Jun 24th, 2:30 PM - 2:45 PM

Session E8: Can We Measure Cumulative Effects of Hydro-Power on Migratory Fish? Development of a Cumulative Effects Model Framework

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Can we measure cumulative effects of hydro-power on migratory fish?

Fish Passage 2015: Groningen (The Netherlands), June 24th

Iain Stewart-Russon, Simon Palmer and David Fraser

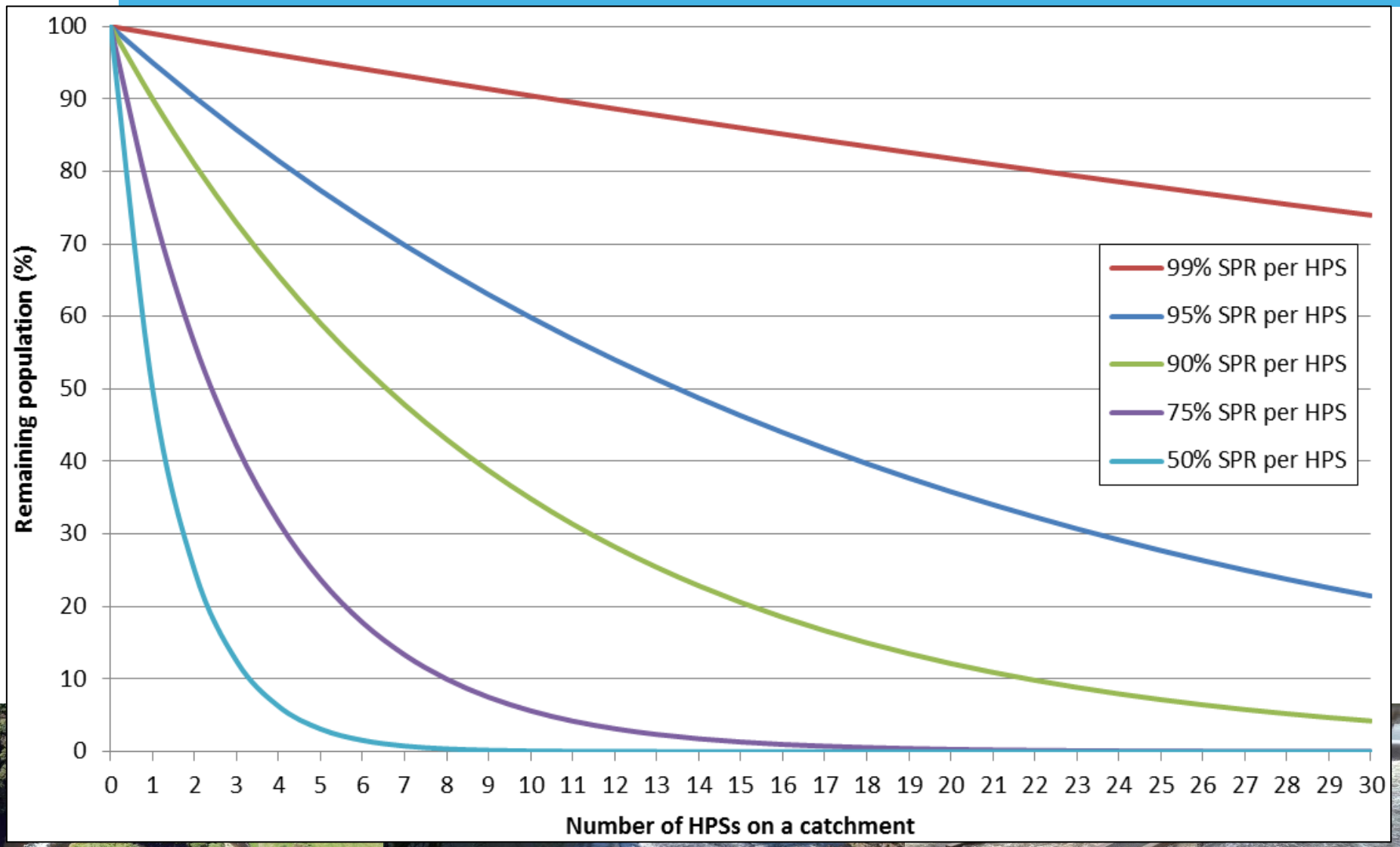
Background

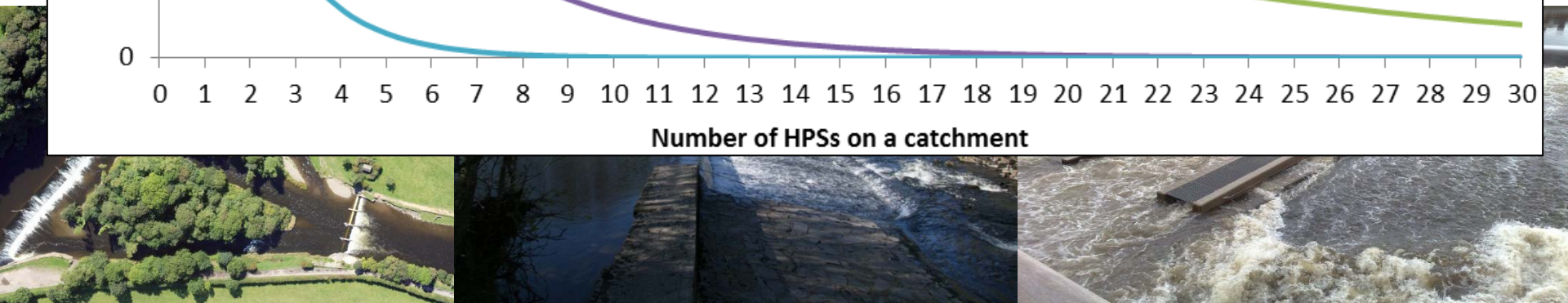
- **Questions:**
  - Can cumulative impacts occur?
  - Are they important?

- **How can these be measured?**



Background


Remaining population (%)
100
90
80
70
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Number of HPSs on a catchment
