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2024-2025 Nechako White Sturgeon Habitat Restoration

Angie Coulter and Steve McAdam

Background

The Nechako white sturgeon population has been in decline for over five decades and has been listed as Endangered under Canada's Species At Risk Act since 2006. The cause of population decline has been identified as poor survival during the early life history stages (egg and larvae) due to degraded substrate conditions within spawning habitats. The Nechako White Sturgeon Recovery Initiative has used a two-pronged approach to conserve the species: 1) a hatchery program to produce juvenile white sturgeon and preserve the genetic diversity of a declining population and 2) spawning habitat restoration. In 2011, a 40 m x 200 m restoration site was installed in the Nechako core spawning area in Vanderhoof, British Columbia (Figure 1, NHC 2012). Gravel and cobble were added to create a pad of good quality spawning habitat. Subsequent detection of juveniles born in 2011 suggests that restoration was effective, however, the effect only lasted one year due to fine sediment infilling the interstitial spaces within the restored substrates.

The identification of rapid infilling diminished the effectiveness of restored substrates led to a series of studies to characterize bedload movement and measures to address infilling. A series of investigations of bedload sand movement (NHC 2012, Gauthier-Fauteux 2017, Gauthier-Fauteux 2018) established that sand preferentially moves through the northern side channels within the spawning reach. That finding explains both the rapid infilling at the Lower Patch location as well as the much more limited infilling at the Middle Patch. Another informative study used an underwater camera (a 'substrate cam') for long-term evaluation of localized changes in substrate composition at a location just downstream of the Lower Patch (NHC 2022). Two key observations from the substrate cam were periods when good quality gravel substrate was present and other episodes when a sheet of sand rapidly covered the underlying substrate.

Recognition that sand will always be moving through Lower Patch spawning habitat focused restoration effort toward the removal of fine sediment, or substrate 'cleaning'. A Spyder walking excavator was used in 2016 to clean substrate at depths up to 1.5m. This cleaning method aimed to remove sand by dropping mixed substrates through the water column to allow sand to be selectively transported downstream by the current. While that effort did lead to downstream sand displacement, the effect on surficial substrates and interstitial habitat could not be documented due to high turbidity (NHC 2016). Additionally, a recruitment response was not detected in 2016. To avoid depth limitations, diver operated suction dredging and raking was tested in 2020 (NHC 2020). While divers could effectively clean substrates, the rate of cleaning was slow and only a small area received effective treatment. Additionally, while divers were not depth limited, the velocity limits of safe diving were reached at a about the same discharge level that limited the Spyder excavator.

The focus subsequently shifted to identifying substrate cleaning methods that could be used at a range of discharge conditions over the whole area of the Lower Patch (and other locations within the spawning reach). The NWSRI subsequently worked with Sea to Sky Energy Solutions who developed the 'tubescreen' substrate sorting tool (Sea to Sky 2022). The tubescreen worked by using a tube-shaped configuration of tines to lift and sort benthic substrates when it was dragged along the river bottom. Both the spacing and the angle of the tines allowed cobble and gravel grains to be lifted away from the finer sand fraction (which passed through the tines), with the gravel and cobble then selectively deposited as a surface layer to create suitable interstitial habitat. Once the effectiveness of the tubescreen was demonstrated (Sea to Sky 2022, Coulter and McAdam 2022) the next step was to test it within the deeper and faster habitats within the mainstem Nechako River.

Figure 1. The Lower Patch restoration site in the Nechako white sturgeon core spawning area. The yellow polygon denotes the 40 m x 200 m gravel and cobble pad installed in 2011.

Pre-Season Testing

October 2024

The goal of the October 2024 field testing was to evaluate the effectiveness of the previously designed tubescreen (Figure 2), under realistic conditions of the Nechako white sturgeon spawning habitat. Our expectation was that the tubescreen would be effective within mainstem habitats. However, it was important to confirm this, as well as any additional challenges related to using this approach in deeper mainstem habitats. An additional goal was therefore to familiarize ourselves with the logistics of operating of the tubescreen in the spawning area to aid the design for the large-scale spring cleaning.

