

# IBIS

## Conservation Limits of Atlantic salmon (*Salmo salar*)

Julie Miller BSc(Hons) Mres  
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Stirling



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# What are conservation limits?

## Atlantic salmon

- Endangered
- Annexe II of the EU habitats directive (92/43/EEC).
- Some rivers: Special Areas of Conservation (SAC)
- Freshwater framework directive (2000/60/EC)
- NASCO precautionary approach (1998)



# What are conservation limits?

- Spawning stock level that produces max. sustainable yield
- Safe biological limits
- Management targets (MT) are derived from conservation limits (CL)
- CL/MT depend upon the model used to calculate



# Types of models for CL/ MT

- Limits derived from reference points of stock–recruitment series
- Whole wetted area models
- **Habitat quantity/quality and egg deposition models**



# The Foyle Catchment and CL model

- 4500km<sup>2</sup> wetted area
- SACs since 2005– 15% of UK population found here
- CL/MT and The Foyle Area (Control of fishing) regulations2010



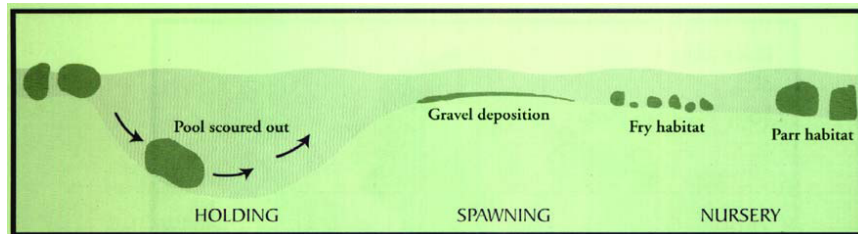
**Figure 1:** Image of the area of Foyle catchment from [www.fishpal.com/Ireland/Foyle/Map.asp](http://www.fishpal.com/Ireland/Foyle/Map.asp)



# The Foyle Model

## GIS and land-based habitat Survey

Department of Agriculture for Northern Ireland (DANI)  
Methodology for habitat classification for salmonids



### ANNEX 1 HABITAT CLASSIFICATION

**NURSERY AREA**

**GRADE 1**

- 50 – 250mm DEPTH
- 0.5 – 8 % GRADIENT
- STABLE COBBLE/BOULDER SUBSTRATE > OR = 70% BED COVER
- PROVIDING ADEQUATE COVER

**GRADE 2**

MARGINALLY OUTSIDE GRADE 1 ON ONE COUNT ONLY

**GRADE 3**

WELL OUTSIDE GRADE 1 ON ONE OR MORE COUNTS

**GRADE 4**

ABSENT, DEEP, CHANNELISED, SILTY etc.

**SPAWNING AREA**

**GRADE 1**

- FLOW 300 – 600 mm/s
- WATER DEPTH 150 – 700 mm
- 70% SUBSTRATE 30 – 80mm DIAMETER
- GRAVEL DEPTH :  
TROUT = 50 – 150 mm  
SALMON = 200 – 500 mm