99% SPR per HPS
95% SPR per HPS
90% SPR per HPS
75% SPR per HPS
50% SPR per HPS



How to assess cumulative effects?

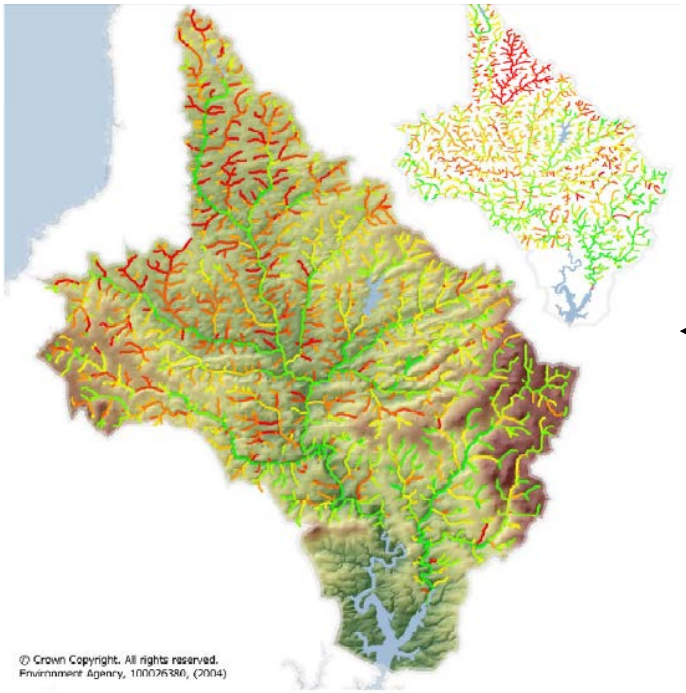
- **Model**
  - Model element 1 – Hydropower scheme design
  - Model element 2 – Spatial population element
  - Model element 3 – Life cycle element

Model element 1- Hydropower scheme elements

- **Effects include:**
  - Entrainment / impingement
  - Additional migratory impediment (up and downstream)
  - Loss of habitat for freshwater life stages
  - Mitigation
- **Effects of Barrier can be included / excluded**
- **Quantification**
  - Pre-set values
  - Manual entry / override
  - Consenting standards (e.g. EA – US = 90%, DS = 95%)

