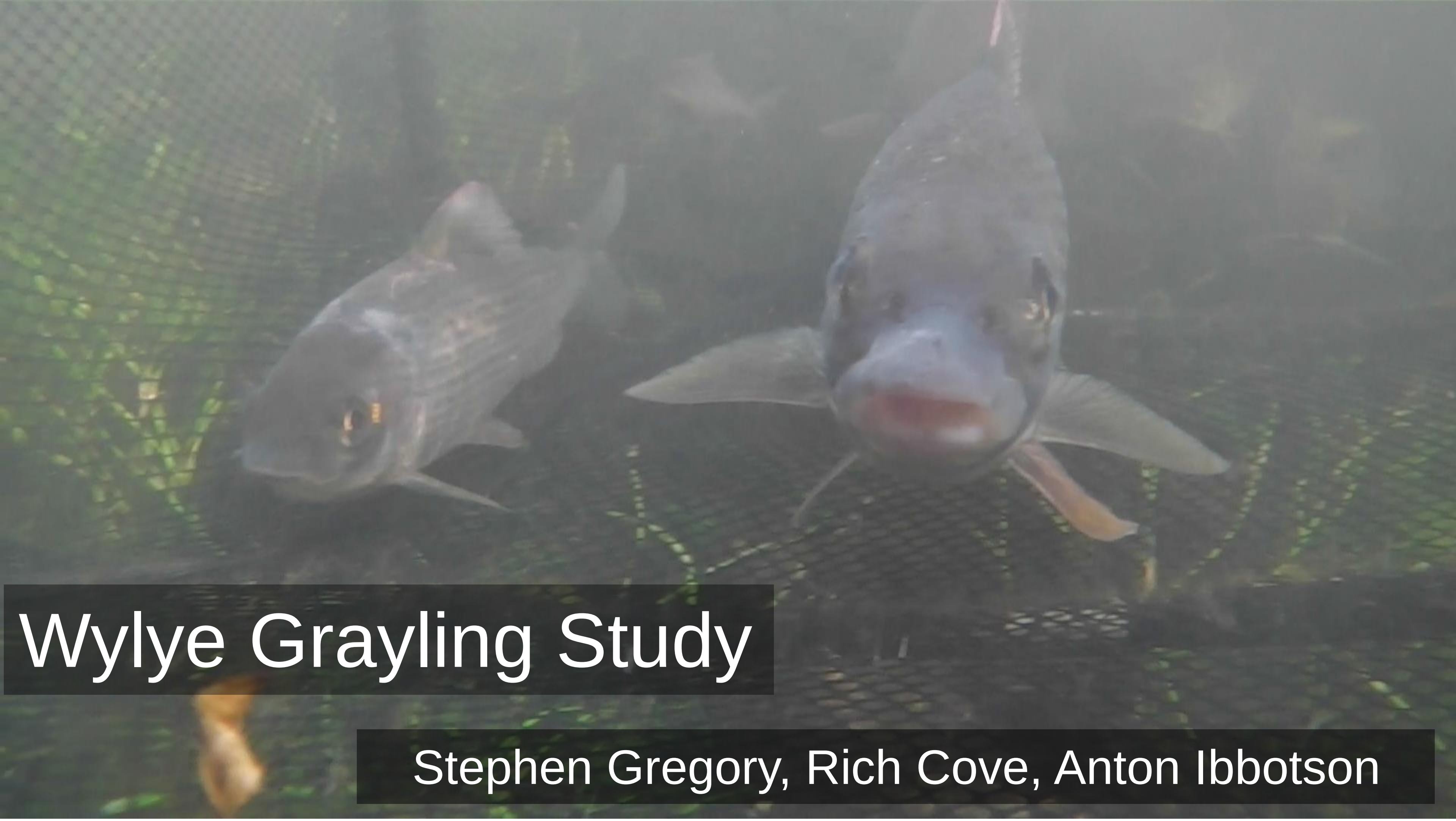

Wylye Grayling Study

Stephen Gregory, Rich Cove, Anton Ibbotson

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Game & Wildlife Conservation Trust

Biosketch: Stephen D. Gregory

- Education:
  - BSc Zoology (University of Swansea)
  - MSc Ecology (University of Oxford)
  - PhD Ecology & Statistics (University of Paris)
- Projects:
  - Foraging behaviour of Lesser horseshoe bats, Swansea
  - Food competition between native & black rats, Galapagos
  - Demographic consequences of sociality in animals
  - Effects of climate and habitat change on Orangutan, Borneo
- Current:
  - Drivers of salmon population dynamics, UK and France
  - Grayling population dynamics on the Wylye, UK

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In 1996…

In 1996…

Anton Ibbotson

In 1996…

Wylye Grayling Study begins!

Anton Ibbotson

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In 1996…

Me!

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Wylye Grayling Study

Wylye Grayling Study: longest grayling dataset

- 1996 – 2016: 21 years!

Wylye Grayling Study: longest grayling dataset

- 1996 – 2016: 21 years!
- 10973+ records from 9514 individual grayling
  - Length
  - Scales

Wylye Grayling Study: longest grayling dataset

- 1996 – 2016: 21 years!
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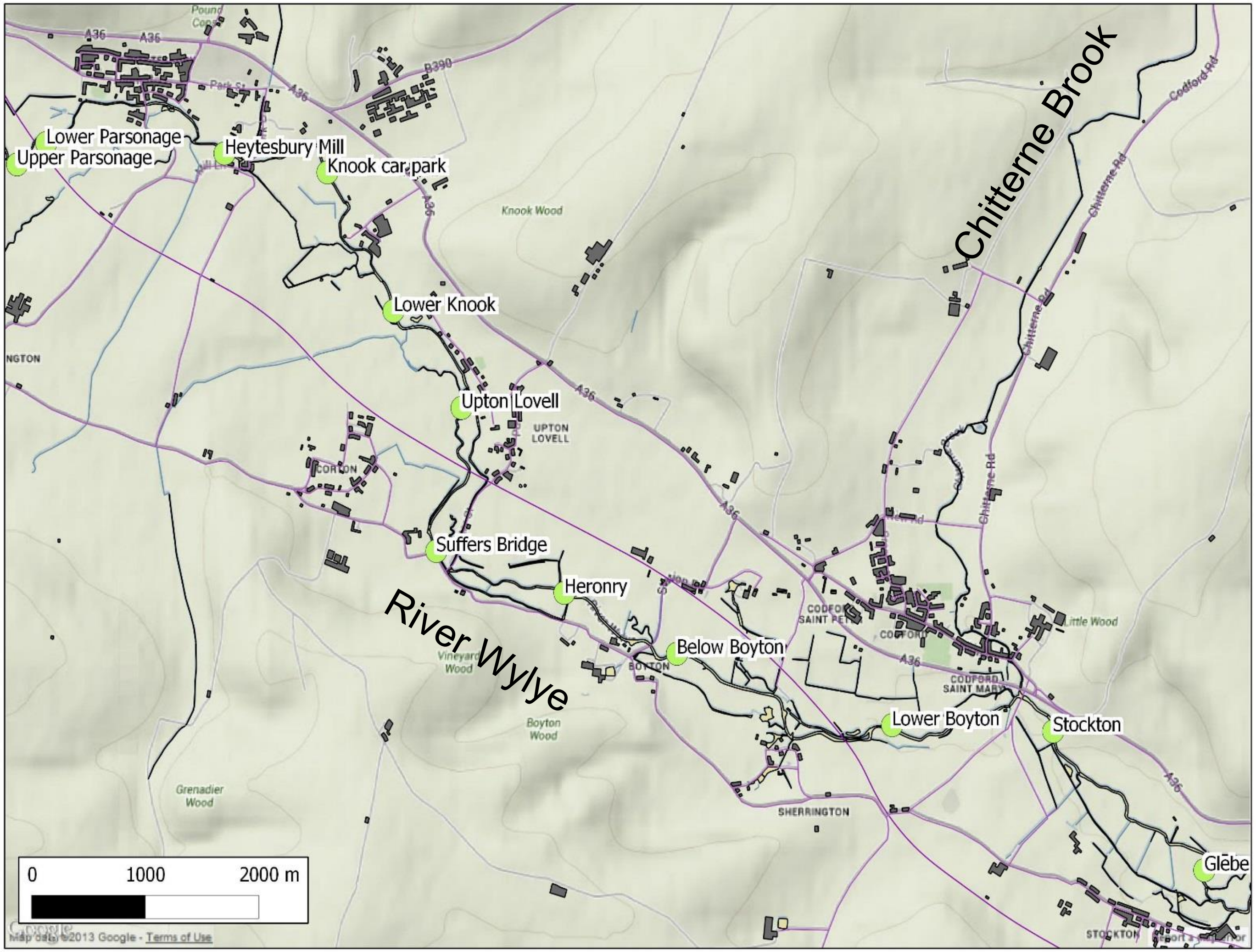
  - Length
  - Scales
- River flow
  - Stockton Park
  - Norton Bavant

