Number of restored spawning sites (action C2) within project ReBorN in county of Norrbotten (LIFE15 NAT/SE/000892)

Picture 1 Manual construction of spawning site Vitbäcken (project area Piteälven 2021
Picture 2. Spawning ground description in GIS application (photo Robert Andersson)
Picture 3. Spawning area Råneälven with natural deposit from upstream erosion zone

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Summary

One of the objectives in the ReBorN project was to create 2 300 spawning sites in total. In the county of Norrbotten we managed to create 2 879 spawning sites. The number of expected spawning beds was underestimated since we did not know, in detail the geological conditions in the rivers. We found more gravel that suits spawning beds. Since the spawning beds are one of the limiting factors in our rivers in the abundance of salmon and trout we have created as many spawning beds as possible.

The distribution and size of the spawning sites has a large variation and it mainly depends on the size of the watershed. In the larger rivers large spawning areas can be made where the conditions are suitable. In the smaller tributaries the size of each spawning site becomes substantially smaller in size. To be able to make an adequate estimate of the number of spawning sites the total area on each site is divided by 6m² which represents a functional area used by fish to spawn. The spawning sites are made both with excavators and final adjustments are made manually or the whole process is done manually according to the "Hartijoki method". No additional gravel has been used in the county of Norrbotten.

Between the first count of spawning sites and the final count, we made a second control count during the adjustments this shows that we have lost spawning sites in most of the rivers. The reason for this loss which is significant in some of the larger rivers and it is not completely known.

Spawning sites are made for both migratory and stationary species with a focus on Brown Trout (*Salmo trutta*) and Salmon (*Salmo salar*). The spawning beds can also be used by additional stationary species for example Grayling (*Thymallus thymallus*).

These new constructed or reconstructed spawning sites will allow, **more** fish to use ecological functional spawning areas and **improve** egg to fry survival.

Picture 4. Manually constructed spawning site in tributary to Piteälven (Photo by Robert Andersson)

Background

During the period of transporting timber in the rivers and streams the structures of the riverbeds were badly damaged. Spawning material was either transported downstream when the water velocity increased, and boulders and stones were removed or pressed into the riverbed when timber bounced on the bottom of the streams. This destroyed many spawning sites. One of the objectives in the ReBorN project was to create 2300 spawning sites in total.

Earlier restorations have not put in equally much effort in spawning sites, and therefore results have not always been as intended. Knowledge of the importance of fully functional spawning sites is gained quite recently.

Improvement of spawning sites is necessary to succeed with ecological restoration goals. The quality of spawning sites quality is by far the largest factor affecting restocking of depleted fish populations. The Hartijoki method, which has been slightly altered to fit work with excavators, regulates overflowing current and makes the gravel beds fully oxygenated and gives the fry possibilities to hide deep in the bed during the egg yolk period. These two are the key factors for successful hatching. In addition to spawning site restoration the need of juvenile habitats downstream spawning sites has also been fulfilled during the restoration process.

Method

Restoration or creating spawning sites is made either in one or two steps. Large material is removed with excavators equipped with special buckets with gripping bars, and final adjustments are made manually with, for the purpose, special tools- In small areas with intermediate or small material the work has been done manually.
Spawning beds are preferably done in areas with intermediate current approx. 0.6 m/sec. The first step is to remove large boulders and stones and to make the the bottom "soft and airy" by removing fine sediments. Optimum water depth varies between 0.2 m up to 1.6 m. A finished bed contains natural gravel in a mixture of small stones from 0.5 cm-8 cm in diameter. The boulders and oversized stones are used to create a support on the downstream end of the spawning area and to regulate flow in and over the bed. The goal is to get a waterflow to pass through the gravel bed.