Figure 2. Tubescreen substrate sorting tool on the bank of the Nechako River at the Lower Patch white sturgeon spawning site.

The tubescreen was tested on October 29th at the Lower Patch gravel restoration site, a high use site for sturgeon spawning. Water depth was approximately 1.5 m. The tubescreen was pulled over near-shore habitats using a shore-based excavator that held a long bar within the excavator claws. The tubescreen was pulled in an upstream direction by rotating the excavator with its arm holding the tow-bar extended. The use of 6 m of chain between the tow-bar and the tubescreen as well as the downward angle of the tow-bar allowed the tubescreen to be towed horizontally (i.e. running across the riverbed) rather than causing the tubescreen to tilt upward. After pulling the tubescreen over the test area, it was fully lifted out of the water by the excavator and repositioned at the downstream end of the test section to be pulled upstream again. Each of these 'pulls' affected an arc that was about 20 cm wide (due to the rounded nature of the tubescreen) and 4 m long. This meant that multiple 'pulls' were required to achieve one cleaning 'pass' over the test section. The initial goal was to test the effectiveness of 2, 4, 6, and 8 passes over 2 m x 4 m treatment patches. The effectiveness of this pilot treatment was monitored using an underwater camera deployed from the tender boat.

When initial pulls showed that the tubescreen was not effectively cleaning the test areas, the treatment plan had to be modified. The test area was largely comprised of compacted cobble substrate embedded in sand and small gravel. Our observation in near shore tests showed that the tubescreen teeth could not 'engage' with the cobble dominated substrate.

Although some cobble grains were turned over, most grains were simply pushed by the tubescreen. When the tubescreen encountered cobble that it could not push, the tubescreen rolled laterally rather than penetrating the substrate. The cleaning effects demonstrated in the 2022 tests were therefore not reliably repeatable at this location. After inspecting the 2022 field study site, it was clear that substrate at that location was less compacted than in the Lower Patch, which explained the more limited effectiveness of the October 2024 tests.

In response to the poor initial performance of the tubescreen within actual spawning habitat, we modified the setup for onshore testing by adding rock anchors upstream from the tubescreen to scarify the substrate in the tubescreen path. The rock anchor successfully scarified the substrate when suitably oriented, which allowed the tubescreen to 'engage' with the substrate and provide the desired sorting effect. Using a smaller rock anchor provided the best effect, apparently due to the width of the scarified furrow caused by the narrow spacing of the anchor tines. The rounded edge of the tubescreen teeth engaged fairly well with the disturbed substrate between the two furrows created by the anchor tines. When successfully deployed, this arrangement allowed loose unconsolidated material to move through the tubescreen in a manner similar to the 2022 tests. Unfortunately, the rounded shape of the tubescreen allowed it to roll laterally when the rock anchor faced resistance, and rolling caused the rock anchor to 'disengage' from the substrate (e.g. it would lie on its edge and push surface cobbles rather than scarifying). Despite limitations, using these two tools in combination appeared to be effective when applied to a restricted area (~1 hour of application). Understanding the limitations of the tubescreen, and particularly its tendency to roll laterally in response to heavily embedded substrates, also helped to inform the design of alternate tools.

Monitoring was conducted under the direction of Northwest Hydraulic Consultants (NHC) using underwater camera monitoring and freeze core sampling. Freeze core sampling is a technique to sample the substrate below the riverbed surface. A hollow pipe is inserted 30 cm into the substrate and liquid nitrogen is poured down the pipe to freeze the surrounding substrate to the pipe. The pipe is then pulled to the surface to observe the substrate layers. Preliminary site surveys indicate that the large material placed at the Lower Patch restoration site in 2011 are still present, but the interstitial spaces are filled with fine sediment (Figure 3). After 1 hour of treatment with the modified tubescreen, the conditions in the top two layers of substrate were improved (Figure 4). The large cobble and gravel were brought to the surface and the sand was deposited below, creating clean habitat for white sturgeon egg and larval rearing. Those results were consistent with the findings from the 2022 pilot study (Sea to Sky 2022).