Wylye Grayling Study: survey method

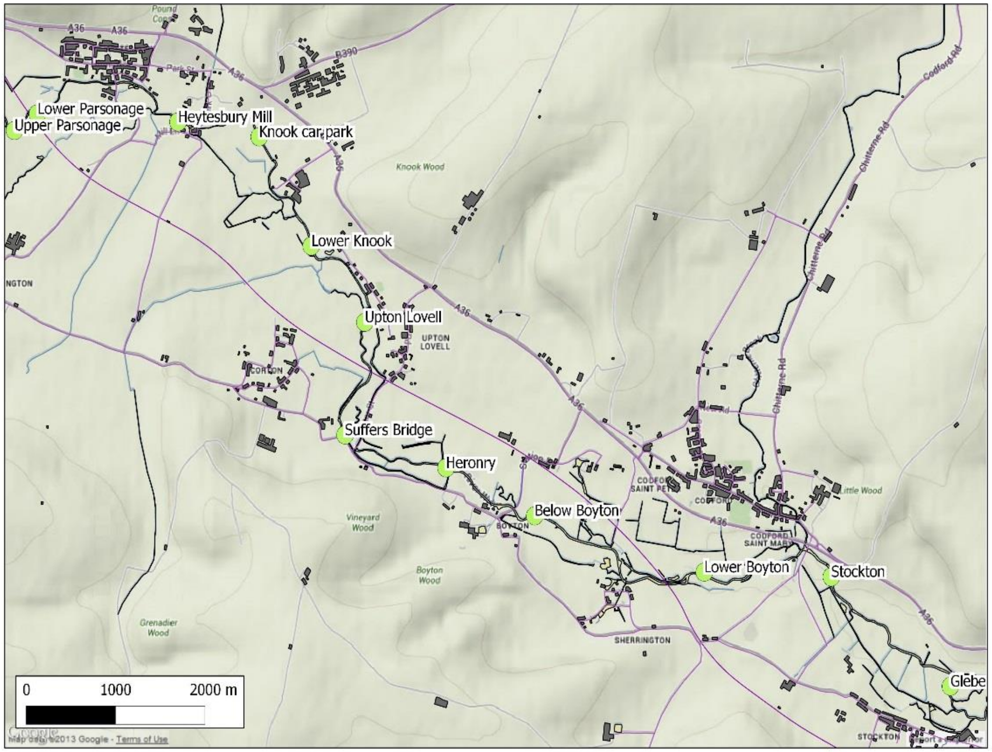
To Warminster



To Salisbury

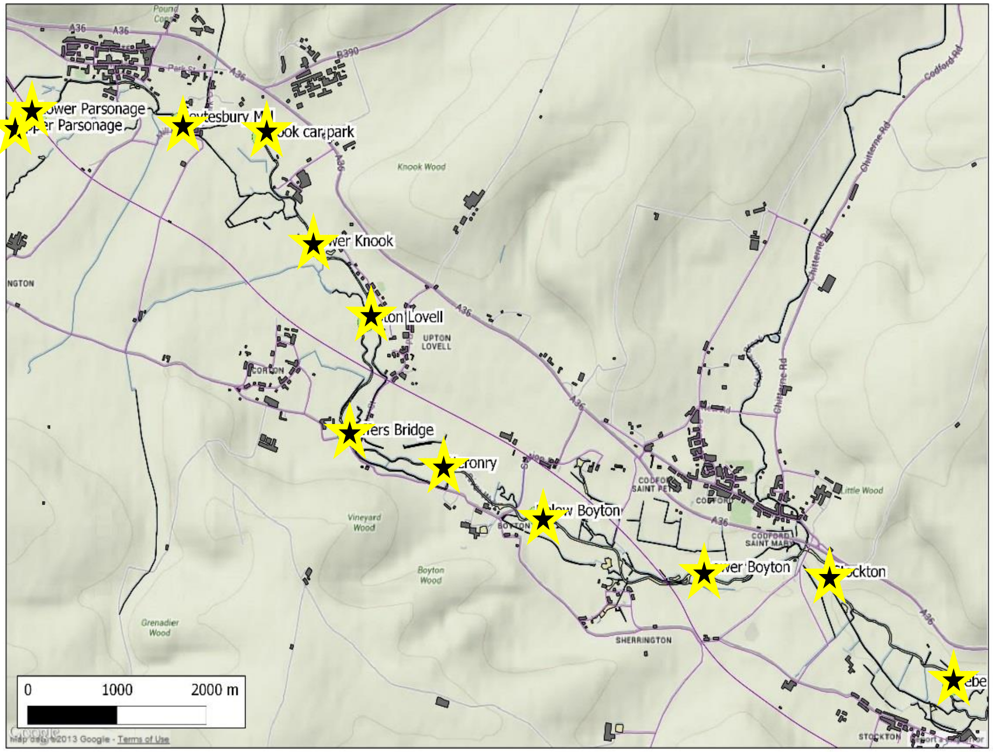
Wylye Grayling Study: survey method

- Electric fishing surveys with “stop nets”



Wylye Grayling Study: survey method

- Electric fishing surveys with “stop nets”
- Single shock survey
  - – relative number
  - – 1996 : 2015



Wylye Grayling Study: survey method

- Electric fishing surveys with “stop nets”
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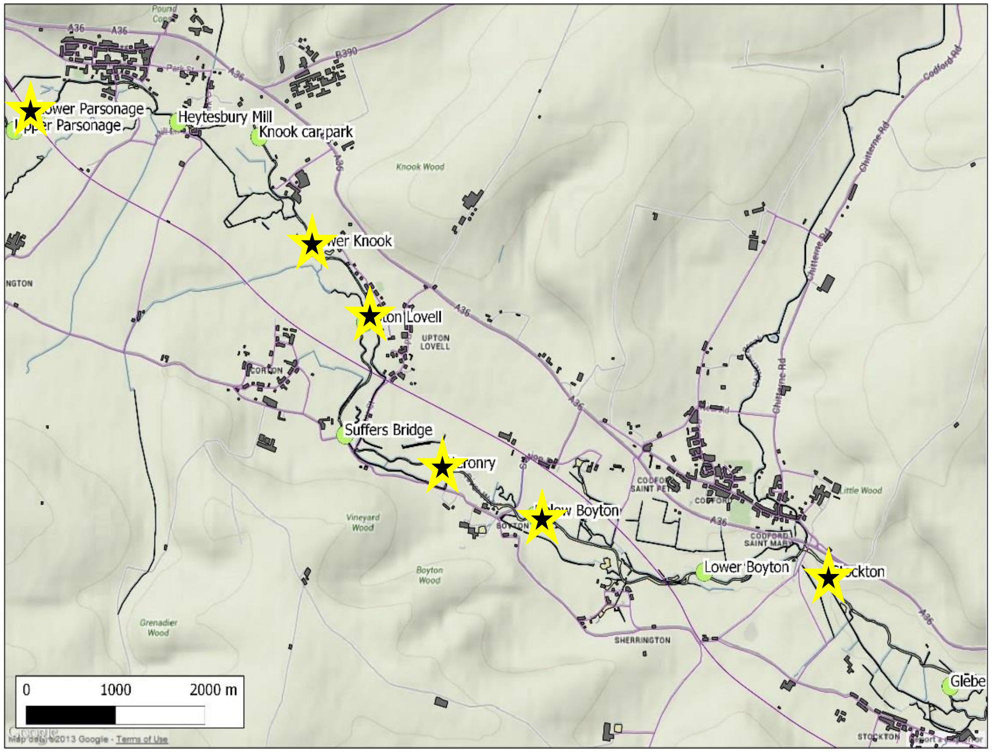

- Three shock survey
  - – actual density
  - – 2009 : 2015

Wylye Grayling Study: survey method

Wylye Grayling Study: individual-based data

- Individual marks

Wylye Grayling Study: individual-based data

- Individual marks

Wylye Grayling Study: individual-based data

- Individual marks

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Long data sets needed to study changes in fish population size and their causes

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Grayling reproduction: a risky strategy

Grayling reproduction: a risky strategy

- Spawn in April – May: weather dependent

Riley, W. D. & Pawson, M. G. (2010) Habitat use by *Thymallus thymallus* in a chalk stream and implications for habitat management Fisheries Management and Ecology, 17, 544-553.

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Grayling reproduction: a risky strategy

- Spawn in April – May: weather dependent
- Eggs shallow in redd:

	Salmon	Trout	Grayling
Depth (cm)	10 – 15	10 – 15	0 – 5

Riley, W. D. & Pawson, M. G. (2010) Habitat use by *Thymallus thymallus* in a chalk stream and implications for habitat management Fisheries Management and Ecology, 17, 544-553.

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Average redd characteristics

Measure	River Pollon	River Suran
Mean bottom velocity	37.2 cm/s	33.7 cm/s
Selected depth	10 – 40 cm	20 – 30 cm

Sempeski, P. and Gaudin, P. (1995), Habitat selection by grayling—I. Spawning habitats. Journal of Fish Biology, 47: 256–265.

Grayling reproduction: a risky strategy

- Spawn in April – May: weather dependent
- Eggs shallow in redd:

	Salmon	Trout	Grayling
Depth (cm)	10 – 15	10 – 15	0 – 5

- Shallow redd ~ risk of “egg washout” in floods

Riley, W. D. & Pawson, M. G. (2010) Habitat use by *Thymallus thymallus* in a chalk stream and implications for habitat management Fisheries Management and Ecology, 17, 544-553.

