MONITORING PROGRAM, 2023 FINAL REPORT

Inverness South Anglers Association

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Acknowledgments

The Inverness South Anglers Association would like the thank and acknowledge the Nova Scotia Salmon Association (NSSA) for the given opportunity of participating in the Gulf Priority Rivers Project. With the guidance from NSSA, ISAA was able to create a monitoring program and implement it on the Mabou Harbour Watershed during the 2023 season. This was a big goal achieved by our association, as ISAA always wished to expand into monitoring work. We are extremely grateful for the continuous support from NSSA and the many educational opportunities that they make available to our association.

Introduction

The Inverness South Anglers Association (ISAA) is a non-profit organization that was established in 2004 with the goal to provide watershed stewardship to three contiguous municipal districts in Southern Inverness County; Inverness, Mabou and Judique. Over the many years of being involved in restoration work, ISAA's restoration crew had successfully restored 15 watercourses and maintains each watercourse on an annual basis. Its with great thanks to all our project partners, volunteers, and ISAA staff for being able conserve and enhance the aquatic habitat within our watersheds.

Our goal at ISAA is the development of sport fisheries which includes three main components: fish habitat restoration, fish stock enhancement and the promotion of recreational fisheries. In 2023, ISAA had the opportunity to partner with the Nova Scotia Salmon Association (NSSA) in year four of the Gulf Priority Rivers Project, where all groups worked together to create and implement monitoring programs within their own watersheds. The monitoring programs consisted of four components: Habitat Suitability Index Assessments (HSI), water temperature monitoring, redd counts and electrofishing. By implementing a monitoring program to the Mull River watershed, ISAA was able to collect baseline data to capture the pre-restoration habitat conditions, water temperatures, and spawning activity by observing redd counts. Unfortunately, electrofishing wasn't completed this season as ISAA was unable to obtain the appropriate equipment and field crew to collect data on population densities. By implementing this monitoring program each year, ISAA will be able to identify any changes that occur on each watercourse restored and will help identify areas where future restoration work is needed.

This report analyzes and discusses the data collected for HSI, temperature monitoring and redd count surveys on the Mabou Harbour Watershed. In total, three (3) sites were chosen for HSI, four (4) sites were chosen for Redd count surveys, and twenty-three (23) sites were chosen for temperature monitoring. These sites were chosen to best represent prior, ongoing, and future instream restoration projects and the habitat conditions of those sites.

Physical Habitat Monitoring

Table 1. Physical Habitat Monitoring sites and activities, 2023.

Site Location	Watercourse	Monitoring Activity	# of sites
Glencoe Mills Rd.	Mull River	HSI Temperature Probes Redd Counts	15 1 1
Mackinnon's Rd. (2022 site location)	Mull River	HSI Temperature Probes Redd Counts	10 1 1
Mackinnon's Rd (unnamed Trib.)	Mull River	HSI Temperature Probes Redd Counts	10 1 1
Shea's Brook	Mull River	Temperature Probes	1
Graham's River	Graham's River	Temperature Probes	1
Moore Brook	Broad Cove	Temperature Probes	1
Glendyre Brook	Mull River	Temperature Probes	1
Mull River	Mull River	Temperature Probes	1
Southwest Mabou River	Southwest Mabou River	Temperature Probes Redd Counts	1 1
Mabou River	Mull River	Temperature Probes	1
Unnamed Trib.	Southwest Mabou River	Temperature Probes	1
Broad Cove River	Broad Cove	Temperature Probes	1
Mull River (Little Mabou Rd.)	Mull River	Temperature Probes	1
MacQuarrie Brook	Mull River	Temperature Probes	1
Western Tributary	Southwest Mabou River	Temperature Probes	1
Mull River (Old Mull River Rd.)	Mull River	Temperature Probes	1
Glendyre Brook	Mull River	Temperature Probes	1
Mull River (Murray's Bridge)	Mull River	Temperature Probes	1

The assessment of physical habitat was completed by the following protocols contained in the *Nova Scotia Fish Habitat Suitability Assessment: Field Manual* (Nova Scotia Salmon Association, 2019)

Habitat Suitability Index Assessment

The Nova Scotia Fish Habitat Suitability Index Assessment (HSI) is intended to standardize freshwater fish habitat assessment while making use of habitat suitability variables and values specific to the rivers of Nova Scotia. This index standardizes field method assessments for variables such as site identification, water quality, channel cross-sections, substrate, cover, riverbanks, riparian areas, and benthic macroinvertebrates.

The field methods are based on a Habitat Suitability Index methodology developed by the U.S. Fish and Wildlife Department, specifically the Brook trout HSI and have been modified to represent the unique features of Nova Scotia watercourses. Additional HSI variables for Atlantic salmon have been drawn from the literature and used in the salmon habitat assessment. The methods are based on freshwater hydrology and geomorphology that develop the physical habitat and water quality that are commonly degraded by anthropogenic (human) impacts of fish habitat quality.

Mull River

The Mabou Harbour Watershed is divided into 4 sub-watersheds. This study was conducted in the headwaters section of the Mull River. Figure 1 shows the delineated watersheds of the Mabou Harbour watershed. Figure 2 shows the delineated Headwaters section of the watershed in which our assessments were conducted. The area of this is 21.22 km2 in size and has an estimated bankfull width of 8.11m. In previous years ISAA has restored 3 sections of the headwaters watershed by installing 81 instream structures. This includes digger logs, deflectors, rock sills, and bank stabilization, all done by hand. Baseline data was collected on Reach #1 (as shown in figure 3) prior to restoration structures being installed, allowing for future studies to accurately reflect the restoration efforts. This site is known as MBR01 and MBR01B.

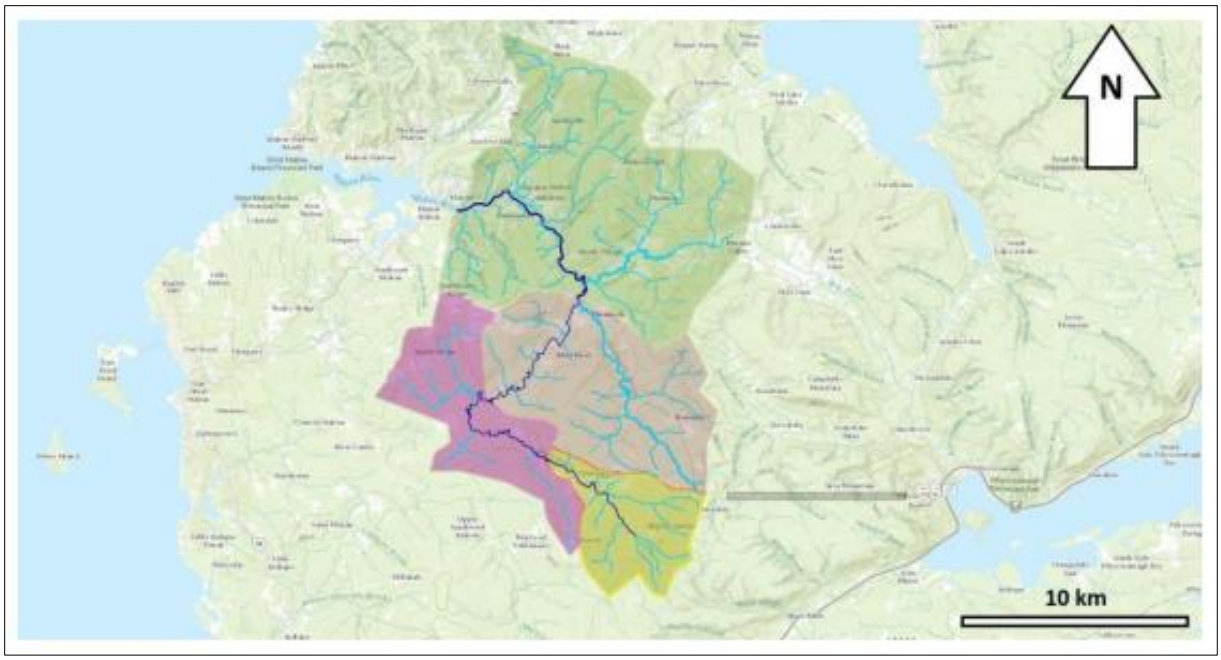

Figure 1: Showing Mabou Harbour Watershed divided into four (4) sub-watersheds.