Figure 3. Freeze core sample of the ambient substrate in the Lower Patch restoration site before testing of the tubescreen sediment sorting tool. The large gravel and cobble layer installed in 2011 has persisted (left), but the interstitial spaces are infilled with fine sediment.

Two other observations are worth noting regarding tubescreen effectiveness. First, the bed topography affected the ability of the tubescreen to engage with the substrate and the tubescreen was less effective in flat areas. A slightly sloping bed at the top end of the test section allowed the tubescreen to effectively engage its teeth into the substrate, which improved sorting effectiveness. A second observation of these small-scale deployments was that the tubescreen may take a few meters to initiate effective sorting due to the need to ‘fill up’ with sufficient unconsolidated substrate. Test areas as short as 4 metres may not provide representative results, though notably the 2022 test sections were only slightly longer than 4 m. The main outcome of this testing is that further discussion about tubescreen effectiveness and redesign options were needed prior to implementing larger scale applications.

Figure 4. Freeze core sample of the substrate in the Lower Patch restoration site after testing the modified tubescreen sediment sorting tool. The large gravel and cobble have been raised to the bed surface and the fine gravel and sand have been deposited deeper into the bed. The ice frozen to the pipe (left) indicates that large substrate was present at the surface but did not adhere to the pipe.

Winter 2024/2025

The Nechako White Sturgeon Restoration Advisory Group (NWS-RAG) was formed in 2024 to provide guidance regarding the implementation of spawning habitat restoration. This multi-disciplinary team (federal and provincial biologists, fluvial geomorphologists, community working group members and local contractors) guides restoration activities in the Vanderhoof spawning reach. During Winter 2024-2025, the NWS-RAG team reviewed the results of the October 2024 testing and decided that the tubescreen was not suitable for implementation at the Lower Patch restoration site. Observations from the fall 2024 tests supported the design of two alternate substrate cleaning tools. Over the winter of 2024/2025, WLRS worked with local contractors (M4 Enterprises) and members of the NWS-RAG to design and test potential shore-based substrate cleaning implements. Two options were developed for implementation in conjunction with a long arm excavator that was able to enter the river channel up to a depth of ~1m. Winter preparation also included converting the excavator to plant-based oils to prevent pollution in the Nechako River.

The first option was termed the 'rake' and was designed as a modified bucket for a long reach excavator (Figure 5). The concept of the rake was that the tine spacing (~10 cm) would allow the operator to pick up a load of large substrate (large gravel and cobble) from the bottom of the river and the smaller particles (small gravel and sand) would sift through to remain in place. The separated large substrate would then be deposited back into the river where it was taken from, creating a layer of suitable substrate at the surface. The second restoration tool tested was termed the 'sled' (Figure 6). The sled was designed with a similar concept to the original tubescreen, but was flat rather than round. The sled was designed to be towed in an upstream direction by rotating the outstretched excavator arm. Teeth at the front of the sled would dig into the substrate and cause large gravel and cobble to pass up and over the sled as it was towed. The tine spacing would allow particles <10 cm through and layer the larger rock on top. The flat design was intended to combat the rolling effect observed in the tubescreen trial. Both the rake and the sled were tested on land within the M4 Enterprises works yard to demonstrate that they could effectively sort a substrate mixture containing gravel, cobble, and sand.

Figure 5. In-river testing of the rake on the Lower Patch, April 2025.