Model Element 2 – Spatial population element

Define extent of Habitat

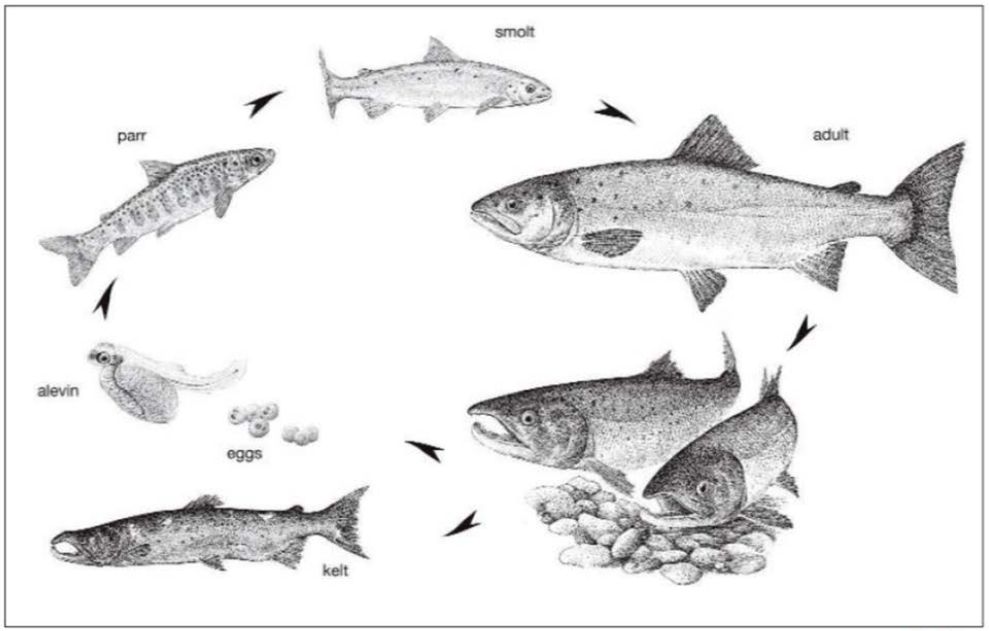


Define max no of fish supported by habitat

Altitude class (m)	Stream Order							
	1		2		3		4	
	Fry	Parr	Fry	Parr	Fry	Parr	Fry	Parr
0-49	9.65	1.87	14.11	3.49	18.73	3.93	22.58	2.66
50-99	4.79	3.33	12.06	5.33	19.62	6.39	20.62	5.73
100-149	5.09	6.39	17.04	7.27	34.15	7.70	40.94	7.59
150-199	8.77	11.51	27.27	8.87	50.20	7.93	54.68	8.21
200-299	26.38	18.06	30.34	9.70	14.83	8.39	3.08	11.68
300-399	44.64	7.02	1.56	7.40	-	-	-	-