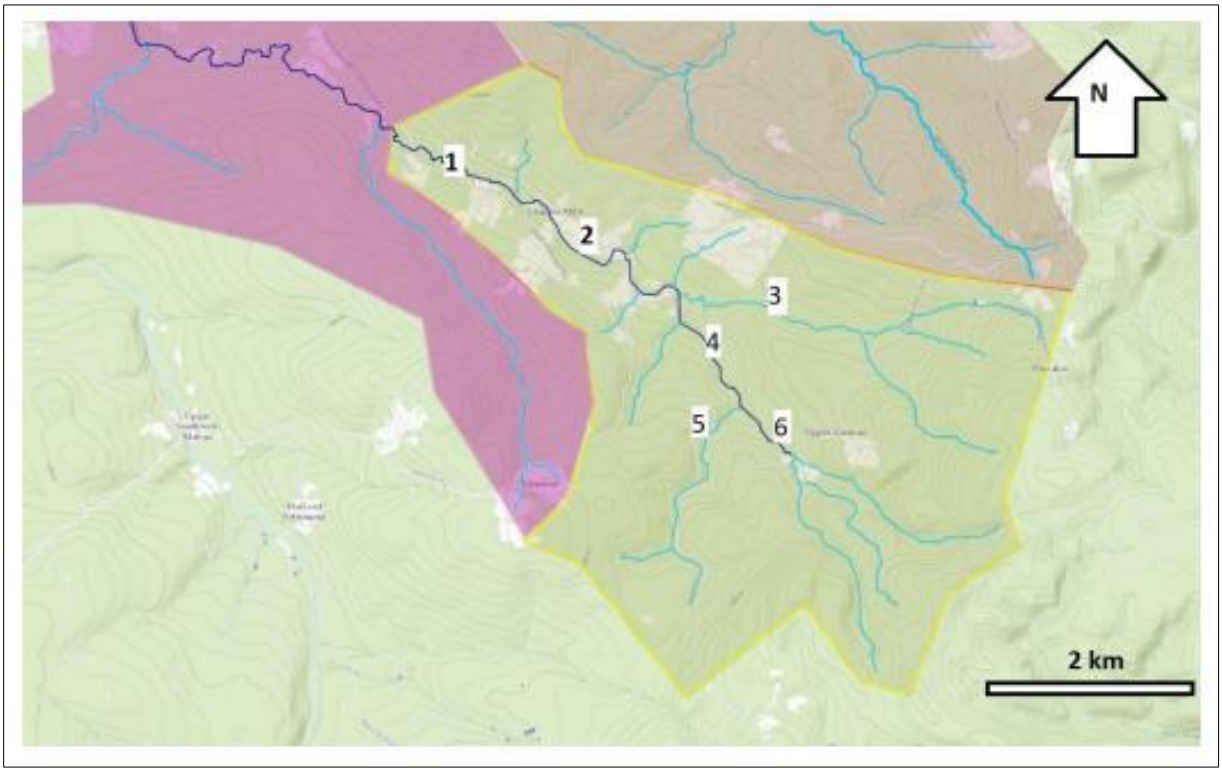

Figure 2: Showing Headwaters sub-watershed and all 6 Reaches.

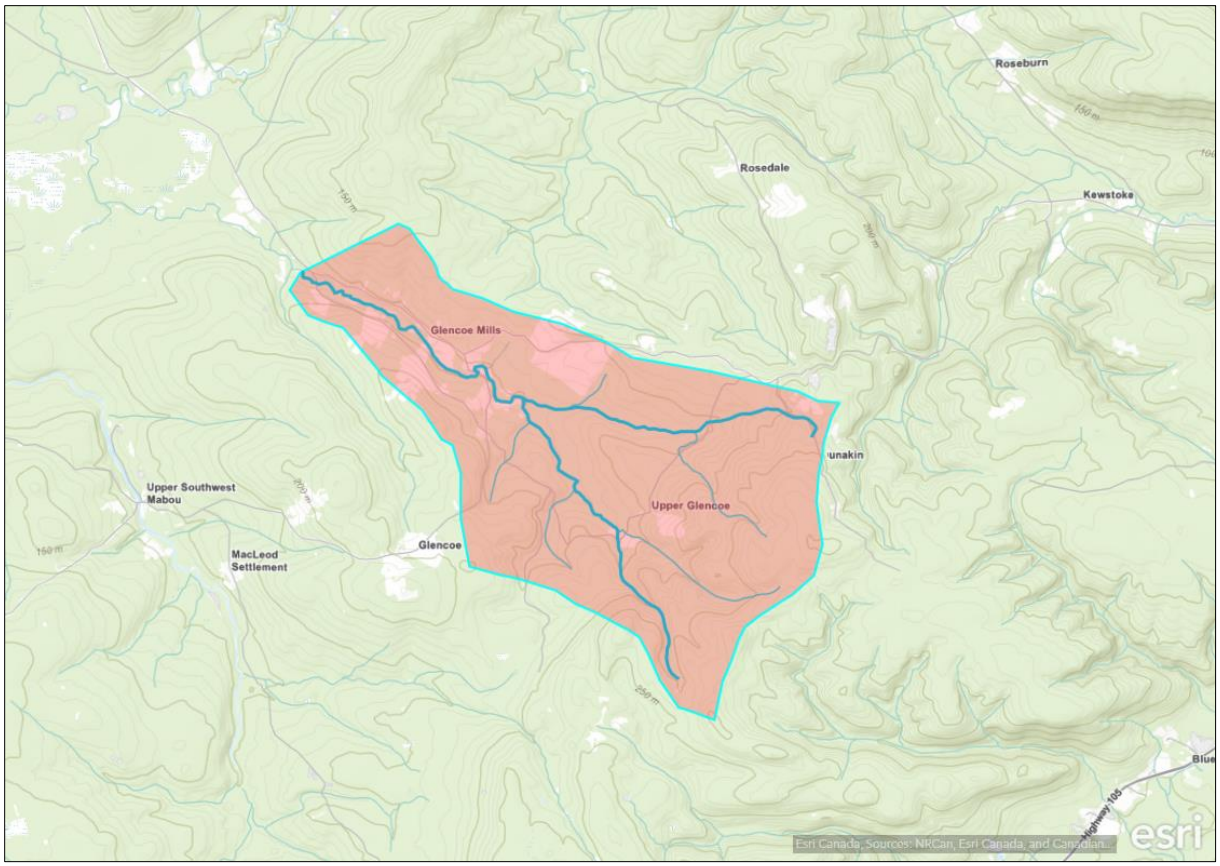

Figure 3. Showing the delineated watershed represented in our HSI assessments.