How to find suitable places for restoring or creating spawning areas:

- Preferably in the first 1/3 of the rapid (natural drift of fry after hatching is approximately 300 m the first year).
- Area with lots of extractable spawning gravel.
- Area that could distribute high waterflows to protect the spawning bed from erosion
- Good areas for juveniles directly downstream spawning site. It can be constructed in the further restoration process if necessary.
- Deeper areas and overhanging trees to provide shelter for spawning fish.
- Area upstream where new spawning gravel could be recruited and transported with waterflow to the spawning site.

During 2021 we had a mobile excavator which purpose was to adjust spawning sites. This was really successful because some of the spawning sites that were made during the previous field seasons were made in sub optimal conditions, low or high water levels. For the spawning beds to be fully functional adjustments where needed.

Spawning site size is related to stream size and are often site-specific, in small tributaries there might be only a few m^2 gravel beds which are still fully functional. In large rivers they might be several $100m^2$ of spawning areas. To be able to measure number of spawning sites, one (bed) is considered to be around 6 m^2. In very small tributaries small single spawning sites can be less than $6m^2$, these are counted as one

The spawning areas were mapped in a field GIS application or with a GPS and measurement noticed in a protocol. Later the areas were compiled in a GIS shape file and the geometry were analyzed.

Results

During the 6-year project 2 879 spawning beds have been created within the project areas in the county of Norrbotten and in total 17 257 m² of spawning area is now available for fish. The county of Norrbotten has been working in five different river systems and in total, including tributaries, nine different areas (table 1 and 2).

In all project areas, there is a loss of spawning beds between 2020 and 2021. The loss of spawning beds variates largely between rivers and are the loss is more extensive in the bigger systems (table 3).

River	Total area m²	Number of beds (6 m²)	Number of sites/river
Långträskälven	396	66	14
Åbyälven	3 482	641	76
Stockforsälven	1 173	196	14
Vitbäcken	1 515	253	42
Råneälven	4 632	772	86
Solälven	1 224	204	60
Rutnajoki	40	7	4
Vassaraälven	1 630	272	31
Linaälven	2 805	468	55
Total sum:	**17 257**	**2 879**	**382**

Table 1. Number of spawning beds from all rivers including tributaries within the ReBorN project areas in Norrbotten

River system/River	Total area m²	Number of spawning beds (6m²)	Number of sites in river system
Byske/Långträskälven	396	66	14
Åbyälven	3 482	641	76
Pite/Vitbäcken/Stockforsälven	2 688	449	56
Råne/Rutnajoki/Solälven	5 896	983	150
Kalix/ Lina/Vassara	4 435	740	86

Table 2. Number of spawning beds distributed in the different project areas.

Riversystem	Number of beds 2020 (6m²)	Number of beds 2021 (6m²)	Loss between years	Percentage loss of total between years
Byskeälven	294	66	228	78%
Åbyälven	673	641	32	5%
Piteälven	475	449	26	5%
Råneälven	1528	983	545	36%
Kalixälven	834	740	94	11%

Table 3. Loss of spawning beds between 2020 and 2021.

Discussion

One of the objectives in the ReBorN project was to create 2 300 spawning sites (6 m^2). By the end of field season 2021 and after 6 years of restoration 2 879 spawning sites have been created within the catchment areas of the five main river systems in the ReBorN project areas in the county of Norrbotten. The total accessible spawning area within the project is 17 257 m^2. Spawning sites have been created both in the main rivers and in the small tributaries, the variation in size is largely due to the natural conditions and variations within and between the different river systems.

During the project a large effort has been made to optimize and adjust spawning sites, during the last season of the project we have assigned one excavator with a small crew and a mobile unit to assess spawning sites made during previous seasons and make adjustments to optimize them. This turned out to be very cost-efficient and we managed to do a lot in a short period of time. The need for adjustments is hard to estimate because the total restoration process in the river might alter high flow conditions which affects the stability and longtime survival of the spawning sites. It has been favorable to work in a project that lasts several years, where there has been time to assess this question and make adjustments that will give a better long-time result.