- GIS based spatial population model
- Can generate pop data for any point

Model element 3 - Life cycle element

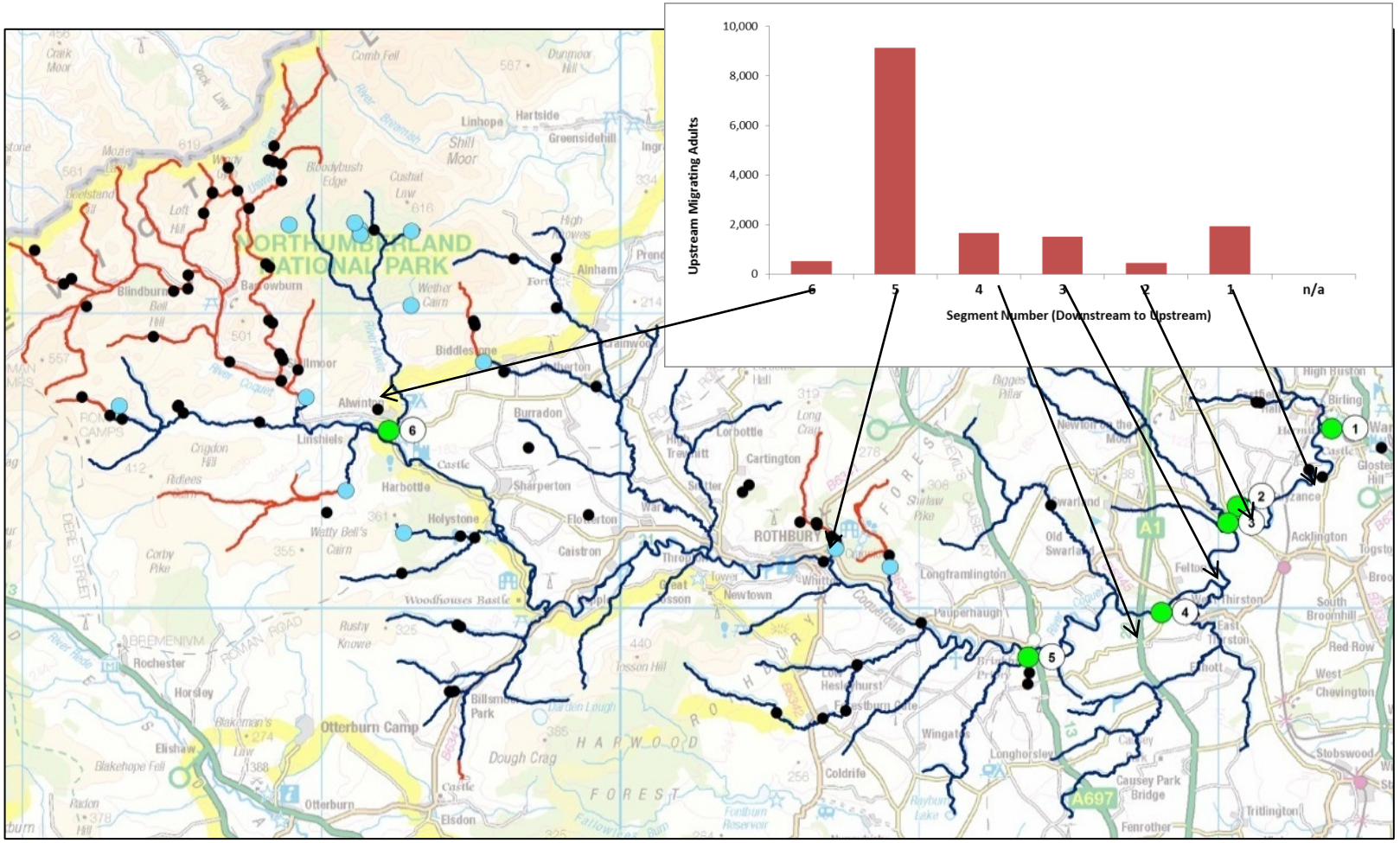


Sarah Wroot

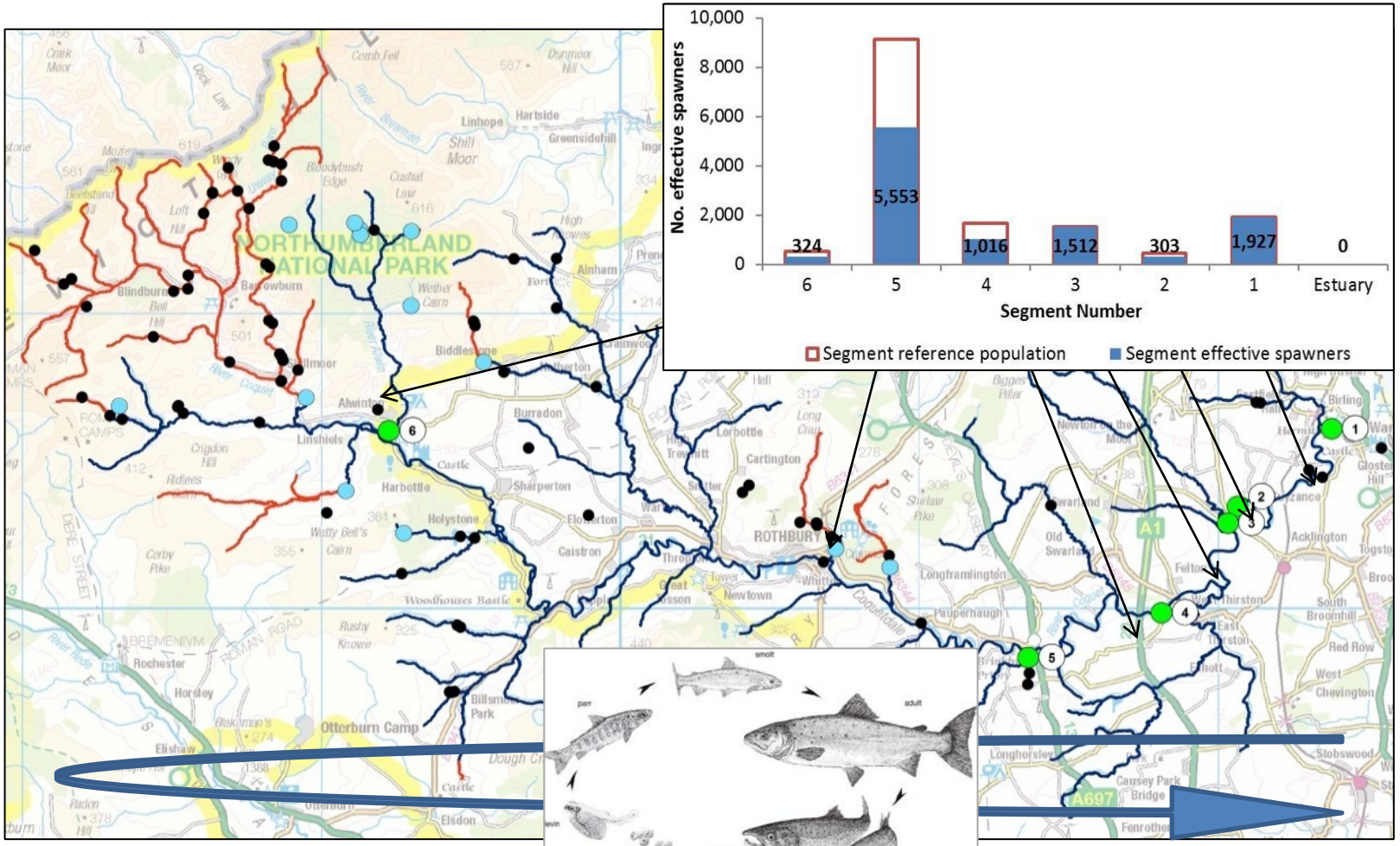
The Atlantic salmon has several life stages (beginning bottom right). The adult female lays eggs, which are fertilized by the male. The spent adults are then known as kelts, and while a few return to sea to spawn the following year, most die. The eggs hatch into alevins, dependent on their yolk sacs; then grow into fry, parr and smolt, when they first migrate to sea. Up to four years later, they return to their natal river to spawn.