April 2025

Pilot testing of the rake and sled were conducted on April 29th and 30th to test and refine those tools for larger scale applications conducted just prior to the May spawning window. In-river testing showed that the rake was ineffective at sorting the substrate of the Lower Patch. The first challenge was penetrating the substrate surface when reaching out long distances with the long arm excavator. The substrate is sufficiently compacted with sand and digging into the substrate requires significant downward force. Sufficient force could be applied when working close to the excavator. However, when the excavator arm was extended to work further into the river channel the substrate's resistance, combined with the increased leverage, caused the excavator to lift (i.e. rather than the rake to dig in). A key part of that limitation was the spacing of the tines on the rake. Tines that are of appropriate spacing to engage the target substrate particle size (<10 cm) create lots of resistance. Increasing the tine spacing would reduce resistance but would be too far to achieve the substrate sorting objective. This observation showed that when the substrate is highly compacted two functions are required; disruption of the compacted substrate and sorting to improve surficial habitat quality.

Figure 6. The 'sled' substrate sorting tool on land at the Lower Patch restoration site, April 2025.

The sled was also tested by observing the effect of 1, 3, 5 or 8 passes of the sled over a nearshore area of the restoration site. These areas were located at NHC monitoring sites 6 and 7. After 8 passes of the sled, the substrate condition appeared to have improved (reduced periphyton and sediment visible on the surface of the rocks, lower amounts of subsurface sand). This result was deemed sufficient for full scale testing in May over the Lower Patch site.

Full Scale Testing

May 2025

Testing full scale operation of the sled across as much of the Lower Patch as possible was the focus of the May 5th-9th work window (wild sturgeon spawning begins May 15th). Initial work showed that the upstream and inshore portion of the Lower Patch could be reached using the long arm excavator, but access to most of the Lower Patch (i.e. the downstream and mid-channel areas) was limited by water depth. The excavator applied 8 passes of the sled to all areas that could be reached, resulting in treatment of approximately 18% of the Lower Patch. The treatment area also included the region that the rake and sled were tested in, which would have resulted in up to 8 additional passes for that restricted area in the previous week.

Figure 7. Testing operation of the sled using a winch and pulley system, May 2025.

Methods to access deeper downstream areas were also investigated, including a winch and pulley system and barge-based deployment. A winch, pulley and cable system was tested to assess the feasibility of pulling the sled from a fixed upstream point located on the excavator. This method used a winch located on a shore-based excavator combined with a pulley on the instream excavator (Figure 7). Conceptually, this method would allow the sled to be pulled a distance equivalent to the length of the cable on the winch (possibly followed by adding additional cable to extend the total pull length). However, in practice this method wasn't suitable. The operation was slow and the sled was more prone to snagging on large substrate or wood debris. The horizontal orientation of the pulling cable in this set up was the main cause of increased snagging, whereas when using the excavator alone (as described above) snagging was remedied by using the excavator to pull the sled up vertically to dislodge it.

Snagging of the sled on the riverbed resulted from both the size and weight of the sled and the ability to lift it vertically when snagged. In order to address the second concern, testing investigated the use of a small barge (a dock with 8 plastic barrels for flotation) to both float the sled downstream and then lift the sled vertically when it became snagged. Conceptually, if the sled could be lifted into the water column and then floated to the downstream end of the pad, it could then be pulled upstream to perform substrate cleaning over the whole length of the Lower Patch. Unfortunately, those tests were unsuccessful. First, the weight and size of the sled relative to the small size of the barge meant that the barge was undersized. In future tests, both a larger barge and a smaller sled should be evaluated as potential solutions. A second challenge was that the apparatus used to lift the sled (a tripod mounted in the middle of the sled and manual ratcheting winches, or come-alongs, to lift the sled) was also undersized relative to the size and weight of the sled. As above, a lifting set-up with a higher capacity would be required if a barge was used to deploy and 'un-snag' a sled using the current design. While larger apparatus is the general solution to using the sled as currently designed, the most important limitation to improving the deployment apparatus is establishing an effective sled design. Therefore, further work to confirm an effective sled design is a necessary precursor to further work to develop the deployment methods.