Sampling Sites

For the purposes of this study, 4 locations were chosen to conduct HSI assessments. These sites are known as MBR01, MBR01B, MBR02 and MBR03, all located in the headwaters of the Mull River. Figure 4 shows a map of where sites MBR01 and MBR01B are located which is the most recent restoration project site from the 2023 season. These two sites are located within the same project reach, and site MBR01B is an extension of MBR01. A total of 15 sites were sampled between MBR01 and MBR01B to give a clear representation of the pre-restoration habitat conditions within this section of river.

Figure 4: Showing Reach #1 where HSI MBRO1 and MBR01B were conducted.

Site MBR02 and MBR03 are located further up in the headwaters of the watershed are project sites that were previously restored in 2022. A total of 10 sampling sites were taken at each HSI location.

Methodology

The following steps for collecting bankfull width and bankfull height are found below (adapted from the NSHSI field assessment protocol):

- At each cross-section, a bankfull width and its height above the water level is taken.
- Start measuring from the left bank looking downstream.
- Pin the measuring tape into the banks or have a colleague hold the tape at the bankfull level and record the width on the field sheet.

Channel width, in particular bankfull width and wetted width are both measured at each transect (Figure 5).

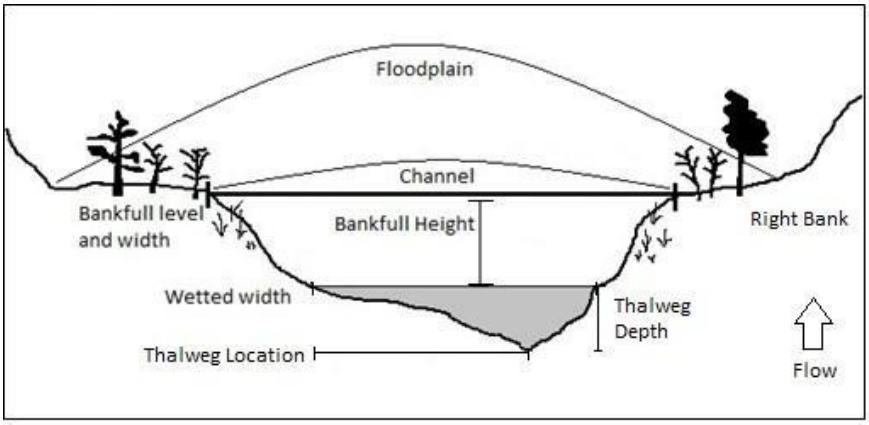

Figure 5. Visual guide for taking channel measurements.

Using a meter stick or second measuring tape, measure the bankfull height from the water surface to the top of the bank and record it on the field sheet.
The following steps (adapted from the NSHSI Protocol) are followed when measuring wetted width and wetted depths:

- At each cross-section, a wetted width and three wetted depths are taken at distances of ¼, ½, and ¾ across the wetted portion of the cross-section from left to right looking downstream.
- Pin the measuring tape into the banks or have a colleague hold the tape perpendicular to the banks at the edge of the water and record the width on the field sheet under wetted width.
- Divide the wetted width by 4 to determine the length of each quarter section.
- Starting at the left bank use the meter stick to determine the depth of the water at distances of ¼, ½, and ¾ across the wetted portion of the cross-section.
- Use the water level on the downstream side of the meter stick to determine depth as the level on the upstream side may be affected by stream velocity.
- An estimated negative depth, or height above the water level, should be taken if a measurement is located with no water depth in the adjacent area (an island or section of riffle with no significant depth or flow). A measurement of zero can also be taken if the river bottom is approximately the same height as the water level.
- A depth can be taken in a nearby representative area of the location if a depth location is on a rock or other feature that would misrepresent the cross-section (a boulder above the water level but with the adjacent area exhibiting depth).

Substrate composition is measured using a quadrant tool to calculate the composition of various substrate types (fines, cobble, gravels, boulders, and bedrock). Substrate size and embeddedness is measured using a random rock grab method, whereby three rocks are randomly selected from observed spawning areas and measure and record the diameter. Siltation lines are observable features on instream substrate that indicate the extent of siltation within the channel, the percentage of each rock that is below the silt line is recorded as a measure of embeddedness. The higher the percentage of rock that is covered by silt, the higher the level of embeddedness. The area of spawning habitat is calculated by recording the dimensions of each observed spawning area.

Cover was measured by using wooden dowels (10 cm and 30cm each) that are representative in size of juvenile fish and adult fish. These dowels were used to quantify the carrying capacity for juvenile Atlantic salmon and Brook trout and adult Brook trout based on the total cover available for each age-class of fish across each HSI transect. Each dowel is manually moved across each transact, where potential cover features are evaluated by physically moving the dowel underneath potential cover (e.g., large rock or embedded wood). If the potential cover is sufficient to provide complete cover for the dowel, it is counted towards the overall number of fish. Cover for fish can be provided by instream debris, over-hanging vegetation and either boulders substrate for adult fish and cobble substrate for fry and parr.

Spawning habitat was evaluated based on substrate composition, substrate size (diameter), the level of embeddedness) and the overall area of spawning habitat. Atlantic salmon and Brook trout require spawning habitat that is comprised primarily of gravel and cobble. The presence of fines, boulders and bedrock are known factors that contribute to increased egg mortality and therefore are calculated against the spawning score. To receive a very good score (<0.80) observed spawning habitat must have an average substrate size between 2cm and 9.5cm and the level of embeddedness must be >5%. Spawning habitat that does not meet one of these criteria receives a moderate score (0.60 to .79) and spawning habitat that does not meet either criteria will receive a poor score (>0.60).

HSI Excel Spreadsheet Evaluation and Interpretation

The NSHSI Excel spreadsheet evaluates data collected in the field based on suitability models so that limiting factors can be easily identified for both Atlantic salmon and Brook trout. The formula calculates 15 important criteria for each species in a range from 0-1, where poor quality is given a value of less than 0.4, moderate quality has a value between 0.4 and 0.8, and good quality has a value of greater than 0.8.

The criteria evaluated are:

- percent pools,
- pool class rating,
- percent instream cover for adults and juveniles,
- dominant substrate type in riffle run areas,
- vegetation along the streambank,
- rooted vegetation and stable rocky ground,
- water temperature, pH, size of substrate in spawning areas,
- Percent fines in spawning areas,
- percent fines in riffle-run areas,
- substrate size class for winter escape,
- thalweg depth during late growing season,
- percent stream shade

In 2023, as part of baseline data collection, HSI surveys were completed to evaluate instream physical parameters at 30 sites over 3 separate locations within the watershed. HSI surveys will continue to be conducted at the same sites in 2024 (year one post-restoration monitoring), 2025 (year two), 2026 (year three), and 2027 (year four).

Full survey results can be found in Appendix C.