Life Cycle model element	
Starting pop. adults	
M:F ratio	0.54
Spawning female adults	
Fecundity	5,723
No. eggs laid	
Egg to fry survival	0.1
Total fry	
Fry to parr survival	0.11
Total parr	
Parr to smolt survival	0.44
Total smolts	
Marine survival	0.07
Returning adult pop.	

Model in Practice

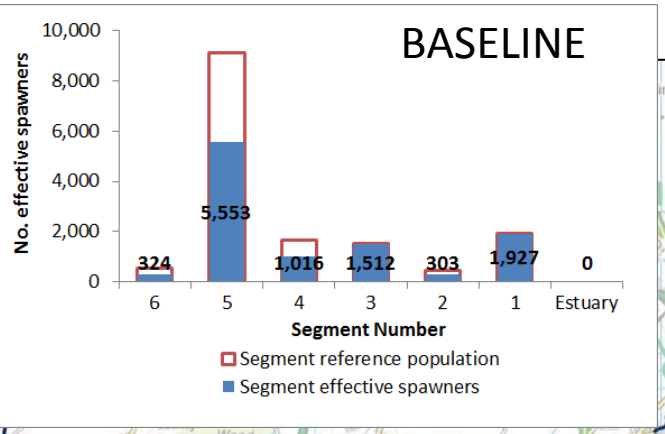


Model in Practice

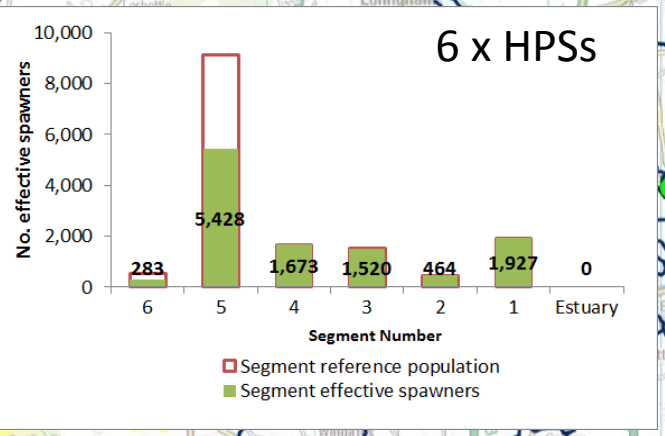


Cumulative Effects Scenario

Barrier/ Segment	Structure Description	Existing upstream passability
Estuary	-	n/a
1	Warkworth Dam	0.72
2	Guyzance Mill	0.91
3	Acklington Dam	1.00
4	Felton Dam	0.93
5	Weldon Mill	1.00
6	None	1.00