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UK flooding


D.R. Beattie
Wendy's Hairstyl'st
Flood
POLICE
Flood
Flood

UK flooding

- 4 of 5 UK wettest recorded years since 2000
  - (2000 [1], 2012 [2], 2008 [4], 2002 [5])

UK Met Office: http://www.metoffice.gov.uk/

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UK flooding

- 4 of 5 UK wettest recorded years since 2000
  - (2000 [1], 2012 [2], 2008 [4], 2002 [5])

- January 2014 = England's wettest in *c.*250 years

UK Met Office: http://www.metoffice.gov.uk/

UK flooding

- 4 of 5 UK wettest recorded years since 2000
  - (2000 [1], 2012 [2], 2008 [4], 2002 [5])
- January 2014 = England's wettest in c.250 years

High rainfall -> High river flows

UK Met Office: http://www.metoffice.gov.uk/

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Wylye January 2014

Frome

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The Piscatorial Society

Game & Wildlife Conservation Trust

Frome: 2012

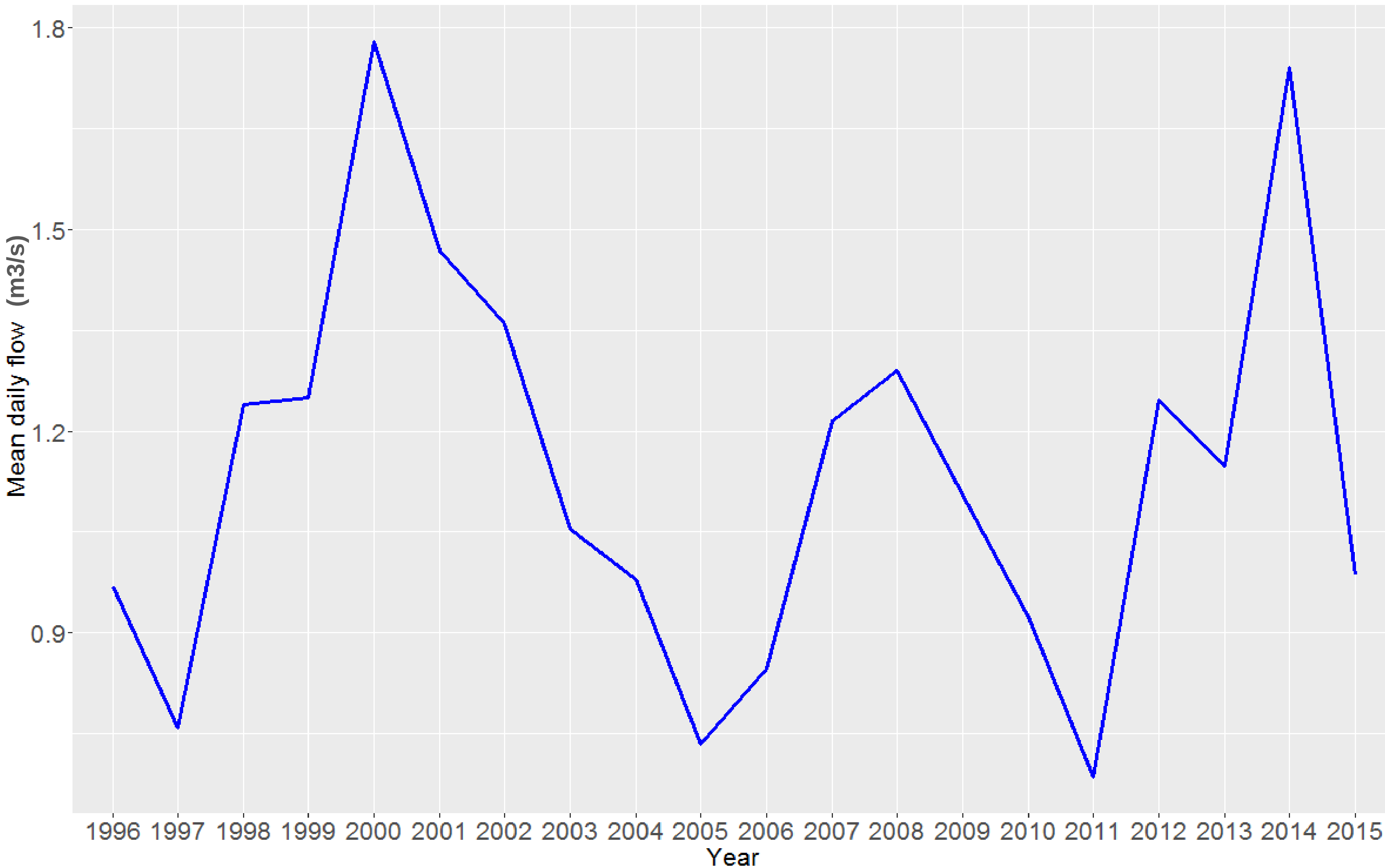
Questions

Questions

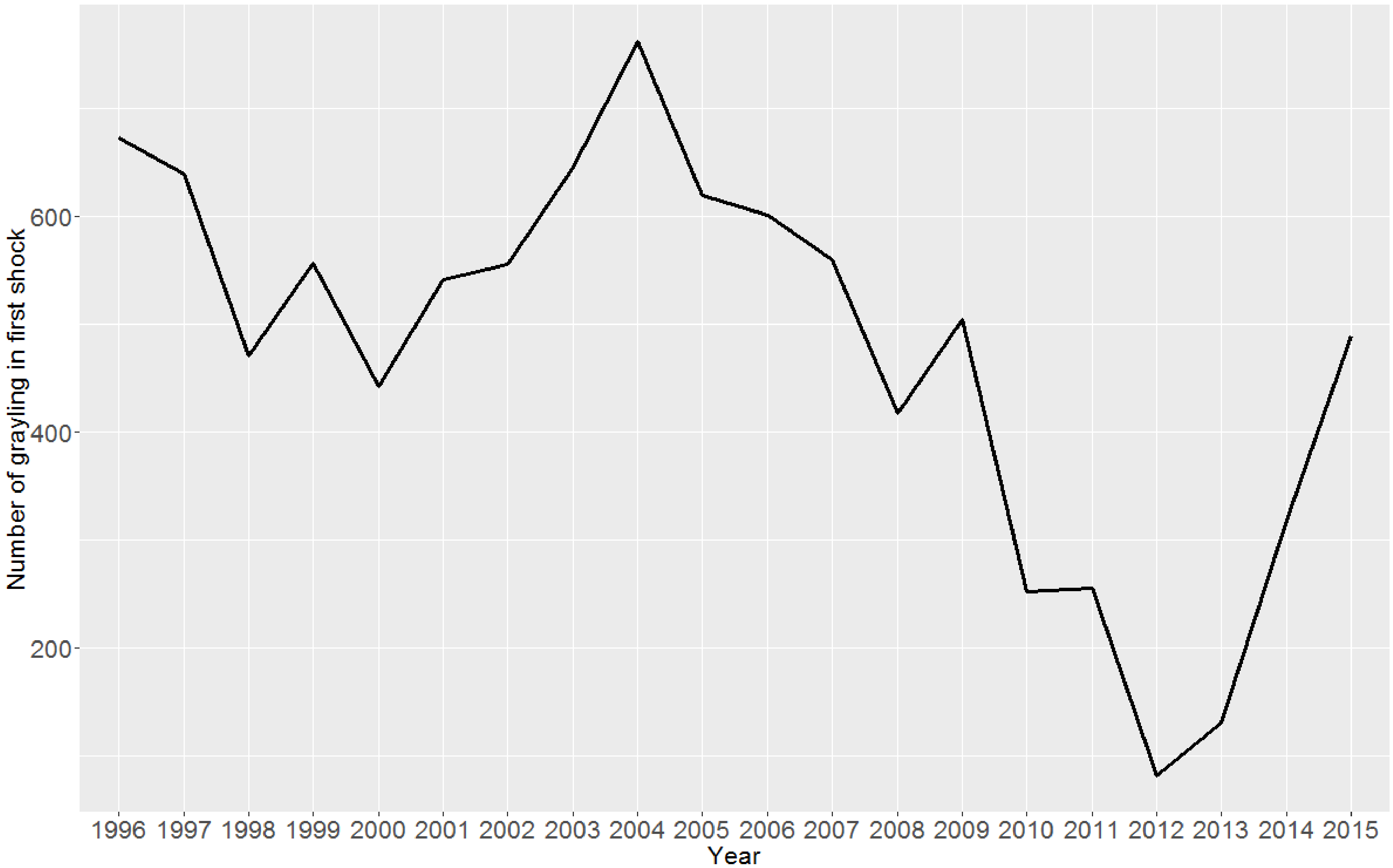
How might flooding affect grayling populations?

- Shared patterns in flow and grayling counts?