Monitoring Results

The data collected for each habitat suitability index assessment conducted was entered into excel spreadsheet which was used as a scoring system to generated result for each sampling site. The results are then used to determine the habitat suitability for Atlantic salmon and brook trout for those project locations. Each year, ISAA will collect HSI data at the same sampling sites, so result can be compared and the habitat conditions and changes within the watercourse can be measured.

Channel Depth

Channel depth is measured by recording the thalweg (deepest section of the channel) and is important metric for assessing fish migration potential. For Atlantic salmon and Brook trout a thalweg depth greater than 15cm is an important requirement for upstream migration, therefore thalweg depth is measured and recorded at each transect throughout the HSI study site. Instream structures are installed to promote the narrowing of the channel, which will reconnect the floodplain, thus promoting the recovery of natural instream features.

Thalweg depth is an important metric to determine the ability of juvenile Atlantic salmon and adult Brook trout to migrate upstream in search of cold-water refugia. Thalweg depth of less than 15cm can prohibit upstream migration of fish. For a summary of the 2023 thalweg depths from the four HSI sampling sites, please see table 3.

Table 2. Thalweg Channel depth summary for 2023.

Site	Sites with thalweg depth > 15cm	Sites with 1 thalweg depth measurement < 15cm	Sites with 2+ thalweg depth measurements < 15cm
MBR01	4	6	0
MBR01B	3	2	0
MBR02	5	5	0
MBR03	8	2	0

Late Season Growing for Adult Brook Trout

This metric is used to assess overall depth of pool habitat. This is important for Brook trout parr and adults they primarily feed in pool habitat. A lack of sufficient depth in these areas increases the impacts of predation and mortality during feeding periods. A thalweg depth of 40cm or greater is required for a very good score, a depth of 20-40cm is required for a moderate score, and a depth less than 20cm is considered poor. For the 2023 depth of pool habitat scores, please see table 4.

Table 3. Depth of pool habitat scores for 2023.

Site	Poor (<20cm)	Moderate (20-40cm)	Very Good (>40cm)
MBR01	5	4	1
MBR01B	4	1	0
MBR02	3	7	0
MBR03	3	7	0

Fry Water Depth

This metric provides a score to the thalweg depth in riffle habitat, an important metric for both Atlantic salmon fry and Brook trout fry. A depth of 20cm or greater is required for a very good score, a depth of 10-20cm is required for a moderate score, and a depth less than 10cm is scored as poor. Overall, each site received a very good score with thalweg measurements of 36 cm, 32cm and 21cm respectively. For the 2023 fry water depth scores, please see table 5.

Table 4. Fry water depth scores for 2023

Site	Poor (<10cm)	Moderate (10-20cm)	Very Good (>20cm)
MBR01	0	0	10
MBR01B	0	0	5
MBR02	0	0	10
MBR03	0	0	10

Parr Water Depth

This metric provides a score to the thalweg depth in run habitat, which is critical for Atlantic salmon parr rearing. A depth of 30cm or great is required for a very good score, a depth of 20-30cm is required for a moderate score, and a depth less than 20cm is scored as poor. This provided an overall score of very good. For the 2023 parr water depth scores, please see table 5.

Table 5. MBR01 Parr water depth scores for 2023.

Site	Poor (<20cm)	Moderate (20-30cm)	Very Good (>30cm)
MBR01	0	1	9
MBR01B	0	2	3
MBR02	0	2	8
MBR03	0	5	5

Pool Class Rating

Pool class rating is evaluated by measuring low flow pool depth and the amount of pool cover. See table 6 for pool class rating methodology.

Table 6. Pool class rating methodology (adapted from NS Fish Habitat Assessment 2019 Field Manual)

Pool Class	Low Flow Pool Depth	Amount of Cover
Very Good (A)	>1m, or >15% of width	>30%
Moderate (B)	$\leq$15% of width, and $\geq$15cm	5-30%
Poor (C)	<15cm	<5%

Low flow pool depth was measured by subtracting the depth of the tail-end control form the thalweg depth (deepest point of the pool). Percentage of instream cover was measured by calculating the percentage of the pool area that contains suitable cover for fish from birds of prey. Features such as embedded logs, over-hanging vegetation, and deep water that prevents bottom visibility were considered cover for pool habitat as they provide areas for fish to hide without exposure to predators.

The absence of instream debris and lack of pool depth resulted in moderate to poor pool class ratings. Twenty-three (23) pools were found in the 35 HSI sites. The mean low flow depth, mean pool area and average percent of pool cover varied at each location. These metrics are combined to calculate a pool class rating for each HSI site. For 2023 pool class rating scores, please see table 7.

Table 7. Pool class rating scores in 2023.

Site	Poor	Moderate	Very Good
MBR01	5	4	1
MBR01B	4	1	0
MBR02	3	7	0
MBR03	3	7	0

Percent Pool Habitat

The total area in each HSI site that is considered pool habitat is an important metric for evaluating Atlantic salmon and brook trout habitat. Ideally for brook trout, each HSI site is comprise of >50% in pool habitat, while Atlantic salmon require >25%. Most of the Atlantic Salmon's adult life stage is spent in the marine environment, therefore less pool habitat is required for that species' survival. For brook trout, HSI sites with >50% pool area received a very good score, sites with 25-50% received a moderate score, and sites with <25% received a poor score. This resulted in an overall score of moderate. For the results for percent pool habitat for brook trout, please see table 8.

Table 8. Results for percent pool habitat for Brook trout.

Site	Poor (<25%)	Moderate (25-50%)	Very Good (>50%)
MBR01	5	4	1
MBR01B	3	2	0
MBR02	5	3	2
MBR03	4	5	1

For Atlantic Salmon, HSI sites with >25% pool habitat received a very good score, sites between 10-25% pool habitat received a moderate score, and anything less than 10% pool habitat was scored as poor. For the results for percent pool habitat for Atlantic Salmon, please see table 9.

Table 9. Results for percent pool habitat for Atlantic salmon.

Site	Poor (<10%)	Moderate (10-25%)	Very Good (>25%)
MBR01	6	1	3
MBR01B	3	2	0
MBR02	5	3	2
MBR03	4	5	1

Substrate

To quantify substrate, each HSI site was divided into three transects, spaced at intervals equal to 2 widths the channel design width. The substrate was evaluated at each transect using a $1m^2$ quadrant divided into 20 squares, each squares representing 5% of the substrate surface area. The quadrant is used at 3 points

across each transect to measure substrate, providing a representation of the total cross section of the channel. Substrate material was classified as fines, gravels, cobbles, boulders, or bedrock.

Dominant Substrate Type in Riffle and Run Areas

Riffle and run habitat features should contain substrate of at least 50% cobble and the percentage of either boulders or gravel should not exceed 25% each. Furthermore, the presences of any fines or bedrock in either of these features is a sign of degradation and reduces the value for this metric, as the presence of fines in these areas can adversely affect survival, food production, and escape cover from predation (Raleigh, R.F., 1982).

The values for both Atlantic salmon and brook trout are based on the same conditions for this metric. For the riffle and run habitat scores for 2023, please see table 10.

Table 10. Riffle and run habitat scores for 2023.

