Weirs cause aggregation of Atlantic salmon redds

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Introduction

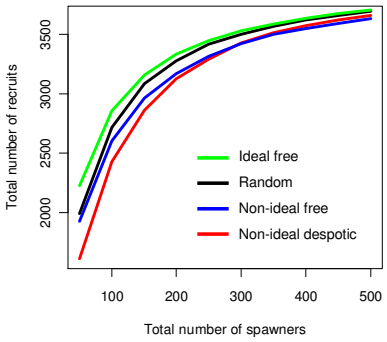
In most populations, competition for resources is local, so aggregation in suboptimal sites curtails population growth rate[1]. If aggregation in suboptimal sites increases at low density (non-ideal despotic distribution), small populations may suffer Allee effects[2].

Atlantic salmon juveniles undergo local competition for food and shelter. Juvenile distribution is greatly determined by the choice of spawning site, made by mothers[3,4]. 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



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).

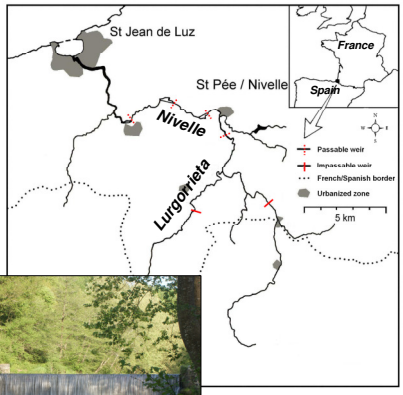
Analysis: Bivariate point pattern analysis: density of redds within *r* suitable hydromorphic units downstream from weirs.

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

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

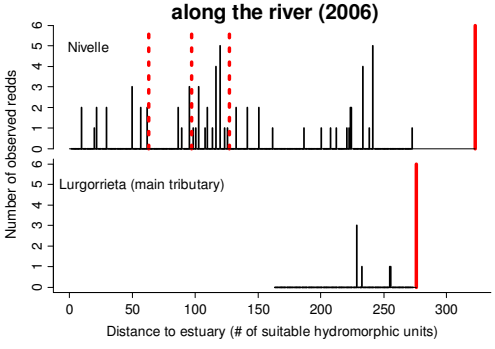
→ compare to 99th centile of 999 random distributions within suitable habitat

The Nivelle river and its weirs

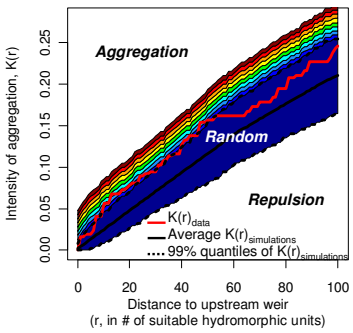


Results

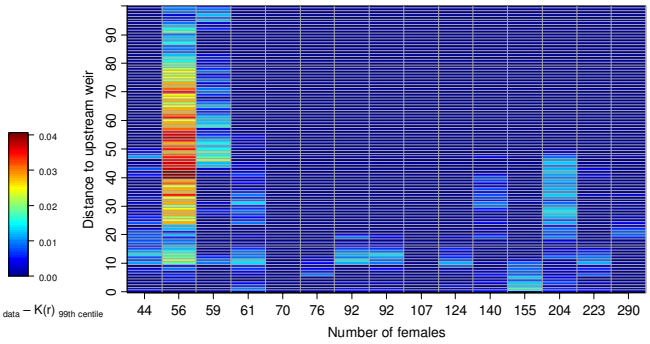
Distribution of redds and weirs along the river (2006)



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[5], 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

[1] Law et al. 2003, *Ecology* **84**: 252-262
[2] Kokko & Sutherland 2001, *Evol. Ecol. Res.* **3**: 537-551
[3] Foldvik et al. 2010, *J. Anim. Ecol.* **79**: 501-509
[4] Einum et al. 2008, *J. App. Ecol.* **45**: 930-938
[5] Garcia de Leaniz 2008, *Hydrobiologia* **609**: 83-96

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