Barrier/ Segment	Structure Description	With HP upstream passability
Estuary	-	n/a
1	Warkworth Dam	0.90
2	Guyzance Mill	0.90
3	Acklington Dam	0.90
4	Felton Dam	0.90
5	Weldon Mill	0.90
6	None	0.90



Hydroscheme passability assigned 90% upstream passability

Cumulative Effects Scenario

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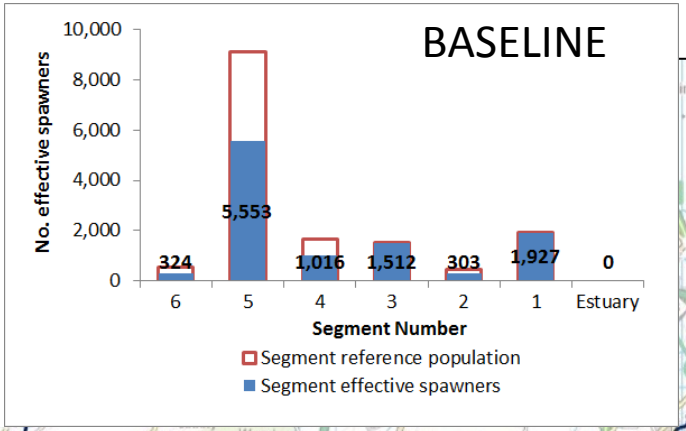
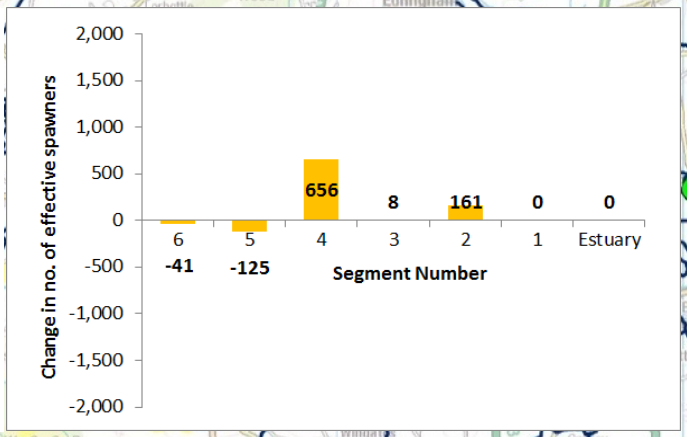


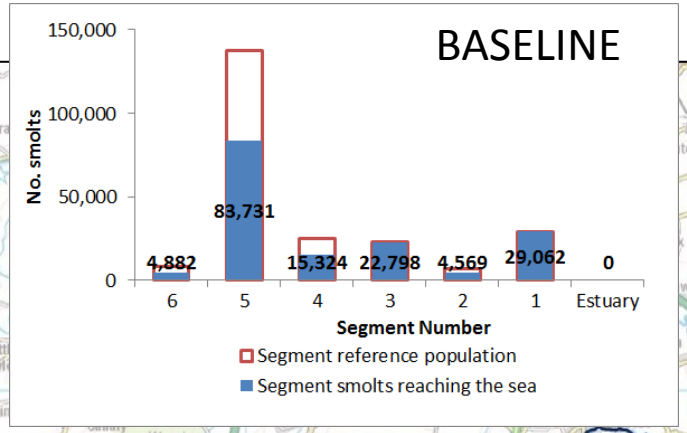
Barrier/ Segment	Structure Description	With HP upstream passability
Estuary	-	n/a
1	Warkworth Dam	0.90
2	Guyzance Mill	0.90
3	Acklington Dam	0.90
4	Felton Dam	0.90
5	Weldon Mill	0.90
6	None	0.90



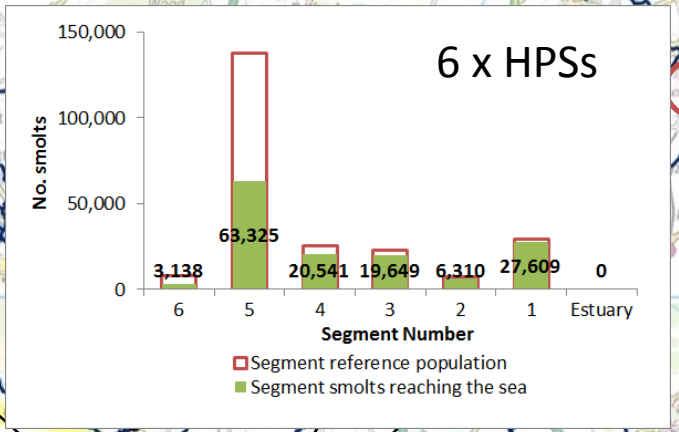
Hydroscheme passability assigned 90% upstream passability