Site	Poor	Moderate	Very Good
MBR01	0	8	2
MBR01B	1	3	1
MBR02	0	6	4
MBR03	0	8	2

Instream Cover

A score was generated based on the overall composition of each measured area and is dependant on the characterization of each transect (e.g., pool, riffle, or run). Riffle habitat should contain a mixture of cobbles and gravels while pool and run habitat should contain mostly cobble and boulders. Pools, riffles, and runs provide cover for different life cycles of Brook trout and Atlantic salmon. Riffle habitat provides cover for the Atlantic salmon fry, run habitat provides cover for Atlantic salmon parr and adult brook trout, and pools provide cover for adult Atlantic salmon. Scores are generated for each life stage based on their requirements for cover and the level of embeddedness at those sites.

Instream Cover for Fry

High numbers of juvenile densities are associated with large, deep, low-velocity pools with abundant instream cover, overhanging vegetation, and gravel-cobble substrate (Raleigh, R.F., 1982). For scores for instream cover for Brook trout fry for 2023, please see table 11.

Table 11. Scores for instream cover for Brook trout fry for 2023.

Site	Poor	Moderate	Very Good
MBR01	0	6	4
MBR01B	0	4	1
MBR02	0	1	9
MBR03	0	3	7

The full results for instream cover for Atlantic salmon fry can be found in Appendix C: Table 3, Column D. For the scores on instream cover for Atlantic Salmon for 2023, please see table 12.

Table 12. Scores for instream cover for Atlantic salmon fry for 2023.

Site	Poor	Moderate	Very Good
MBR01	0	6	4
MBR01B	0	4	1
MBR02	0	0	10
MBR03	0	2	8

Instream Cover for Atlantic Salmon Parr

A high pool percentage and pool class rating is considered essential cover for salmon parr as they provide salmon the ability to successfully migrate, access suitable holding habitat, and the ability to survive and spawn successfully (Raleigh, R.F., 1982). For the scores on instream cover for Atlantic Salmon parr in 2023, please see table 13.

Table 13. Scores for instream cover for Atlantic salmon parr in 2023.

Site	Poor	Moderate	Very Good
MBR01	9	1	0
MBR01B	4	1	0
MBR02	9	1	0
MBR03	0	5	5

Instream Cover for Brook Trout Parr and Adults

Brook trout parr occupy the same habitat features as those of adult Brook Trout, therefore a single metric is used to score both life stages. For the scores on instream cover for brook trout parr and adults for 2023, please see table 14.

Table 14. Scores for instream cover for Brook trout Parr and Adults in 2023.

Site	Poor	Moderate	Very Good
MBR01	9	1	0
MBR01B	4	1	0
MBR02	9	1	0
MBR03	0	3	7

Spawning Habitat

Spawning habitat is evaluated on two metrics: substrate size and embeddedness. A very good score contains substrate ranging form 2-9.5cm in size and is less than 5% embedded. A moderate score meets 1 of these 2 criteria, and a poor score does not meet either criterion.

Spawning habitat for Brook Trout was present in 17 out of 35 total sites, and spawning habitat for Atlantic Salmon was also present in 15 out of 35 total sites. For a spawning summary for the four HSI sites, please see tables 15-18.

Table 15. MBR01 Spawning site summary for 2023.

	Total Spawning Sites	Poor Substrate	Moderate Substrate	Very Good Substrate
	2023	2023	2023	2023
Brook Trout	5	4	1	0
Atlantic Salmon	4	0	4	0

	Total Spawning Sites	Heavily Embedded (poor)	Moderately Embedded	Not Embedded
	2023	2023	2023	2023
Brook Trout	5	3	2	0
Atlantic Salmon	4	3	1	0

Table 16. Showing MBR01B Spawning site summary for 2023.

	Total Spawning Sites	Poor Substrate	Moderate Substrate	Very Good Substrate
	2023	2023	2023	2023
Brook Trout	1	1	0	0
Atlantic Salmon	1	0	1	0

	Total Spawning Sites	Heavily Embedded (poor)	Moderately Embedded	Not Embedded
	2023	2023	2023	2023
Brook Trout	1	0	1	0
Atlantic Salmon	1	0	1	0

Table 17. MBR02 Spawning site summary for 2023.

	Total Spawning Sites	Poor Substrate	Moderate Substrate	Very Good Substrate
	2023	2023	2023	2023

Brook Trout	7	7	0	0
Atlantic Salmon	6	0	6	0

	Total Spawning Sites	Heavily Embedded (poor)	Moderately Embedded	Not Embedded
	2023	2023	2023	2023
Brook Trout	7	2	2	3
Atlantic Salmon	6	3	1	2

Table 18. MBR03 Spawning site summary for 2023.

	Total Spawning Sites	Poor Substrate	Moderate Substrate	Very Good Substrate
	2023	2023	2023	2023
Brook Trout	4	4	0	0
Atlantic Salmon	4	0	3	1

	Total Spawning Sites	Heavily Embedded (poor)	Moderately Embedded	Not Embedded
	2023	2023	2023	2023
Brook Trout	4	0	0	4
Atlantic Salmon	4	0	0	4

Riparian Zone Vegetation

Riparian zone vegetation was evaluated by measuring the percentage of ground covered by trees, shrubs, grasses, and hedges, and bare ground within 10m from the bank's edge. For the riparian zone vegetation scores for 2023, please see table 19.

Table 19. Riparian zone vegetation scores for 2023.

Site	Poor	Moderate	Very Good
MBR01	0	0	10

MBR01B	0	1	4
MBR02	0	0	10
MBR03	0	0	10

Riverbank Stability

The metric is evaluated by measuring the percentage of each streambank that is covered in stable rooted vegetation and the percentage of streambank that is actively eroding. The scores for both Brook trout and Atlantic Salmon are shared in this metric. For the riverbank stability scores for 2023, please see table 20.

Table 20. Riverbank stability scores for 2023.

Site	Poor	Moderate	Very Good
MBR01	0	2	8
MBR01B	0	0	5
MBR02	0	0	10
MBR03	0	0	10

Summary

The results found in this study showed that the overall habitat conditions range between poor to moderate for Atlantic salmon and brook trout. Overall, the sites lacked in pooling areas and spawning habitat. Our goal for habitat restoration work is to mitigate those impacts by installing instream structures such as digger logs and deflectors. In time, ISAA expects for those habitat conditions to improve as the structures work to restore the stream. Even though the results were poor to moderate, ISAA did observe spawning activity when conducting redd count surveys.

Temperature Probes

As part of our monitoring program, ISAA deployed 22 temperature loggers in 2023 throughout the Mabou Harbour Watershed. These loggers are used to record water temperatures and store the data until it can be offloaded. Loggers were provided by the Nova Scotia Salmon Association through the Adopt-a-Stream program and were deployed in strategic locations to best represent the entire watershed. Loggers were deployed in the early weeks of June and retrieved in the later weeks of September. This allowed for the data to represent the warmest months leading into the spawning season. Of the 22 loggers deployed, 17 were retrieved and analyzed. Figure 6 shows the locations of each logger deployment.