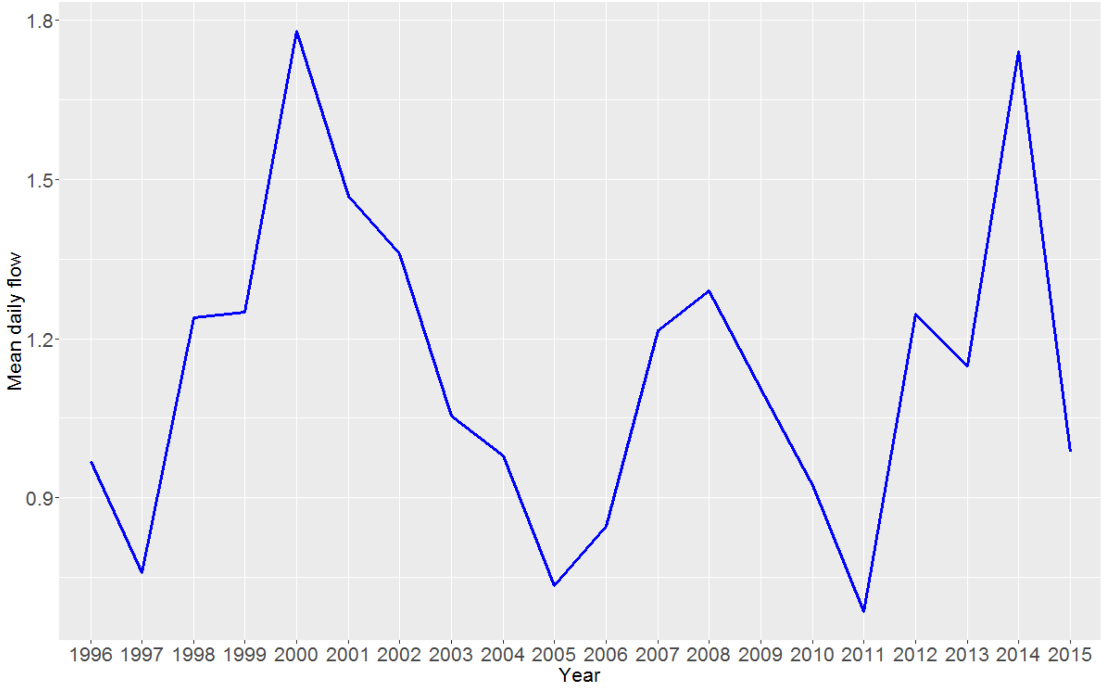
Wylye average daily flow



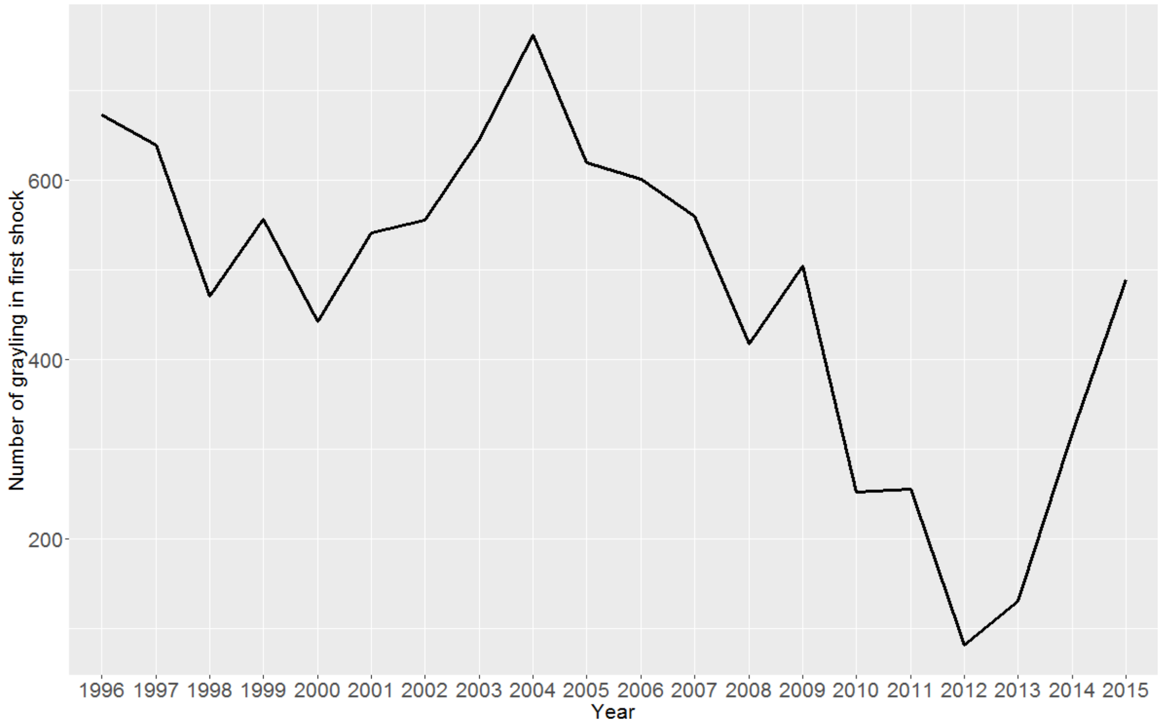
Grayling population: all ages



all ages

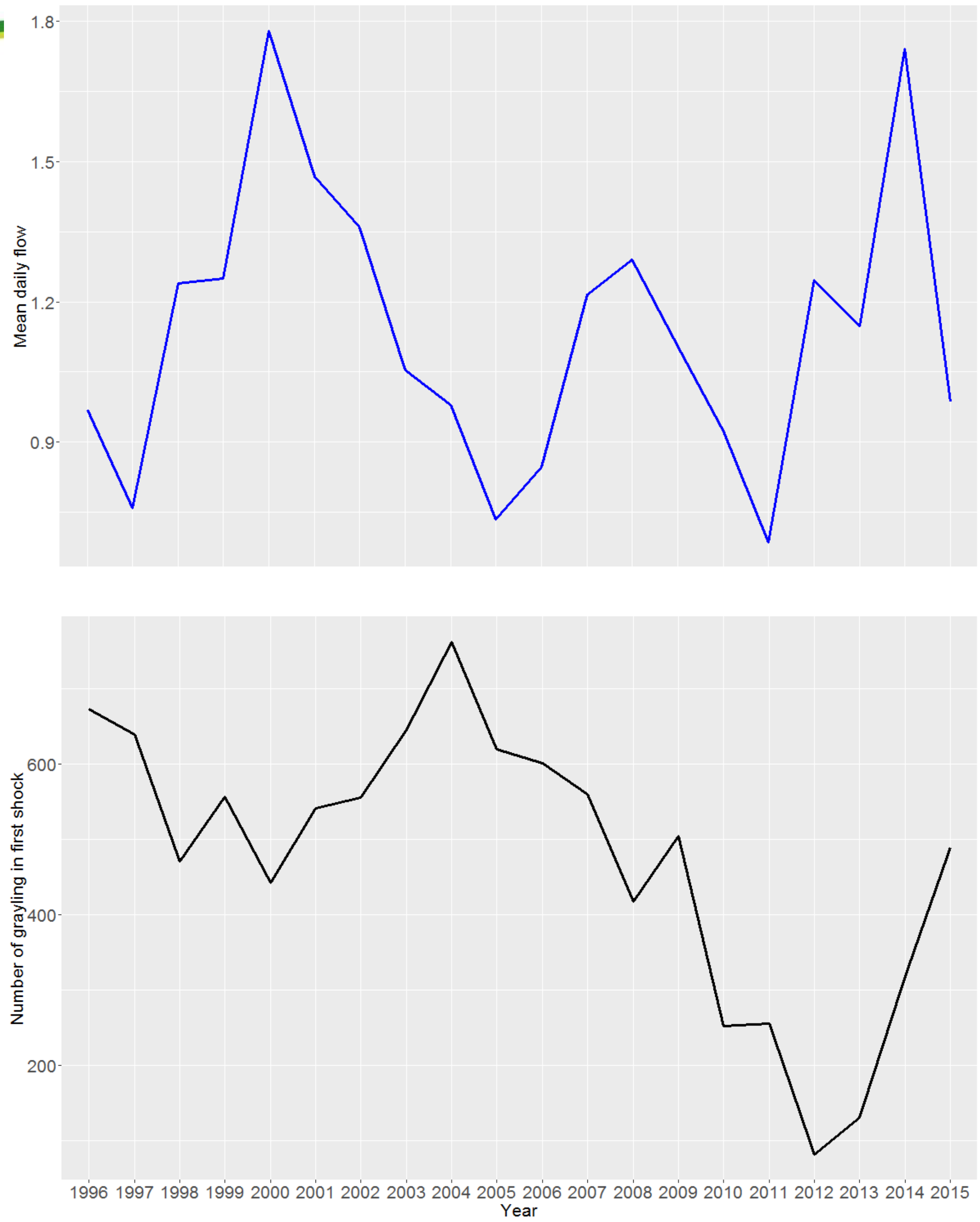


1.8
1.5
1.2
0.9
Mean daily flow
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Year



