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Effects of reinstalling spawning gravel in Danish *lowland streams*

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Introduction

During the 20th century spawning of brown trout (*Salmo trutta L.*) has declined as a result of the straightening and culverting of 90% of the Danish watercourses. Rigours maintenance practises including removal of coarse material have also been an important factor in the decline in natural brown trout reproduction in Danish streams. Re-establishing spawning sites in streams has been a priority for the Danish stream authorities for many years. However, spawning gravel has been re-introduced into the streams by means of trial and error methods and no effect studies of the spawning site restorations have been carried out.

This project aimed at evaluating 32 restoration projects all more than 5 years old. The 32 sites consisted of three general types of gravel bed restoration: 11 sites where gravel beds had been constructed in connection with re-meandering the streams, 13 sites where gravel beds had been constructed without any other restoration, and 8 sites where gravel beds had been constructed after removal of regulation weirs. The primary objective of the study was to evaluate these restoration efforts, and to investigate how successful the restorations have been.

Methods

Spawning activity and substrate composition (four classes: mud, gravel sand and boulders) were determined in March and May 1999. Visible downstream displacement of spawning gravel from the original position was noted and average gravel depth was recorded on each site. In May all sites were electrofished to determine density of young-of-the-year brown trout.

Table 1. Range of physical condition of the 32 reinstalment sites.

Type	Stream order	Width (m)	Distance to sea (km)	Age of instalment
Gravel in connection with re-meandering	1–3	1.5–6.2	1.4–143.9	5–14
Gravel only	1–3	1.3–7.7	2.1–40.2	6–14
Gravel in connection with removal of regulation weirs	1–3	2.1–2.9	9.2–68.4	9–10

Results

The reinstalled gravel was still present in all sites where gravel had been reinstalled in connection with re-meandering and removal of regulation weirs (Table 2). There were a higher proportion of sites where some gravel had been displaced downstream in sites where reinstalment was done without further improvements (Table 2). Spawning gravel was visible at most sites, only two sites where gravel was placed in connection with re-meandering were completely covered with sand (Table 2). Brown trout spawning was found in 45%, 47% and 50% of all sites in the three types of reinstalments (Table 2).

There were no significant difference in coverage by boulders or gravel among the three types (ANOVA, $P > 0.05$), however a higher proportion of the streambed was covered with sand in sites where gravel had been placed in connection with re-meandering (ANOVA, $P < 0.05$). Sites where reinstalment of gravel was done alone had significantly more mud on the streambed (ANOVA, $P < 0.05$, Fig. 1). Overall, there was no significant difference in magnitude of the gravel layer among the three types (Fig. 2).

The highest density of young-of-the-year brown trout was found in sites where reinstalment of gravel was done alone (Fig. 3). However, these sites were generally much closer to the sea than sites in the other two groups, providing easy access for spawning sea-run brown trout with high fecundity.

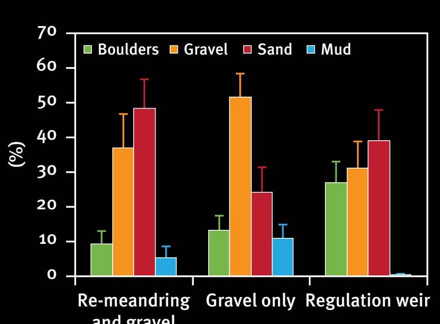

Figure 1. Mean (with SE) substrate composition at the 32 sites.

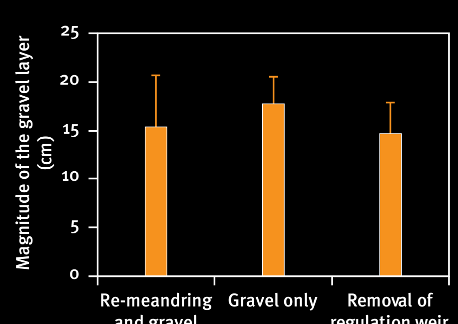

Figure 2. Mean (with SE) magnitude of the gravel layer for the three types.

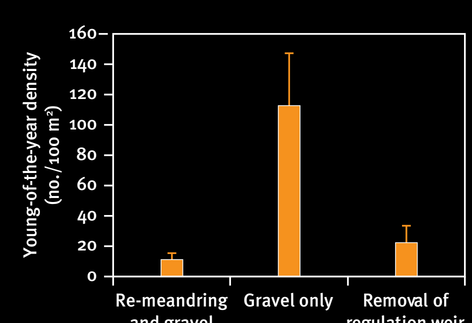

Figure 3. Mean (with SE) densities of young-of-the-year brown trout in sites with reinstalled gravel of three types.

Table 2. Proportion of sites in the three groups where gravel was not displaced downstream, where gravel visible at surface of streambed and with spawning activity.

	Re-meandering and gravel (N = 11)	Gravel only (N = 13)	Removal of regulation weir (N = 8)
Gravel not displaced downstream	11 (100%)	7 (54%)	8 (100%)
Gravel visible at surface of streambed	9 (82%)	13 (100%)	8 (100 %)
Sites with spawning activity	5 (45 %)	7 (47%)	4 (50%)

Conclusion

The study does not provide clear evidence to which of the three types of reinstalment is most successful. Downstream displacement of gravel was most common in sites where gravel was reinstalled without further improvement, however these sites had the highest density of young-of-the-year brown trout, providing evidence that the remaining gravel in these sites are still functional. The results documents that reinstalment of spawning gravel can be an effective way of improving the natural reproduction of brown trout in Danish lowland streams.

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