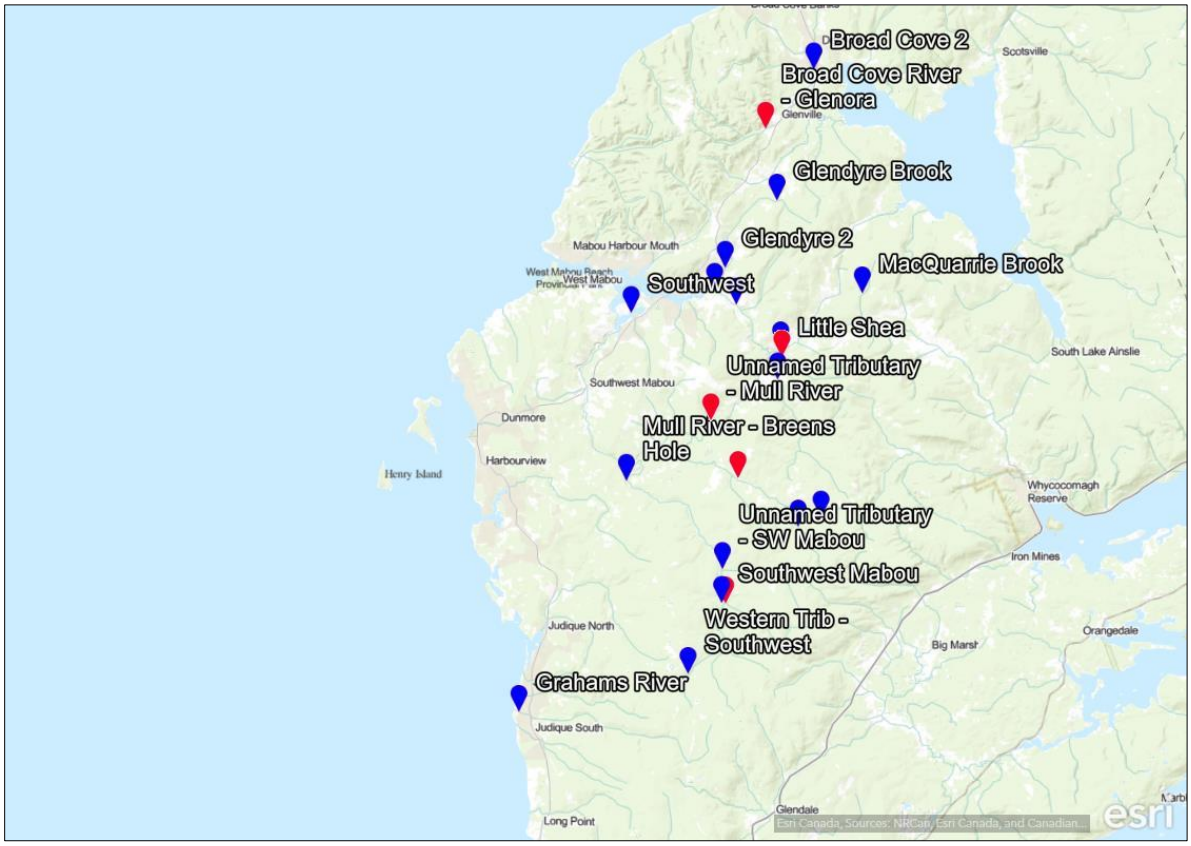

Figure 6: Showing 2023 temp. logger locations throughout the Mabou Harbour Watershed.

Methodology

Prior to deployment, the location of each temperature logger was using the ArcGIS mapping system. Deployment locations were based on previous deployment locations and based on future and ongoing monitoring projects. Locations were then entered into a GPS coordinates system, which was taken into the field to find each deployment site. The ISAA team members then travelled by car and on foot to the chosen locations with prepared loggers. The process of deployment involved securing each logger to a brick anchor using zip-ties. The brick was then fastened to a tree near the watercourse using a rope measuring 6+ feet. This allowed for tethering the anchor brick to a secure point above the riverbank for

easy retrieval and to ensure the probe was not lost in high water events. Each logger identification number was noted prior to deployment as well as the time and coordinates of the deployment location. Loggers were left to collect data every 15 minutes for the duration of the season. Once the loggers were retrieved, the loggers' data was exported, analyzed, and compiled to determine minimum, average and maximum water temperatures.

Equipment/Materials

- Anchor Brick
- Zip-Ties
- Twine
- Probe
- Notebook / Pen
- GPS / Camera

Deployment / Retrieval

Loggers were deployed between June 8th and 19th, 2023. Loggers were then retrieved between September 18th and 25th, 2023, see table 21. Of the 22 loggers deployed, 4 were not found and 1 was found but unable to offload data. It is common to lose probes as high-water events are known to cause the tether rope to snap, taking the probe downstream.

Table 21. Showing 2023 temp logger deployment and retrieval information.

Probe Number	Watercourse	Watershed	Date Deployed	Time Deployed	Date Retrieved	Time Retrieved	Notes
20676897	Shea's Brook	Mull River	2023-06-08	10:00 AM	2023-09-20	11:45 AM	
20676877	Graham's River	Graham's River	2023-06-15	2:00 PM	2023-09-18	1:50 PM	
21028029	More Brook	Broad Cove	2023-06-15	9:00 AM	2023-09-21	9:10 AM	
20813158	Glendyre Brook	Mull River	2023-06-08	1:00 PM	2023-09-20	9:15 AM	
21092864	Mull River	Mull River	2023-06-15	1:00 PM	2023-09-18	12:45 PM	Moran's Pit/Breens Hole
20819831	Unnamed Tributary	Mull River	2023-06-14	9:15 AM	2023-09-18	11:00 AM	Up MacKinnon Road, past 2022 work site
21079490	Southwest Mabou River	Southwest Mabou	2023-06-19	9:45 AM	2023-09-18	10:15 AM	
21079487	Mabou River	Mull River	2023-06-08	9:00 AM	2023-09-20	10:00 AM	Green steel bridge on Celtic Trail by the landing

20822231	Unnamed Tributary	Southwest Mabou	2023-06-19	9:15 AM	2023-09-18	10:30 AM	
21035834	Broad Cove River	Broad Cove	2023-06-08	3:15 PM	2023-09-25	3:45 PM	Foot Cape Road, first bridge
21079479	Mull River	Mull River	2023-06-14	10:30 AM	2023-09-25	9:00 AM	2022 Project location, MacKinnon Road
20676895	Mull River	Mull River	2023-06-18	12:00 PM	2023-09-21	8:00 AM	Little Mabou Road
20874322	MacQuarrie Brook	Mull River	2023-06-15	10:15 AM	2023-09-20	10:25 AM	Jeff Lee's Property
20822242	Western Tributary	Southwest Mabou	2023-06-19	8:45 AM	2023-09-18	9:15 AM	
20676899	Mull River	Mull River	2023-06-09	9:45 AM	2023-09-20	11:05 AM	Old Mull River Road
20822224	Glendyre Brook	Mull River	2023-06-08	8:45 AM	2023-09-20	9:30 AM	Landing
21035829	Mull River	Mull River	2023-06-08	11:15 AM	2023-09-28	10:45 AM	Murry's Bridge
20676914	Unnamed Tributary	Mull River	N/A	N/A	2023-09-20	8:45 AM	By Jim Sinclair's property. Probe might be broken.
Unknown	Little Shea	Mull River	N/A	N/A	2023-09-20	11:30 AM	Missing Probe
Unknown	Broad Cove River	Broad Cove	N/A	N/A	2023-09-21	8:40 AM	Distillery. Missing Probe
Unknown	MacLeod Brook	Southwest Mabou	N/A	N/A	2023-09-18	10:00 AM	Missing Probe.
Unknown	Mull River	Mull River	N/A	N/A	2023-09-18	11:50 AM	2023 Project Location. Missing probe.