**GRADES 2 – 4**

FAILING AS FOR NURSERY HABITAT ABOVE










**HOLDING AREA**

**GRADE 1**

DEPTH MINIMUM 1m IDEALLY > OR = 2 m  
SUITABLE COVER: BANKSIDE/SUBSTRATE STABILITY

**GRADES 2 – 4**

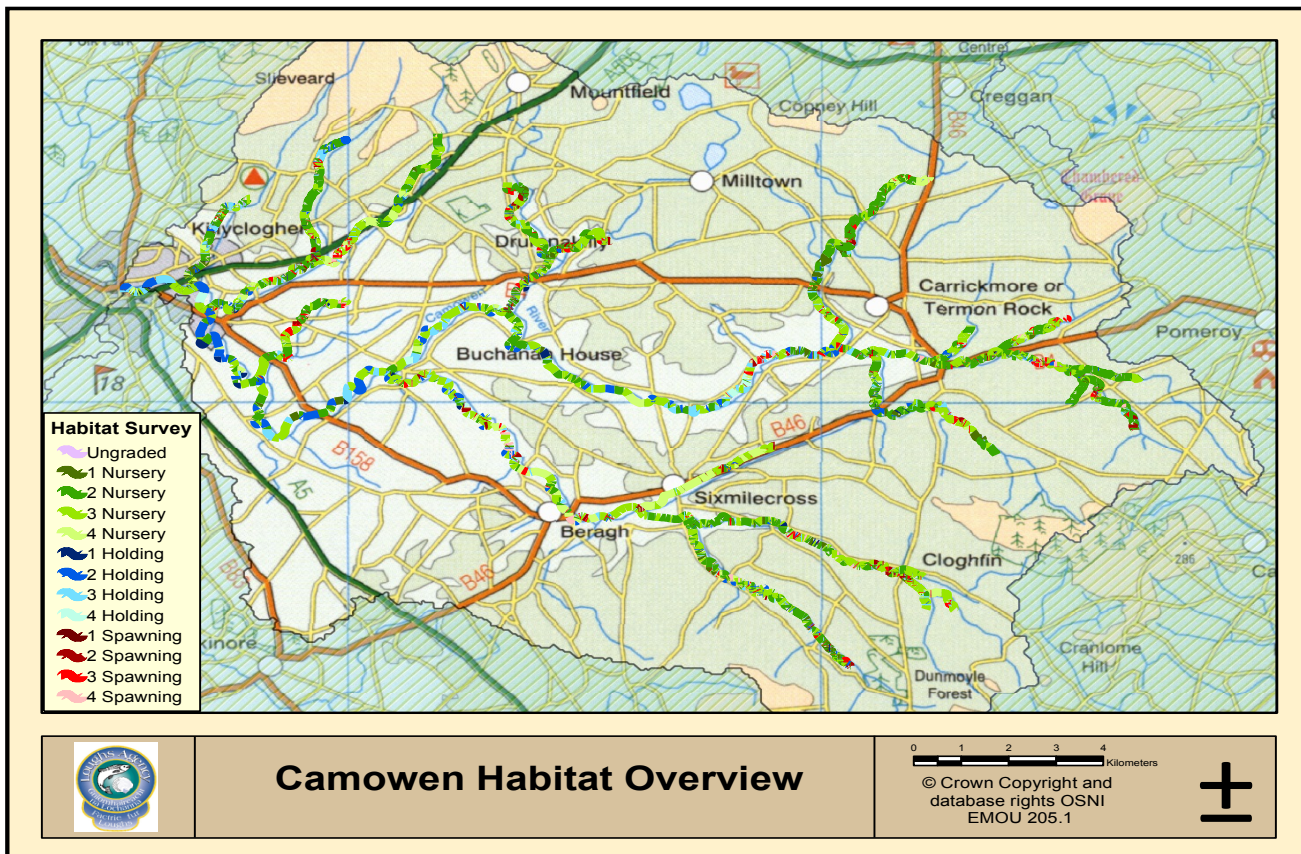
FAILING AS FOR NURSERY HABITAT ABOVE

For further information contact: Department of Agriculture for Northern Ireland  
Fisheries Division, Annexe 5, Stormont, Belfast BT4 3PY. Telephone 01232-522364



# The Foyle Model



# The Foyle Model

- Grade 1 Nursery habitat – 10 eggs/m<sup>2</sup>  
(Kennedy & Crozier 1994)
- Grade 2 Nursery habitat – 5 eggs/m<sup>2</sup>
- Grade 3 Nursery habitat – 2.5 eggs/m<sup>2</sup>
- Grade 4 Nursery habitat – nil





# The Foyle Model

- Correction for potential error etc. 10%
- Female fecundity (1000 eggs/Kg, avg. ♀ – 2.5Kg)
- Sex ratio (60 ♀:40 ♂)
- Management target derived from CL using correction of 25% (natural mortality/poaching etc.)



# Example- the River Finn

| Finn | Area (m <sup>2</sup> ) | Eggs/m <sup>2</sup> | Total Eggs | Plus10%  | Females  | Fish/CL  | MT<br>(+25%CL) |       |      |      |
|------|------------------------|---------------------|------------|----------|----------|----------|----------------|-------|------|------|
| 1n   | 248698.1               | 10                  | 2486981    | 2735680  | 1094.272 | 1823.786 | 2279.733       |       |      |      |
| 2n   | 580129.3               | 5                   | 2900646    | 3190711  | 1276.284 | 2127.141 | 2658.926       |       | CL   | MT   |
| 3n   | 107724.1               | 2.5                 | 269310.3   | 296241.3 | 118.4965 | 197.4942 | 246.8677       | Total | 4148 | 5186 |

Finn fish counter, Killygordon: Angling catch & release

Declaration: if the number of salmon migrating upstream of the River Finn counter during each of any 2 of the previous 5 years has not exceeded MT.



# Addressing Model assumptions

## Female fecundity

**Table 2:** Fecundity values used in models for sensitivity and corresponding source for figure  
(where a range of figures are shown, the lower, middle and upper values were all used as individual values in the model)

| ♀ Fecundity Per kg <sup>-1</sup> | 1,000 | 1,430         | 1000-2000   | 1,100                | 992-1,543      | 1,878               |
|----------------------------------|-------|---------------|-------------|----------------------|----------------|---------------------|
| Source                           | LA    | Shearer(1992) | NASCO(1998) | Cowx & Fraser (2003) | AST/SNH (2012) | Moffet et al (2006) |



# Addressing Model assumptions

## Egg deposition levels

**Table 3:** Egg deposition sensitivity analysis values and corresponding source

| Egg Deposition Per m <sup>2</sup> /Grade | 10                             | 6.6           | 7.4                              | 2.4<br>4.4<br>8.0  | 2.9<br>4.7<br>7.4  | 8.5-10.7                 |
|--|--------------------------------|---------------|----------------------------------|--|--|--------------------------|
| Source                                   | LA<br>(Kennedy & Crozier 1993) | Shearer(1992) | SALMODEL<br>(Crozier et al 2003) | Prevost et al (2003)<br>(10 <sup>th</sup> , median and 90 <sup>th</sup> percentiles) | O'Maoildigh et al (2004)<br>(10 <sup>th</sup> , median and 90 <sup>th</sup> percentiles) | Crozier & Kennedy (1995) |