Geomorphology Monitoring

Substrate monitoring was conducted across the Lower Patch by NHC at three time periods: before testing (April 23rd-25th), immediately after treatment with the sled (May 12th-13th) to observe the effects of the treatment, and one month after treatment (June 18th-20th) to observe the longevity of the treatment effect. The detailed results of the monitoring are provided in the companion report (Northwest Hydraulic Consultants 2025). In summary, moderate to poor substrate conditions for egg and larval rearing were present across much of the Lower Patch restoration site before sled treatment. Most areas were characterised by high proportions of sand and small gravels in the substrate composition. The sled treatment had limited effectiveness to improve these conditions, with improvements created in only one of the test locations. This location was rated as moderate quality for eggs and larvae rearing before treatment due to the high proportion of gravels and cobbles and a relatively low proportion of sand. In general, the restricted areas that showed good quality substrate post treatment were also rated as good quality before treatment by the sled. The findings from the geomorphological monitoring therefore suggest that the sled treatment led to minimal positive change to the ambient substrates and only in a small portion of the treatment area.

Biological Monitoring

Biological monitoring was conducted to evaluate whether yolksac larvae were present within the interstitial habitats of the restored area of the Lower Patch (June 5th-6th). Sampling was conducted using a 'trident' sampler that used subsurface injection of compressed air to 'lift' hiding larvae out of benthic substrates. The sampler has a long pole attached so that it can be deployed from a boat, and also has a rectangular net frame to capture drifting larvae that are dislodged by the upwelling air. Using pressure on the pole, the tines of the trident can be pushed into the substrate until the net frame is flush with the surface of the substrate. Compressed air lines at the bottom tip of the tines leads to air injected into the substrate at depth and then rising through the substrate. The upperward lift provided by the rising air should dislodge larvae and lift them into the water column where they would be swept into the collection net by the river's current.

Validation was conducted to estimate sampling efficacy of the trident sampler by sampling an area containing a known number of yolksac larvae. A gravel bar of wadable depth across from Stoney Creek was selected for testing due to availability of suitable substrate for larval hiding. A 45 cm diameter PVC pipe approximately 85 cm long was placed in the river flush with the bed surface. Ambient gravel substrate from the site was collected and the PVC pipe was filled with approximately 10 cm of rock ranging from small gravel to small cobble, for a water column depth of approximately 70 cm. Three sampling trials were conducted. White sturgeon larvae aged 6 days post-hatch were sourced from the Nechako White Sturgeon Conservation Centre (NWSCC). For each calibration test, 40 yolksac larvae were released into the PVC pipe and allowed to settle for 5 minutes. A driftnet was held to cover the area directly downstream of the PVC pipe. After the 5-minute settlement period, the PVC pipe was gently tipped upstream and removed. The driftnet was kept in place for two minutes to capture any larvae that did not successfully hide in the gravel. After two minutes, the trident sampler was inserted on the downstream end of the rock patch and sampled for 2 minutes. Larval captures from trident net and the pre-sample driftnet were then counted to calculate sampling efficiency. Due to low capture success in the first trial (Table 1), the sampling protocol was modified for the second and third trial. In order to increase sampling area and to provide more realistic control for sampling natural habitats, the trident was moved from downstream to upstream in ~15 cm increments through the placed rock patch. The results from the second and third trials showed that the trident sampler was able to detect larvae with the average efficiency of 35%. The capture efficiency was considered high enough to consider this an effective method, and particularly if effort was increased relative to the short treatment period in the calibration tests.

Table 1. Capture efficiency tests of the trident sampler for white sturgeon larvae. 40 6 days post-hatch larvae were released into the sampling area per trial.

Trial	Drifted	Captured in Trident Sampler	Remained in Substrate	Capture Efficiency
1	10	1	29	3%
2	9	19	12	62%
3	8	9	23	28%

The treated area of the Lower Patch was sampled at a time when yolksac larvae would be present to determine whether yolksac larvae had successfully hidden within restored interstitial habitats. Yolksac larvae could have been present in the substrate either as a result of wild spawning, based on dates of egg collections, or hatchery origin eggs, based on the temperature dependant development rates since fertilization.