600
400
200
Number of grayling in first shock
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Year

all ages


Mean daily flow
1.8
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Number of grayling in first shock
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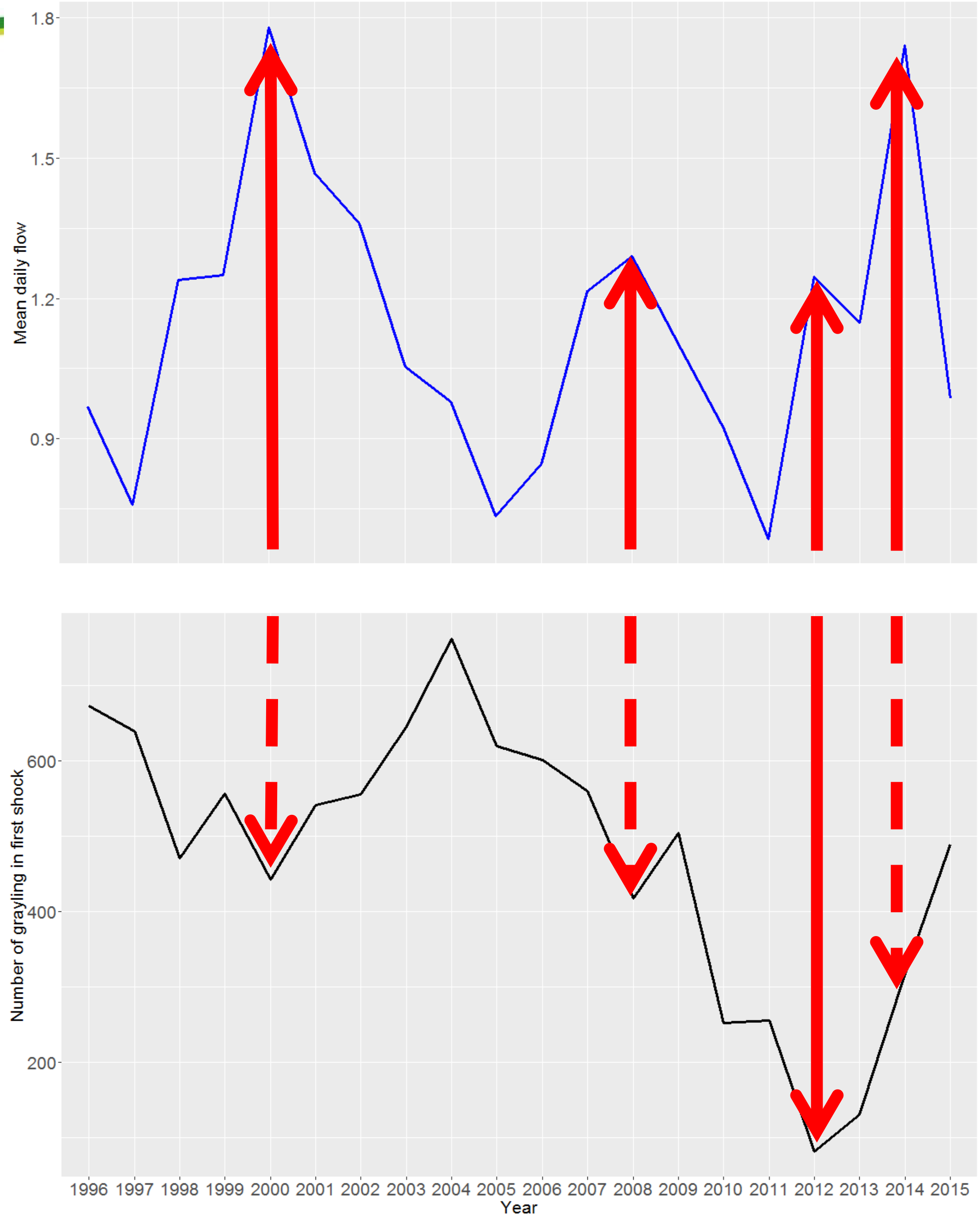
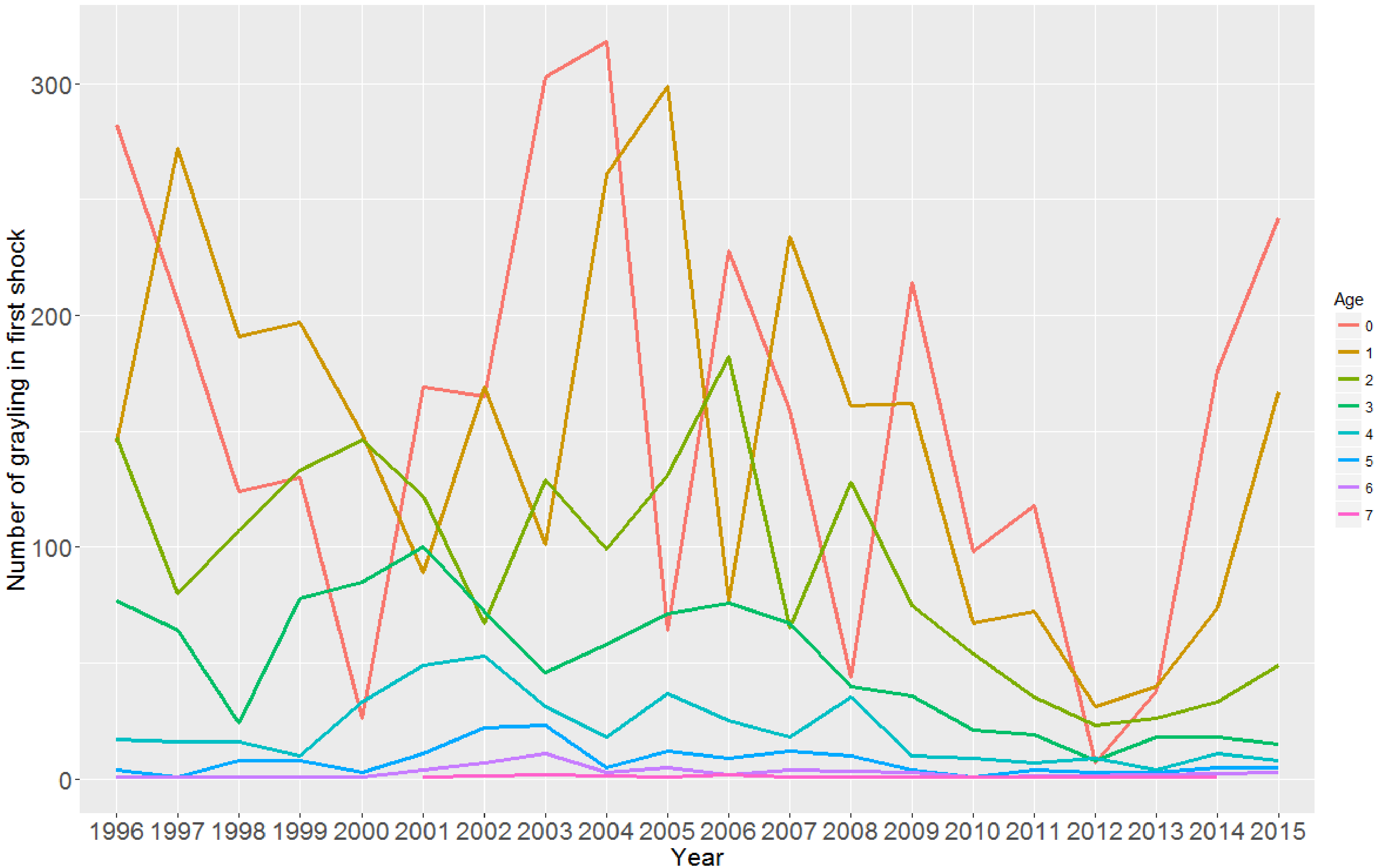
200
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Year