# Addressing assumption

## Habitat assessment:

- Grading– subjective?
- Paucity of quantitative studies connecting habitat quality to juvenile density

**Table 4:** Table showing the current criteria used by the Loughs Agency to grade habitat

| Nursery Habitat |  |
|-----------------|--|
| Grade           | Criteria   |
| 1               | Depth: 50-250mm<br>Gradient- 0.5-8%<br>Stable substrate<br>Gravel/Pebble/Cobble substrate or 70% bed area<br>Moderate/Adequate Cover |
| 2               | Marginally outside grade 1 on one count only   |
| 3               | Well outside grade 1 on one or more counts   |



# Addressing weakness

- Loch Lomond Fishery Trust had high resolution electrofishing juvenile data AND habitat descriptions using same methodology as LA habitat survey
- Initial analysis suggested no difference in juvenile density and grade (K-W chi sq= 1.9557, df =2, p=0.3761)
- Bayesian framework approach to see which habitat features influenced salmon density





# The Bayes analysis

- MCMC models

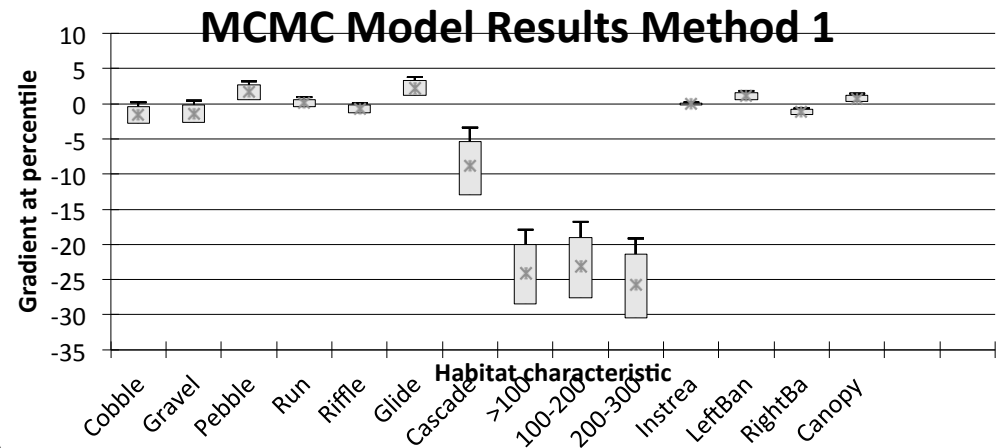
Parameters:

Substrate: 3 levels(Cobble, Gravel, Pebble)

Flow: 4 levels (Run, Riffle, Glide, cascade)

Depth: 3 levels (>100mm,100–200mm,200–400mm)

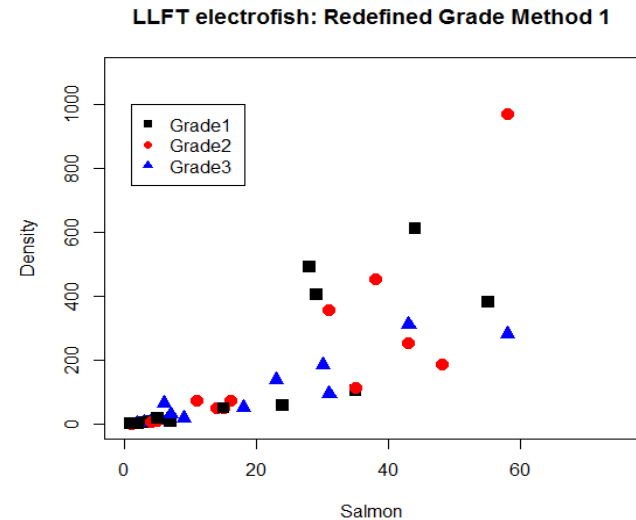
Cover: 4 levels (Instream, Leftbank,RightBank,Canopy)



# The Bayes results

**Table 5:** MCMC Method 1 criteria for grading

| Parameter selection based on subset |   |
|-------------------------------------|---|
| Grade 1                             | Pebble >50%<br>100-200mm depth >50%<br>Glide >50% |
| Grade 2                             | Gravel + Pebble >50%<br>0-200mm >50%<br>Run>50%   |
| Grade 3                             | Survey not meeting 1&2                            |



# Implications and continued work

- Needs investment for target rivers to address assumptions scientifically
- Continued research on-going in this area via the IBIS project Hannele (see her poster)



Kennedy & Crozier (1993) Juvenile Atlantic Salmon, Production & Prediction. Production of Juvenile Atlantic Salmon, *Salmo salar*. Edited by Gibson, R.J. & Cutting, R.E. National Research Council Canada  
NASCO (1998) North Atlantic Salmon Conservation Organisation. Agreement on the adoption of a precautionary approach. Report of the fifteenth annual meeting of the council. CNL(98) 46 pp.4



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