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# Weirs cause aggregation of Atlantic salmon redds



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## Introduction

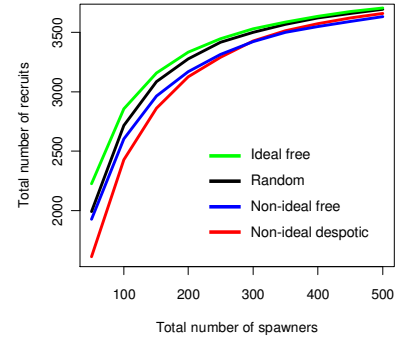
In most populations, competition for resources is local, so aggregation in suboptimal sites curtails population growth rate<sup>1</sup>. If aggregation in suboptimal sites increases at low density (non-ideal despotic distribution), small populations may suffer Allee effects<sup>2</sup>.

Atlantic salmon juveniles undergo local competition for food and shelter. Juvenile distribution is greatly determined by the choice of spawning site, made by mothers<sup>3,4</sup>. This choice may in turn be constrained by obstacles to upstream migration.

→ Is the distribution of Atlantic salmon redds influenced by obstacles?

→ Does the density of spawners modulate this influence?

Simulated productivity vs. density for various spatial distributions



The Nivelle river and its weirs

## Methods

**Study site:** Nivelle river main stream + Lurgorrieta (main tributary), 27.4 km accessible to salmon, 5 weirs > 1.5 m.

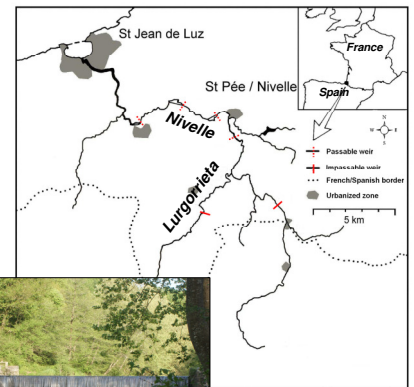
**Database:** map of hydromorphic units suitable for spawning, number of spawning females (estimated from captures at fishways) and location of redds between 1992 and 2006 (weekly census during spawning season).

**Analysis:** Bivariate point pattern analysis: density of redds within  $r$  suitable hydromorphic units downstream from weirs.

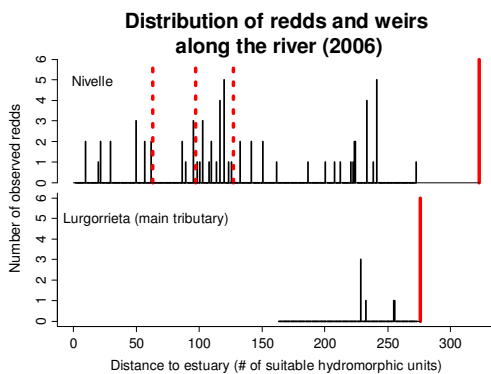
$$K(r, y) = \frac{1}{W \times R_y} \cdot \sum_{i=1}^W \sum_{j=1}^{R_y} \delta_{ij}(r)$$

$W$  = total number of weirs  
 $R_y$  = total number of redds on year  $y$   
 $\delta_{ij}(r) = 1$  if distance between  $i$  and  $j \leq r$   
 $\delta_{ij}(r) = 0$  otherwise

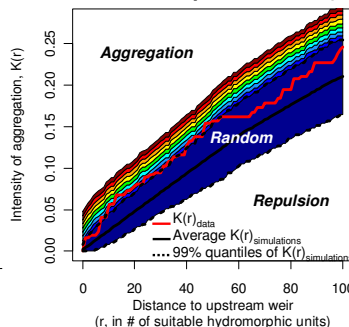
→ compare to 99<sup>th</sup> centile of 999 random distributions within suitable habitat



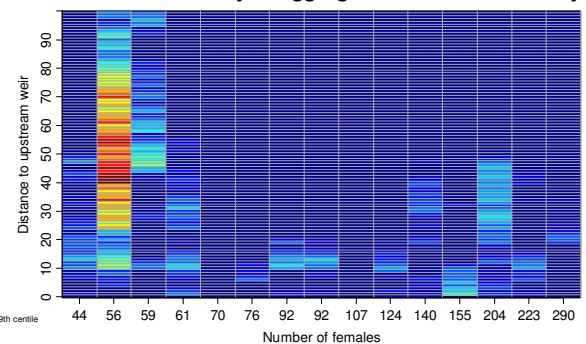
## Results



Intensity of redds aggregation vs. distance from upstream weir (2006)



Scale and intensity of aggregation vs. female density



- Redds usually aggregated in the first 15 suitable hydromorphic units below weirs.
- Aggregation occurred almost every year, at all densities of spawning females in the river.

## Discussion

**Implications for population dynamics:** fish accumulation below obstacles is known<sup>5</sup>, but the aggregation of redds below weirs is a new result. This aggregation may lead to high local densities of juveniles, thereby increasing density-dependent effects on population growth.

**Habitat restoration:** if fish prefer to spawn just below obstacles, habitat improvement should be directed to these zones. Also, opening access to a long stretch of river at one go may lead to aggregation at the new upstream limit and underuse of intermediate zones.

## References

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## Funding