Cumulative Effects Scenario

Barrier/ Segment	Structure Description	Existing downstream passability	Cumulative downstream effect of barriers
Estuary	-	n/a	n/a
1	Warkworth Dam	1.00	1.00
2	Guyzance Mill	1.00	1.00
3	Acklington Dam	1.00	1.00
4	Felton Dam	1.00	1.00
5	Weldon Mill	1.00	1.00
6	None	1.00	1.00



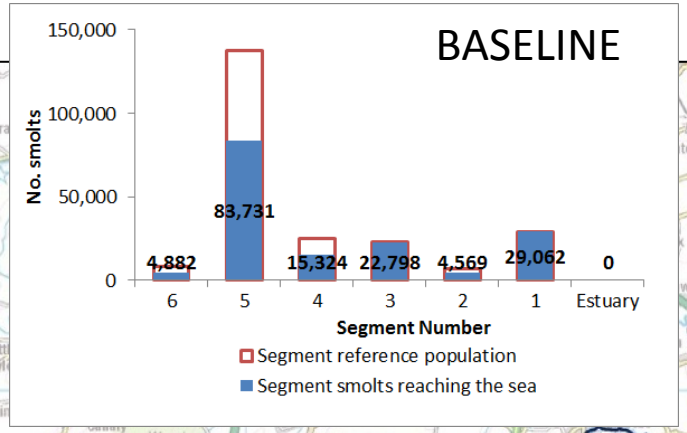
Barrier/ Segment	Structure Description	HP scheme downstream passability	Cumulative downstream effect of barriers
Estuary	-	n/a	n/a
1	Warkworth Dam	0.95	0.95
2	Guyzance Mill	0.95	0.90
3	Acklington Dam	0.95	0.86
4	Felton Dam	0.95	0.81
5	Weldon Mill	0.95	0.77
6	None	0.95	0.74



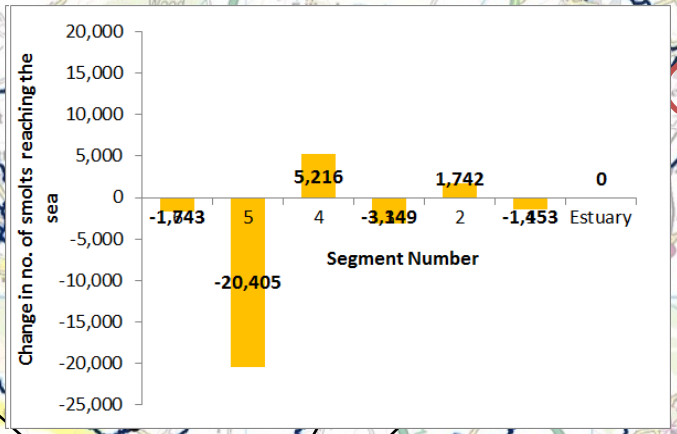
All hydroschemes cause 5% downstream Smolt mortality

Cumulative Effects Scenario

Barrier/ Segment	Structure Description	Existing downstream passability	Cumulative downstream effect of barriers
Estuary	-	n/a	n/a
1	Warkworth Dam	1.00	1.00
2	Guyzance Mill	1.00	1.00
3	Acklington Dam	1.00	1.00
4	Felton Dam	1.00	1.00
5	Weldon Mill	1.00	1.00
6	None	1.00	1.00