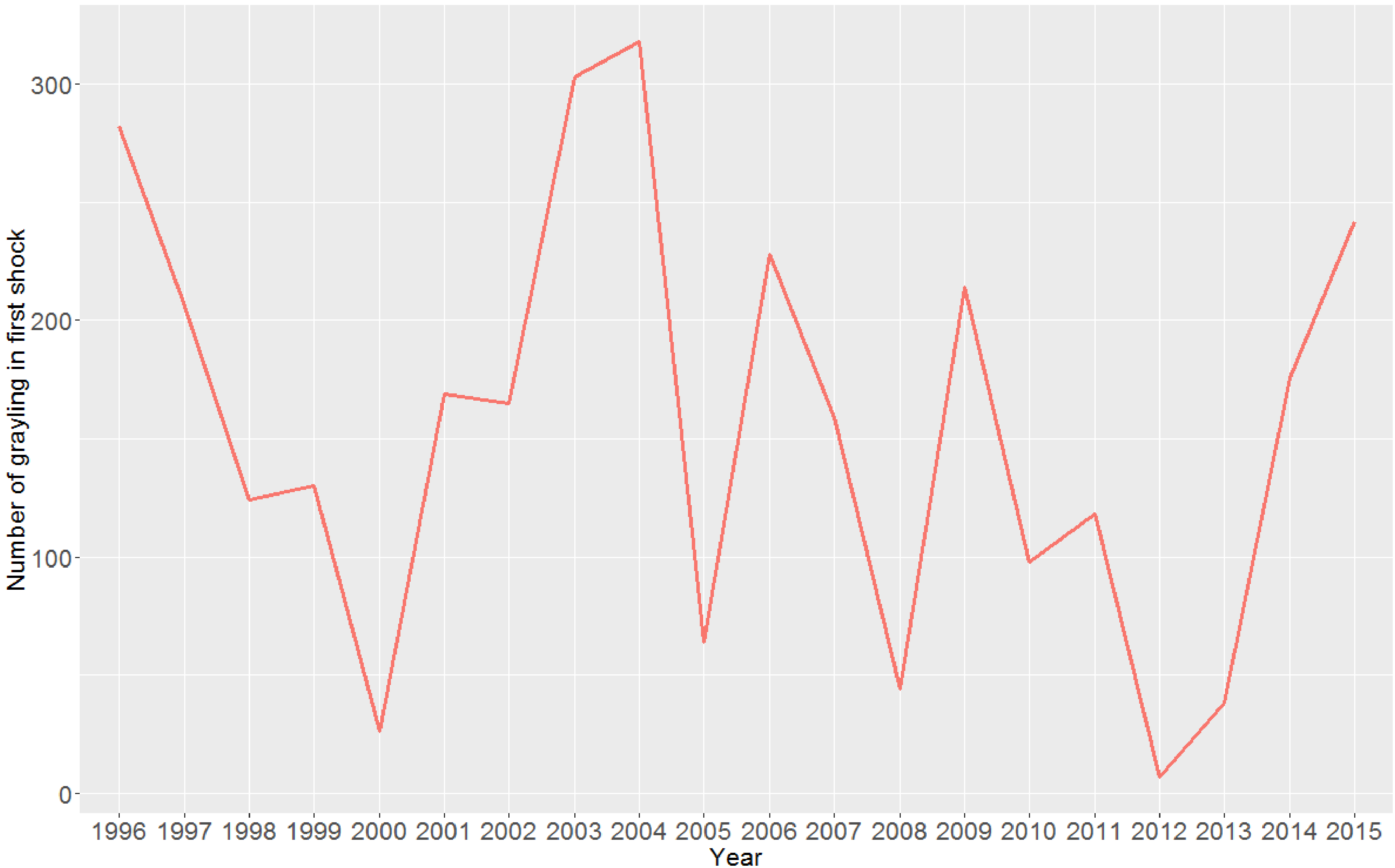
Mean daily flow
1.8
1.5
1.2
0.9
Number of grayling in first shock
600
400
200
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Year