In 2025, fertilized eggs were released onto the Lower Patch treatment area to emulate the releases on the middle patch in previous years. Eggs from the 2025 spawn events were fertilized and released on the Lower Patch restoration site in the location with the best conditions for egg and larval rearing (NHC monitoring sites 6 and 7). Using water temperatures and established larval development rates, we determined that yolksac larvae, if present, would have been hiding in treated substrates as 8 days post-hatch larvae on about June 6th. Unlike previous years, we also investigated whether benthic sampling would be able to detect yolksac larvae hiding within restored substrates. Benthic sampling for outplanted yolksac larvae in restored habitats has previously been successful, but only in shallower side channel habitats (McAdam 2012). A key challenge in this current study was to test methods that could be used in the non-wadable habitats that comprise white sturgeon spawning habitat. The trident sampler was used to sample 10 m of the riverbed immediately downstream of the egg release site. Sampling progressed downstream to upstream in 60 cm increments. Two other 10 m long areas were also sampled near pre-treatment monitoring sites 3 and 11 (see NHC 2025). Those areas were selected for sampling based on the presence existing good quality substrate that may support early life history stages derived from wild spawning. Unfortunately, no eggs or larvae were recovered from any of the three sampling areas in the Lower Patch. Considering the effectiveness of benthic sampling in the efficiency tests, the inability to detect any yolksac larvae when sampling the Lower Patch suggests they are absent or in low abundance at that site. However, it is important to acknowledge that wild eggs and larvae may occur at low densities over a large area, which makes detection challenging. These findings emphasize that sampling eggs and larvae in the benthic habitats of the main river remains a challenge for monitoring in the Nechako River.

The detection of wild juvenile recruitment is the ultimate test of whether habitat restoration is successful. The detection of a recruitment pulse after the 2011 placement of spawning substrate at the Lower Patch demonstrates the potential to generate detectable recruitment in response to experimental habitat restoration. The comparison with 2011 is also relevant since neither eggs nor drifting larvae (captured using a D-ring driftnet) were captured in 2011 (McAdam pers. comm.) despite the subsequent capture of juveniles. The lack of egg or larval detections in the present study is therefore not fully definitive. The annual juvenile sampling work of the NWSRI will provide the ultimate test of whether the 2025 substrate cleaning, combined with the placement of fertilized eggs, produces detectable juveniles. The earliest such fish would be detected is 2027 or 2028.

Conclusions and Next Steps

The substrate cleaning work conducted in 2024 and 2025 represents an important step for habitat restoration to support the recovery of Nechako white sturgeon. Evaluations of early life stage habitat requirements have been scaled up over many years from lab studies, up to small scale field tests, and finally investigating methods for large scale substrate remediation in natural spawning habitat. Findings from the 2024-2025 were informative from a methodological perspective, despite the limited effectiveness of the treatment. These tests are costly and have high levels of uncertainty for the outcomes but are essential for finding the best methods to reliably improve habitat quality.

Next steps in the development of substrate cleaning methods should focus on the following areas:

1. Continued development of substrate cleaning tools to provide selective sorting is recommended. These efforts should focus on methods that can be deployed using floating work platforms (i.e. barges). Size limitations posed by barges (i.e. limited to smaller excavators) may limit the size and type of equipment that can be safely and effectively used.
2. The high sand content of substrates over much of the Lower Patch indicates a need to remove ‘legacy’ sand. Dredging methods should be evaluated as a means to ‘reset’ ambient conditions at the Lower Patch.
3. Visual evaluation of substrates throughout the Lower Patch indicate that some areas may require placement of new rocks to ‘rejuvenate’ the substates.
4. Development of a suite of methods may be required in order to evaluate the best combination to support long term application.
5. Continued juvenile monitoring is required to evaluate recruitment responses to habitat experiments
6. Out-planting fertilized eggs provides valuable support for habitat restoration experiments and allows a more direct test habitat utilization by early life stages.

7. More precise location data is advisable for biological and physical monitoring as it is critical to the planning and implementation of habitat restoration. For example, demonstrating that spawning is limited in areas of abundant sand could simplify substrate restoration at those locations.

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