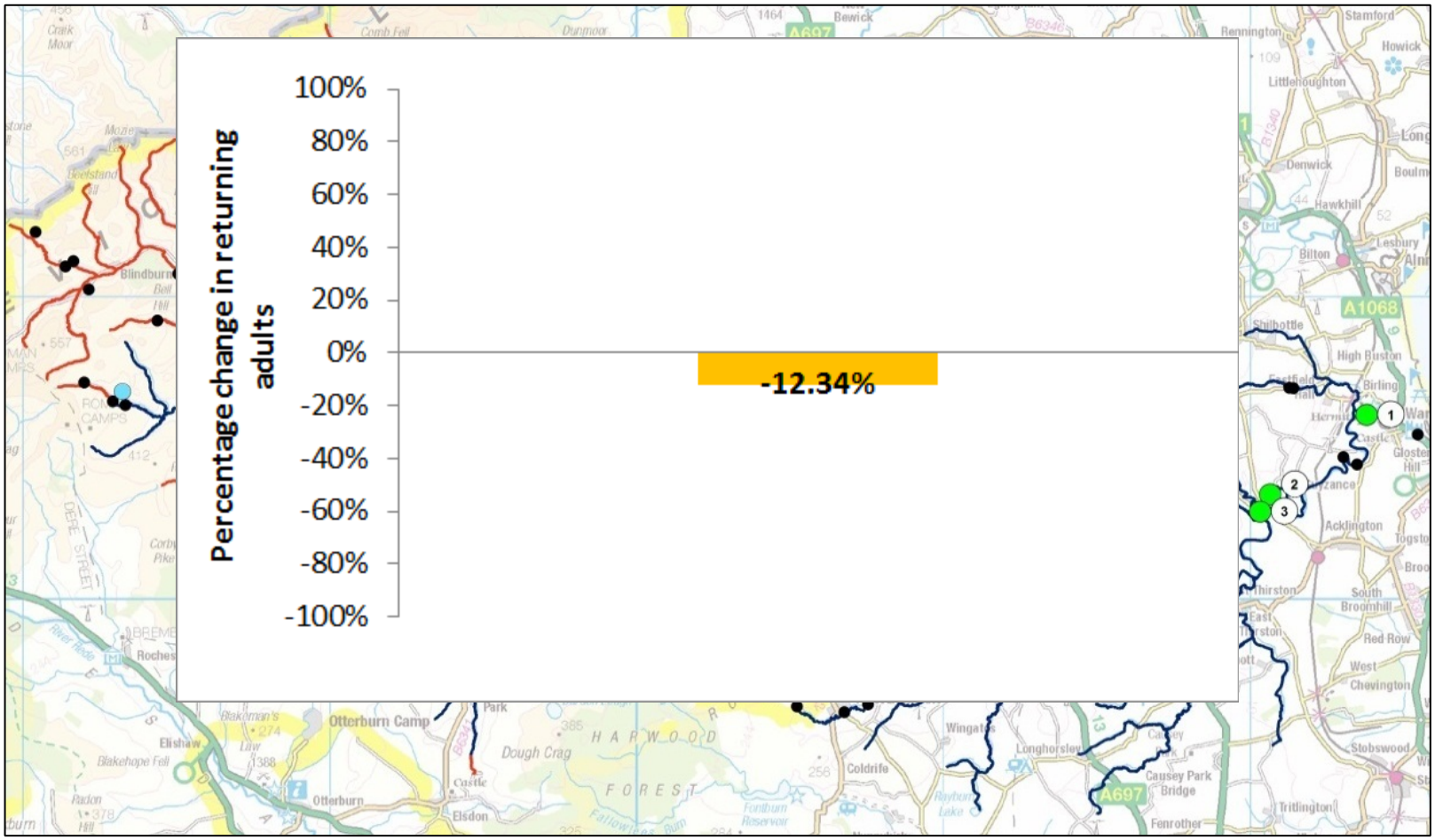


Barrier/ Segment	Structure Description	HP scheme downstream passability	Cumulative downstream effect of barriers
Estuary	-	n/a	n/a
1	Warkworth Dam	0.95	0.95
2	Guyzance Mill	0.95	0.90
3	Acklington Dam	0.95	0.86
4	Felton Dam	0.95	0.81
5	Weldon Mill	0.95	0.77
6	None	0.95	0.74



All hydroschemes cause 5% downstream Smolt mortality

Cumulative Effects Scenario



Key findings

- **Cumulative effects can occur. Magnitude depends on:**
  - Location of the hydropower schemes;
  - Population;
  - Hydropower scheme design / benefits & dis-benefits
- **Model**
  - Easy to use
  - Recognised
  - Can incorporate bespoke site specific data
- **Actual and/or hypothetical hydropower schemes can be assessed:**
  - use as a strategic management tool
  - Applicability beyond hydropower schemes

Further information

- **Report published in January 2015:**
  - **Fraser, D., Palmer, S. & Stewart-Russon, I. (2015). *Cumulative effects of hydropower schemes on fish migration and populations*. Environment Agency Evidence Report number SC120078, January 2015. 81pp.**

- **Report is available at:**
  - **https://www.gov.uk/government/publications/cumulative-effects-of-hydropower-schemes-on-fish-migration-and-populations**


Thank you
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