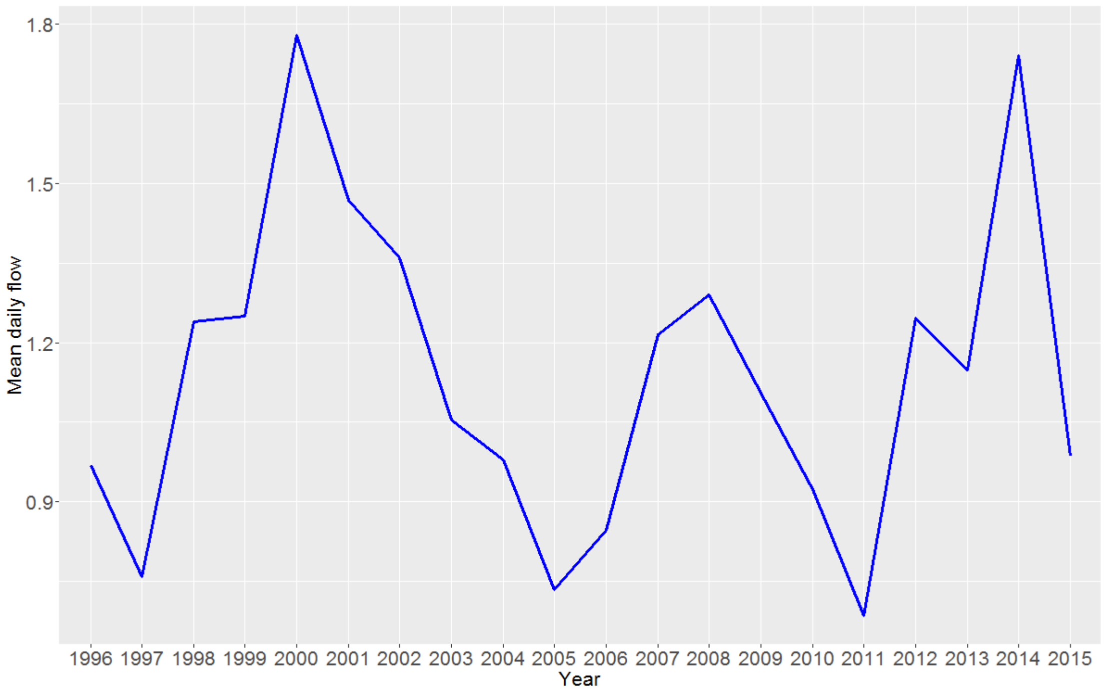
all ages

Grayling population: separate ages

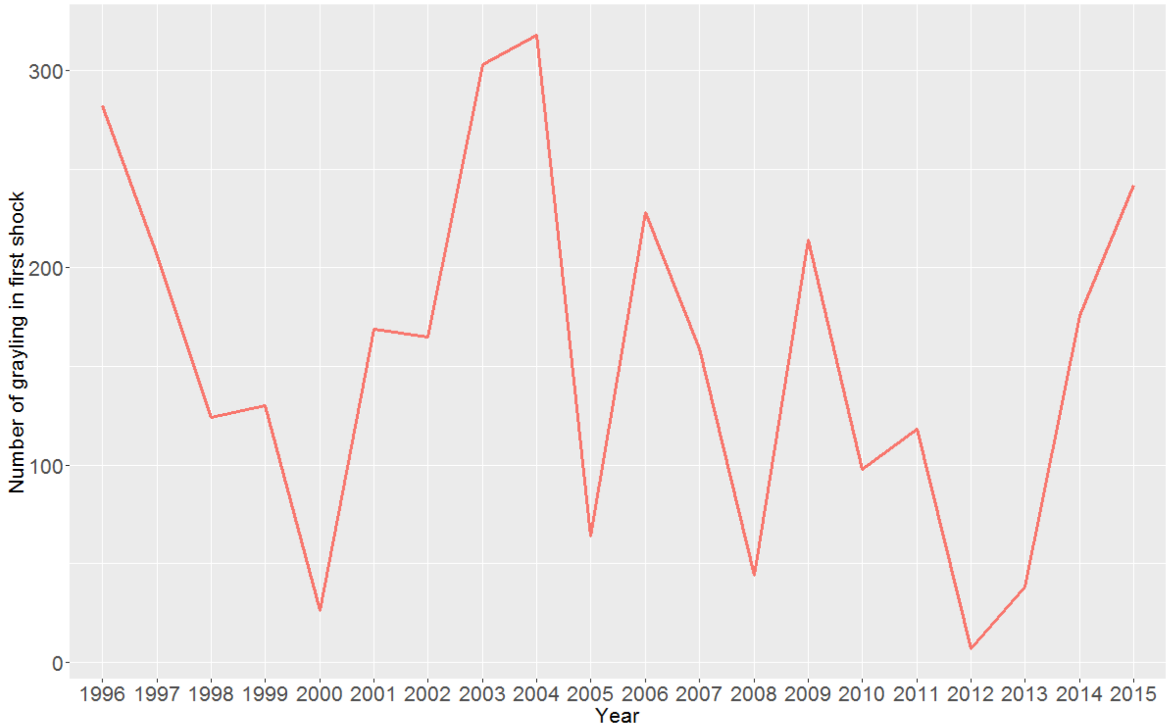


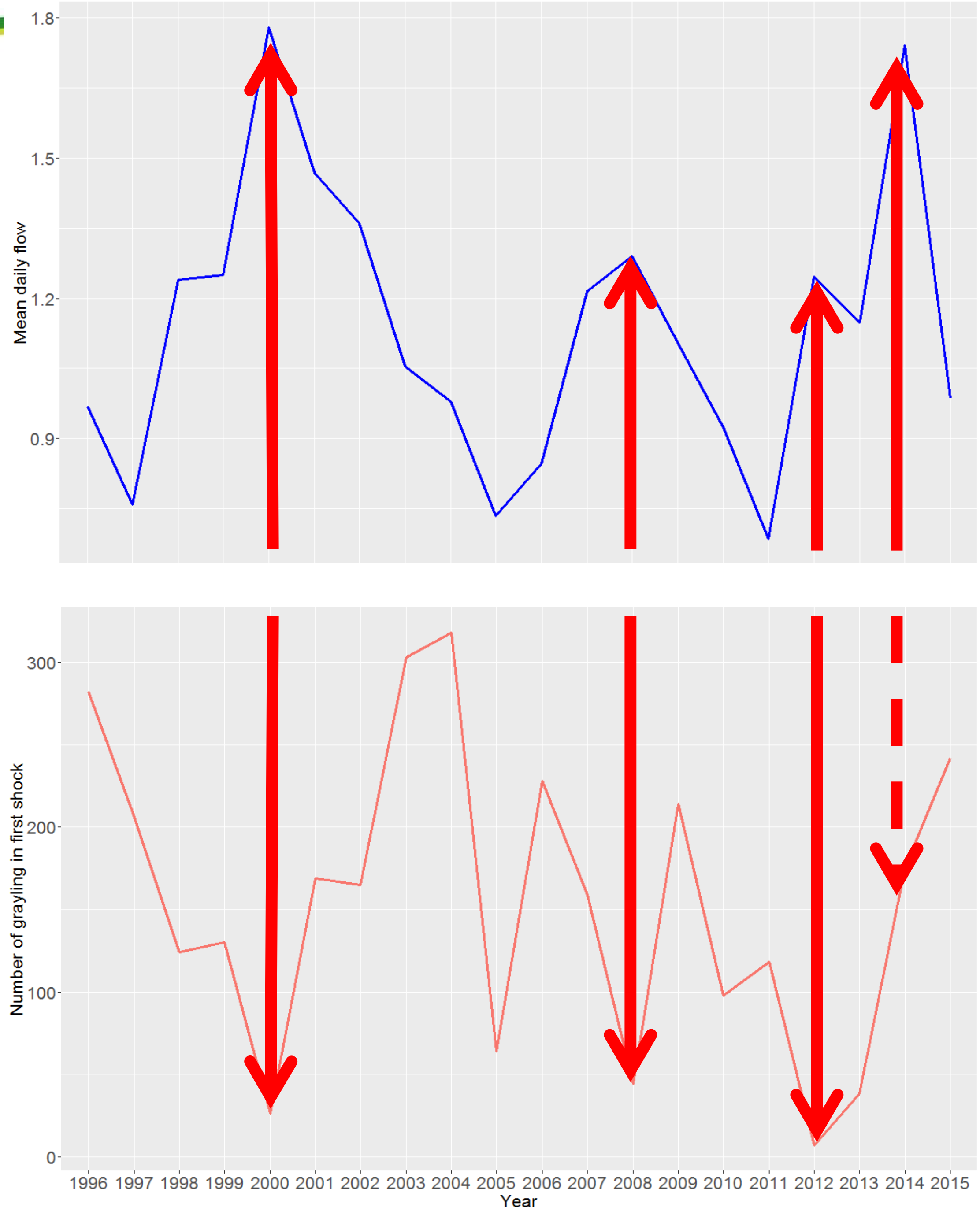
Grayling population: 0+ only




1.8
1.5
1.2
0.9
Mean daily flow
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Year

0+ only


300
200
100
0
Number of grayling in first shock
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Year


1.8
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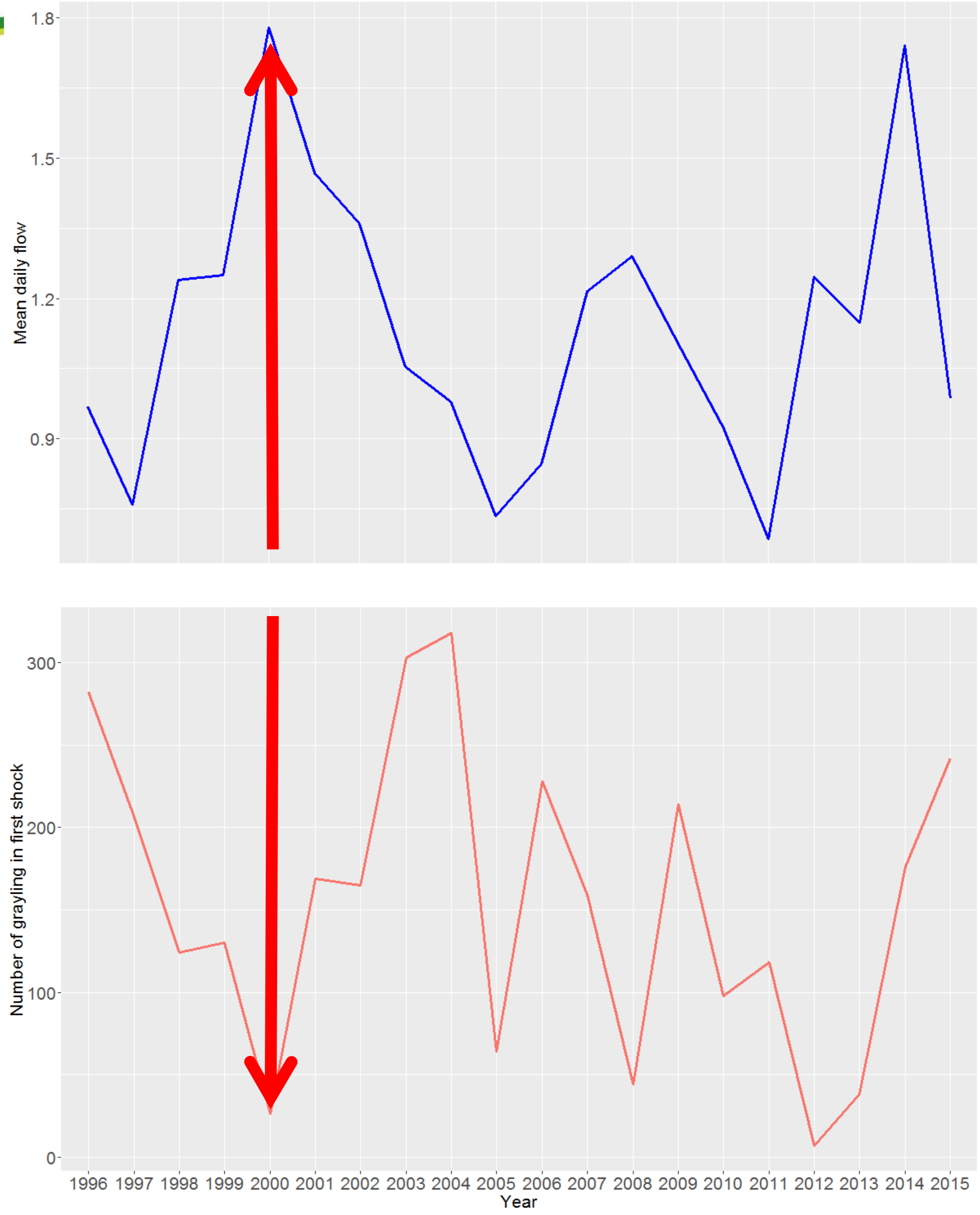
200
100
0
Number of grayling in first shock
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Year

0+ only



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300
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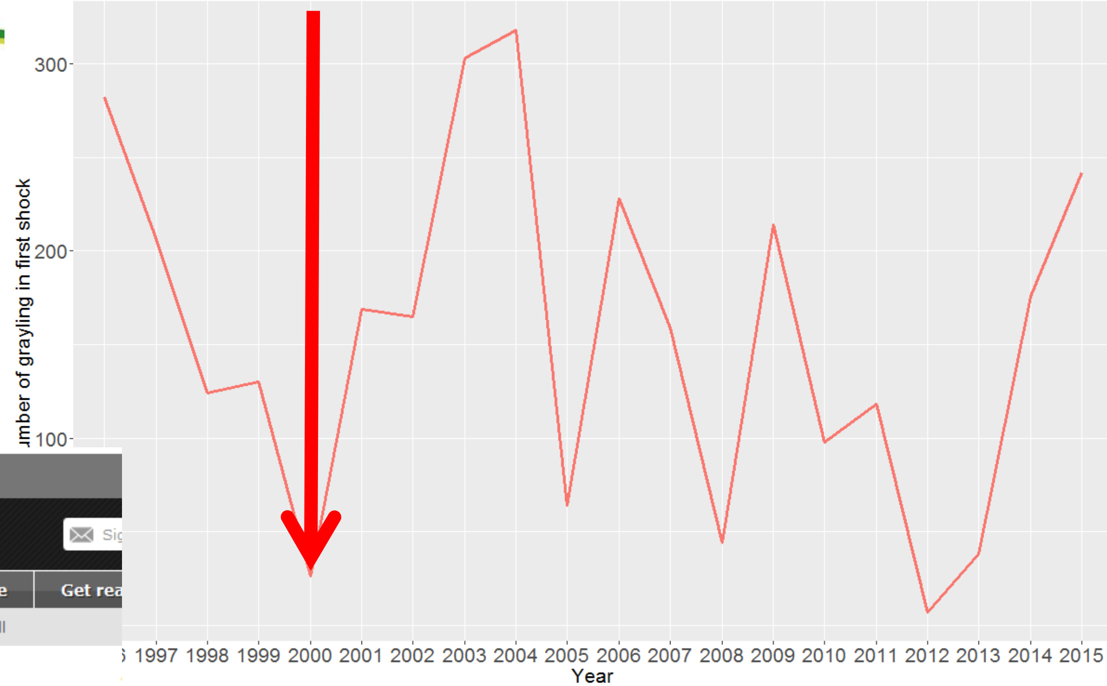
100
0
Number of grayling in first shock
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Year

0+ only

April 2000



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Home ▸ Public ▸ Weather ▸ UK climate ▸ Past weather events ▸ April 2000 - Record rainfall

April 2000 - Record rainfall

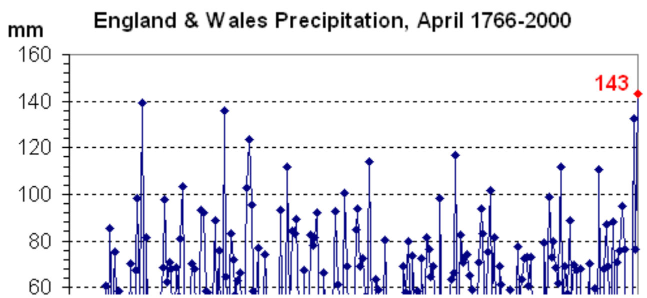
A consistently wet April has led to records being broken throughout the UK

Introduction

Record rainfall

A consistently wet April has led to records being broken throughout the UK.

