spawning habitat occurs on a micro-scale meaning structure placement that is marginally off can result in being unsuccessful. Hence, consulting with professionals and requirements for watershed groups and salmon restoration employees to be properly trained and conduct follow-up monitoring activities is completely necessary.

CQWF has demonstrated successful implementation of tactics used to enhance spawning habitat and create new viable habitat in several reaches of the West River. By developing an Atlantic Salmon Habitat Management Strategy, watershed groups can follow a strategic approach when selecting prioritized project areas that will yield the best results for effort input while documenting what areas of the watershed are used for individual lifestages and what areas are not reaching their full potential.

References

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First diagram link

https://www.researchgate.net/figure/Longitudinal-view-of-a-a-poolriffle-bedform-with-hyporheic-exchange-induced-by-bed_fig1_233664281