Picture 5. Adjusting spawning site one year after construction with mobile excavator unit and crew in Linaälven (project area Kalixälven). Area was used by salmons in autumn of 2021.

The perfect spawning site works every year and in all types of water levels, but this is hardly ever the case, variations in seasonal waterflow makes the sites work unevenly. The solution is to place spawning sites at different depths and at different distance from the shore. The knowledge of constructing functional spawning sites increases every year by working and investigating behavior of restored river systems. Restoration processes are not a precise science, site specific actions are more common than overall flat -rate actions.

Construction of spawning sites are made by several technical and biological decisions by looking at water velocity, depth and available natural material that are given. The differences in life history traits between and within species that are present in the river also affect the optimal location and construction of the spawning beds. There is a variation in for example choice of size in material and placement of the bed if there are large migratory fish or small stationary fish. The work process constructing spawning site with excavators in larger systems have greatly improved during the project. In planning the restoration work process the understanding of natural conditions are essential. When constructing spawning sites with long life span in larger rivers one need to understand how the change in hydrology will affect the riparian zone and the geomorphology.

Questions related to the construction of spawning sites:

- "How will erosion affect the spawning site?"
- "Is there enough material that will last the expected life span with extra material from upstream?"
- "Will there be deposit of fine material clogging the spawning site?"
- "Will water velocity change during the spring flood so the spawning sites will be washed away?"

These are all questions that we now have a broader knowledge on how to assess and it will be beneficial when working with future restoration projects.

<u>Loss of spawning sites</u>

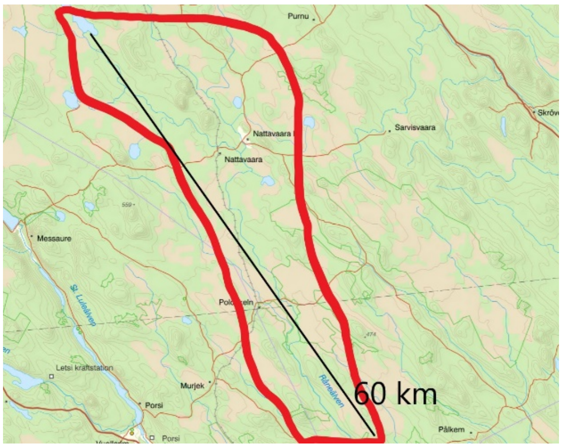
Why is there a loss of constructed spawning sites? There might be several explanations why this happened.

- The restoration work has affected the flow patterns in the actual area in such way that high floods occurring directly after restoration will have a big impact on the spawning beds. Material can be completely or partly flushed away and effect the spawning sites.
- Some beds were made even if the natural conditions where not the best possible, because of long distances between spawning sites within the system.

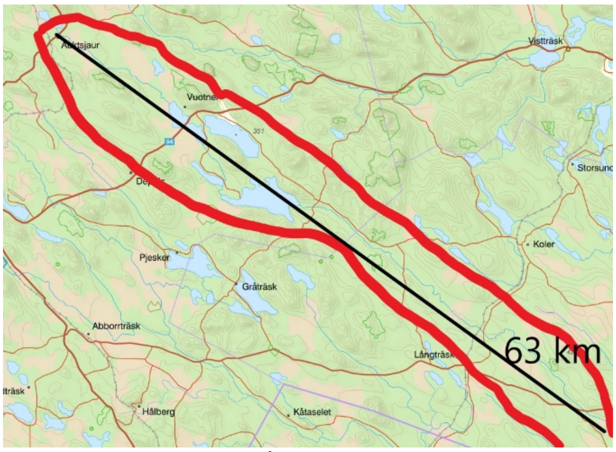
In large rivers there are bigger differences between unrestored and restored areas and changing bigger structures to maximize the effort has bigger effect on the stability in the systems.