Results

Below, table 22 shows the average temperature, maximum temperature, and minimum temperature as well as the dates that the minimum and maximum temps occurred throughout the season at each logger location. It should be noted that several anomalies occurred in the data, most likely resulting from loggers having been above the waterline at times. Temps like 30.457 and 36.620 degrees Celsius are well above

the acceptable 16-degree threshold for salmon survival. It can be assumed that these probes were out of the water at the time of these recordings. This would also affect the average temp. Mid to late July proved to be the warmest time in the season, and Mid-June showing the coldest temperatures. Averages ranged from 13.40 to 21.31 degrees Celsius across all locations in the watershed.

Table 21.. Temperature results for the 2023 temperature loggers.

Site Code	Max (°C)	Date	Min (°C)	Date	Avg. (°C)
20676897	23.484	07/18/23 5:30 PM	9.077	06/12/23 5:45 AM	16.39
20676877	24.931	07/18/23 4:15 PM	9.866	06/21/23 6:30 AM	17.62
21028029	19.092	07/17/23 4:00 PM	8.082	06/21/23 6:00 AM	14.15
20813158	22.046	07/27/23 2:45 PM	6.775	08/25/23 6:30 AM	13.40
21092864	30.457	07/18/23 5:30 PM	10.553	06/20/23 6:30 AM	19.62
20819831	19.377	07/19/23 7:30 PM	8.581	06/21/23 6:45 AM	15.19
21079490	27.665	07/18/23 3:45 PM	9.275	06/21/23 7:15 AM	17.08
21079487	26.390	07/16/23 7:45 PM	9.965	06/12/23 7:00 AM	18.08
20822231	24.448	07/18/23 5:15 PM	9.472	06/21/23 6:45 AM	16.90
21035834	21.569	07/17/23 5:45 PM	8.680	06/12/23 3:15 AM	15.27
21079479	22.429	07/18/23 5:15 PM	9.373	08/25/23 5:30 AM	16.05
20676895	36.620	07/18/23 6:00 PM	6.775	06/21/23 2:15 AM	21.31
20874322	21.282	09/20/23 4:30 PM	9.176	06/21/23 7:30 AM	15.97
20822242	27.272	07/18/23 4:15 PM	10.063	06/20/23 7:00 AM	17.574
20676899	28.357	07/17/23 4:15 PM	7.782	06/12/23 5:30 AM	16.70
20822224	23.484	07/17/23 4:45 PM	8.779	06/12/23 6:00 AM	15.64
21035829	26.977	07/16/23 5:45 PM	9.472	06/12/23 7:00 AM	17.50

Data collected in 2022, listed bellow in Table 23, shows averages ranging between 12.277 and 20.776 degrees Celsius. When compared the 2023 season there is an average increase of 1 degree between the two years.

Table 22. Temperature data from 2022.

Site Code	Max(°C)	Date	Min (°C)	Date	Avg. (°C)
MUL129B	27.075	08/07/22 4:45 pm	6.775	10/04/22 9:00 am	17.878
MUl131	20.043	08/07/22 4:30 pm	6.573	10/04/22 7:30 am	13.870
MUL139	25.805	08/07/22 4:15 pm	5.552	10/04/22 9:15 am	16.301
MUL142A	30.659	08/07/22 3:15 pm	-1.228	10/04/22 7:15 am	17.835
MUL143	21.951	08/07/22 4:30 pm	5.450	10/04/22 10:00 am	12.277
MUL144	23.581	08/07/22 4:00 pm	6.978	10/04/22 9:00 am	14.153
SWM001	41.928	08/07/22 2:00 pm	1.656	10/04/22 7:15 am	20.776
SWM001B	26.488	10/05/22 2:25 pm	7.381	06/05/22 6:45 am	15.820
SWM003B	31.880	07/25/22 4:30 pm	5.552	10/04/22 8:45 am	19.127
SWM002	28.159	08/07/22 3:15 pm	5.860	10/04/22 8:15 am	15.595

Summary

In the 2023 season, temperatures varied greatly, ranging from 6.775 to 30.457 degrees Celsius. Although we can assume that the high-end temps represent a probe above the waterline, we know that an average temperature of 13.40 to 21.31 degrees Celsius is a more acceptable range of environment for salmonids. These results represent a healthy watershed idea for spawning and late stage growing for juveniles.

Redd Counts

Redd count surveys are one method of estimating salmonid population sizes, identifying trends in populations, and gaining information on special and temporal spawning distributions. Redd counts can be carried out with relative ease once staff are trained and experienced. They offer a less expensive and less intrusive method of acquiring information about salmon populations than other methods like mark-recapture programs and operating weirs. Determining presence, absence, or trends in salmon abundance can shed light on overall health of a watershed, as well as indicate specific conditions of watershed health (e.g. water quality, temperature.

Methodology

The purpose of conducting the redd count was established as well as the appropriate spatial scale which was limited to a particular reach. A map was prepared for each reach to be included in the count. Each reach was subdivided into 100m or 50m sections, depending on the size of the watercourse. A data sheet was prepared to record the information while conducting the count. This included information on the redds observed, date, time, etc.. All Equipment needed for the redd count was collected. This is listed below in the Equipment section of this report. Counts were carried out by a crew of two (2) people walking upstream in a pre-determined and georeferenced sections of the watercourse, identifying redds as they were encountered, and information was recorded on the data sheets. All redds were identified to species, measured, labelled, and georeferenced.

Equipment

- Notebook / Pen
- Meter Stick
- GPS / Camera
- Flagging tape

Site Locations

A total of four surveys were conducted between the Mull River, Southwest Mabou River, an Unnamed Tributary to the Southwest Mabou River and MacLeod Brook. Out of those four sites, a total of 7 redds were identified. The following images visually represent the coordinates of those locations. It is assumed that there were redds present but unidentified due to the conditions of the substrate during the time of the survey.