River systems also have different patterns which effects the power of spring floods in the systems. If we compare the two different project sites Åbyälven and Råneälven we can see that Åbyälven has several large lakes and slow flowing areas in the water system. This will have an effect on how the spring flood will be released into the system, it comes slowly and will be retained in the lakes systems. Råneälven has no lakes in the system and the spring flood will be rapid and flushes through the system. Pictures 6, 7, 8 and 9.

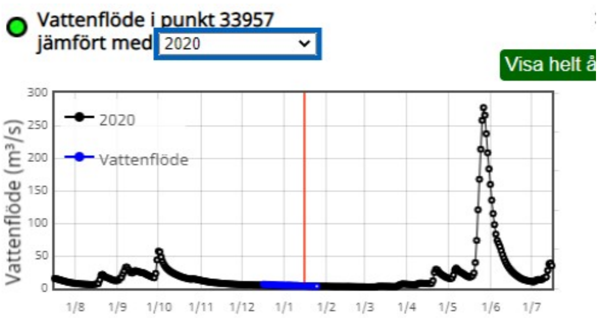
Hence, the effect on material in the river is probably higher in Råneälven than in Åbyälven, this might be one of the explanations to the difference in loss.



Picture 6. Project area Råneälven.



Picture 7. Project area Åbyälven.

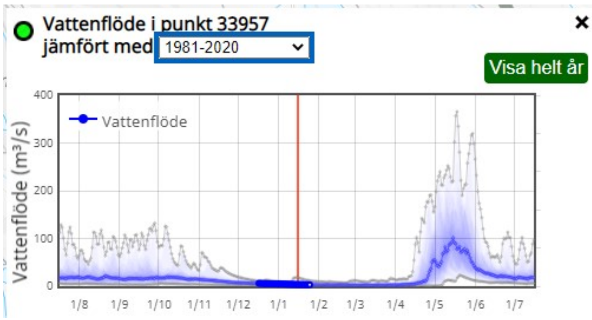


Picture 8. Water flow in project area Råneälven from August to July.

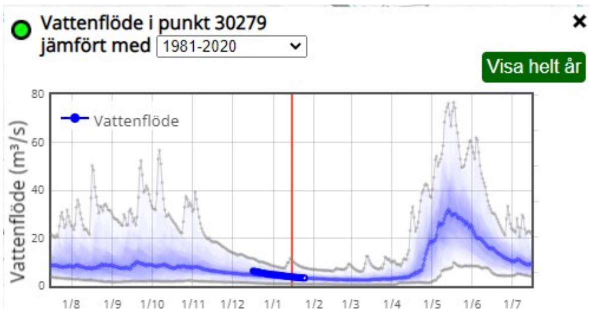
Picture 9. Water flow in project area Åbyälven from August to July.

Another difference is the size of the spring flood, Råneälven has a top of 368 m^3/sec (mean value 1981-2020) and Åbyälven 77 m^3/sec (mean value 1981-2020). Pictures 10 and 11.

Åbyälven only lost 5% of the spawning beds and Råneälven lost 36%.



Picture 10. Water flow (mean value 1981-2020) in project area Råneälven from August to July.



Picture 11. Water flow (mean value 1981-2020) in project area Åbyälven from August to July.

Project areas Byskeälven has, by far, lost most spawning beds – 78 %. Byskeälven was restored in the beginning av the project, mainly in 2017. We have learned much more since then and we have now more knowledge how to create spawning beds in larger areas.

Another thing to investigate more is where the spawning gravel transports. Will it build spawning beds further downstream? Since we only have drone footage of the restoration sites, we do not know how the stream looks like further down. It might be that we have not lost spawning sites, they have re-located. This is something we should investigate more in future projects.

We can only speculate and try to learn from these facts one action that might be wise is to not construct spawning beds at the same time as the restoration process in rivers with high flood regime, but start the construction after the first spring flood has passed through the system.

In the end it is the fish who chooses to spawn or not. Monitoring the spawning sites will give us information how to improve quality and methods making more functional spawning sites in the future.

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