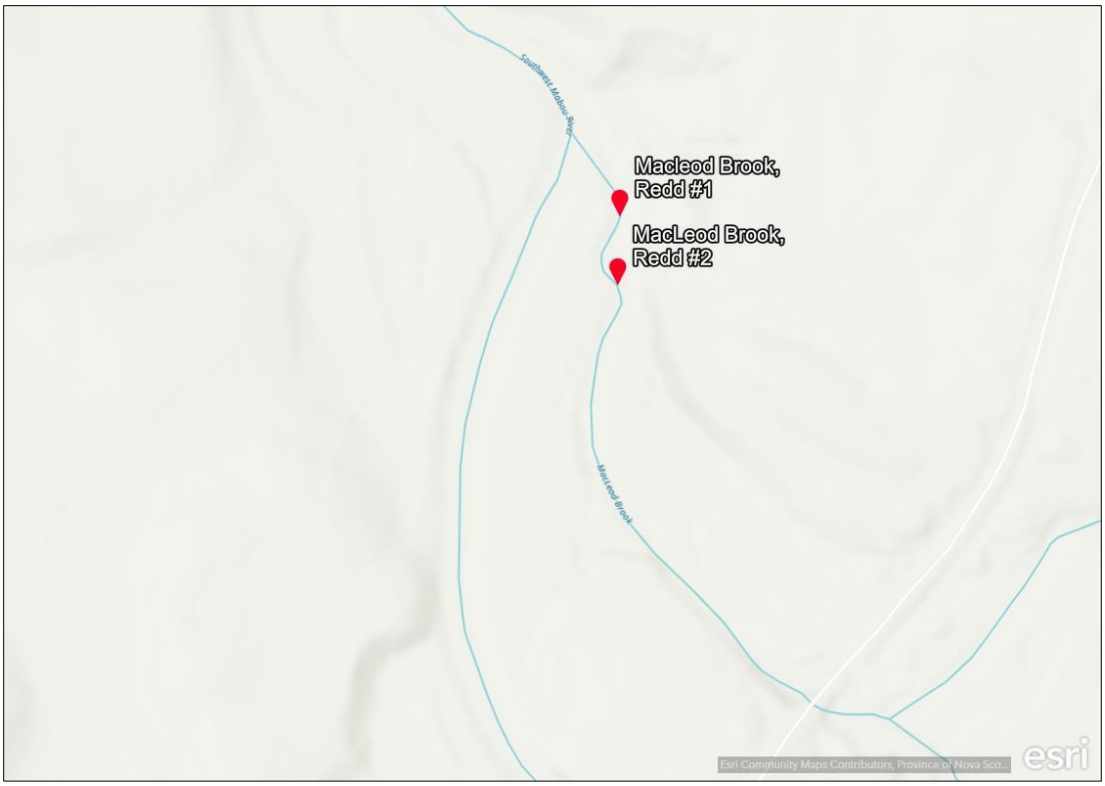

Figure 7: Showing the locations of 2 salmon redds identified on Macleod's Brook

Figure 8: Showing salmon redds identified at 2023 project site.

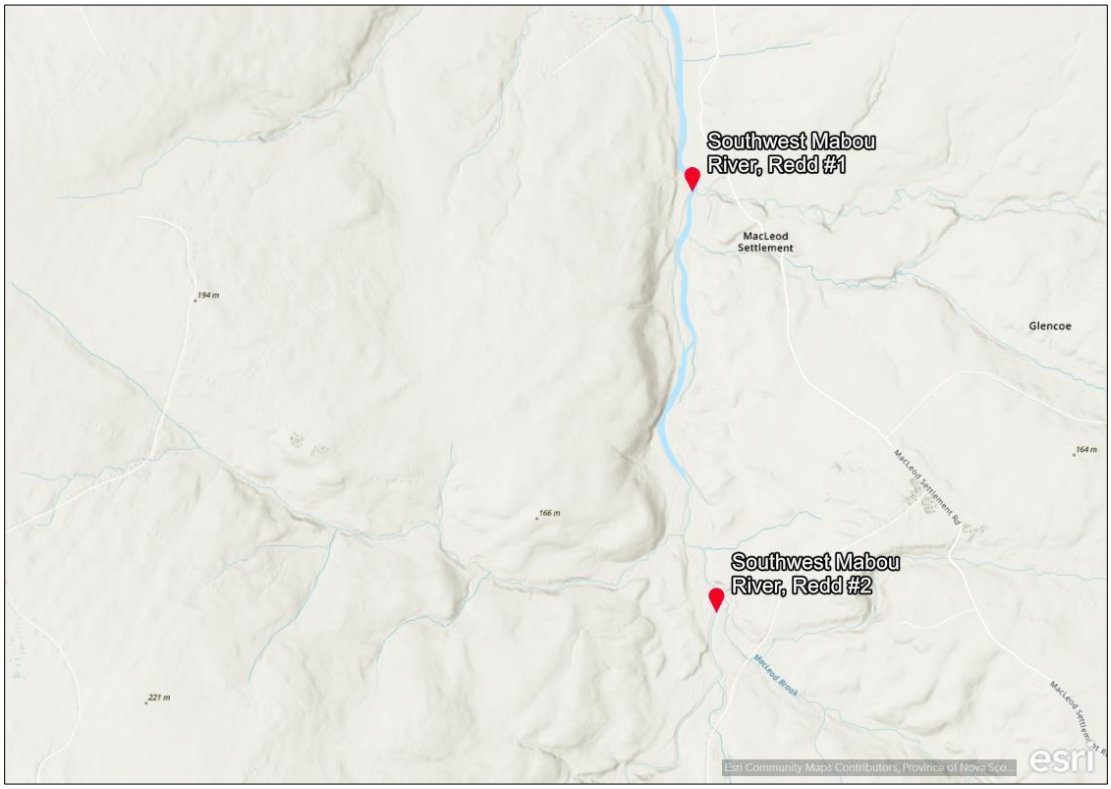

Figure 9: Showing salmon redds identified on Southwest Mabou River.

Results

Two locations were chosen for redd counts. Location 1 was conducted at the project location for 2023, this is the location of HSI sites MBR01 and MBR01B. In total this site reach is 2,175m in length. Location 2 was conducted on the Southwest Mabou River, starting on an unnamed tributary then spanning 1 km upstream from the confluence. The following tables show the results of these surveys.

Table 23. Redd Count Survey on the Mull River, 2023.

Redd Count	Length x Width	GPS location	Notes
1	1m x 0.5m	45 58' 41" 61 20' 26"	Small cobble / gravel Downwelling of a pool
2	0.75m x 0.5m	45 58' 40" 61 20' 23"	Bright, mounded. Small cobble/gravel
3	0.75m x 0.4m	45 58' 41" 61 20' 22"	Small, possible test redd Bright colour, mounded

Active Beaver Dam	Across Digger Log	45 58’ 39” 61 20’ 17”	Impeding fish passage

Table 24. Redd Count Survey on the Southwest Mabou River, Unnamed Tributary and MacLeod Brook, 2023.

Redd Count	Length x Width	GPS location	Notes
1	1.5m x 0.5m	45 56’ 4” 61 21’ 23”	Upstream from unnamed trib. Pot & Mound; Large
2	0.75m x 0.5m	45 55’ 8” 61 21’ 17”	Upstream from MacLeod’s Smaller in length
3	0.5m x 0.5m	45 55’ 9” 61 21’ 15”	Macleod Brook Large Trout or Small Salmon
4	1m x 0.75m	45 55’ 8” 61 21’ 16”	Larger than #3, nearby Possibly same salmon

Summary

Surveys conducted in the 2023 spawning season showed that there are adult salmon returning to the watershed to spawn. It is important to note that an active beaver dam on the 2023 project site does block fish passage. Beyond this point there were no redds identified. This issue raises the question of other blocked fish passage and aquatic connectivity in the region. Although this is a natural occurrence, there are other human caused issues preventing fish passage such as degraded and outdated culverts. On the Southwest Mabou River, there were several large redds identified. This is an indication of a high population of large breeding females making good use of the idea spawning habitat that the Southwest has to offer. With future restoration efforts it is ISAA’s goal to increase spawning habitat throughout the Mabou Harbour watershed.

Appendix "A"

List of Tables

List of Figures

References

NSSA. (2018). *A Field Methods Manual Nova Scotia Fresh Water Fish Habitat Suitability Index Assessment.* Nova Scotia Salmon Association .