According to the England and Wales precipitation series (an index which begins in 1766) the total was 143 mm(using best available data/estimates on 2 May 2000) making it the wettest April since records began. Previous highest April totals were in 1782 (139 mm), 1818 (136 mm) and 1998 (133 mm). The chart below shows the series April 1766-2000.



1999 – 2000

125 -> 26 =

80% decrease in 0+

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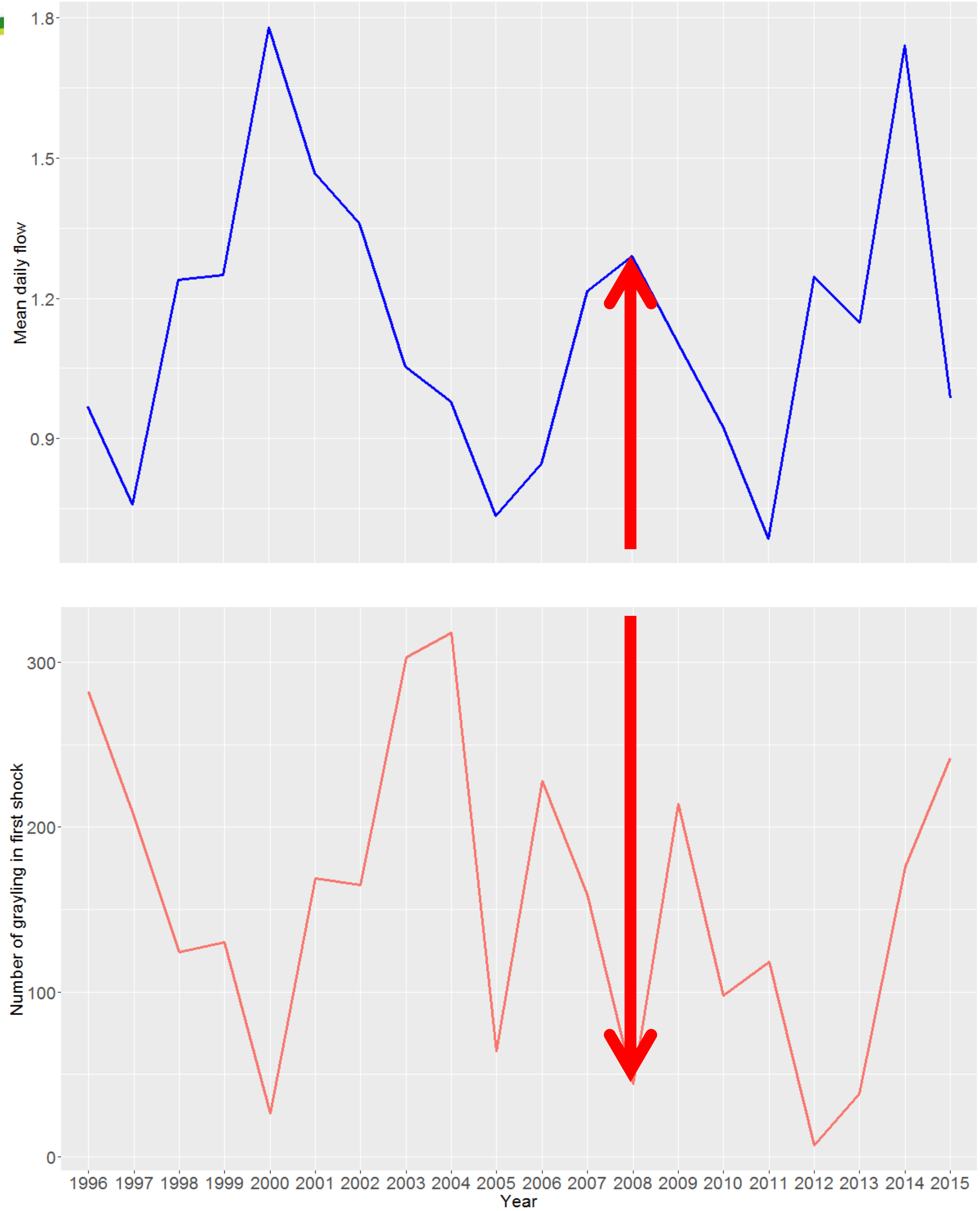
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Mean daily flow
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100
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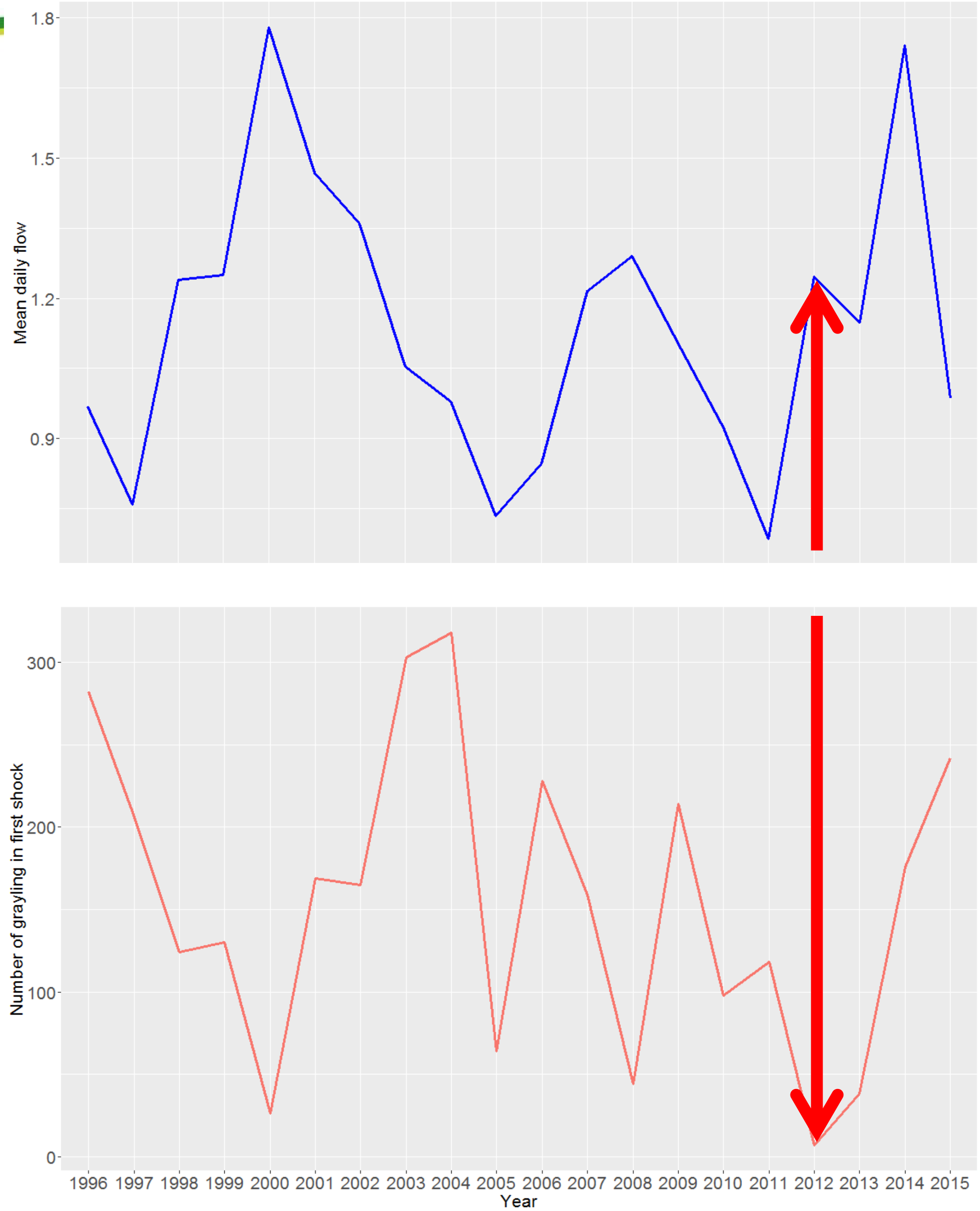
Number of grayling in first shock
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Year

0+ only



Mean daily flow
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1.5
1.2
0.9
Number of grayling in first shock
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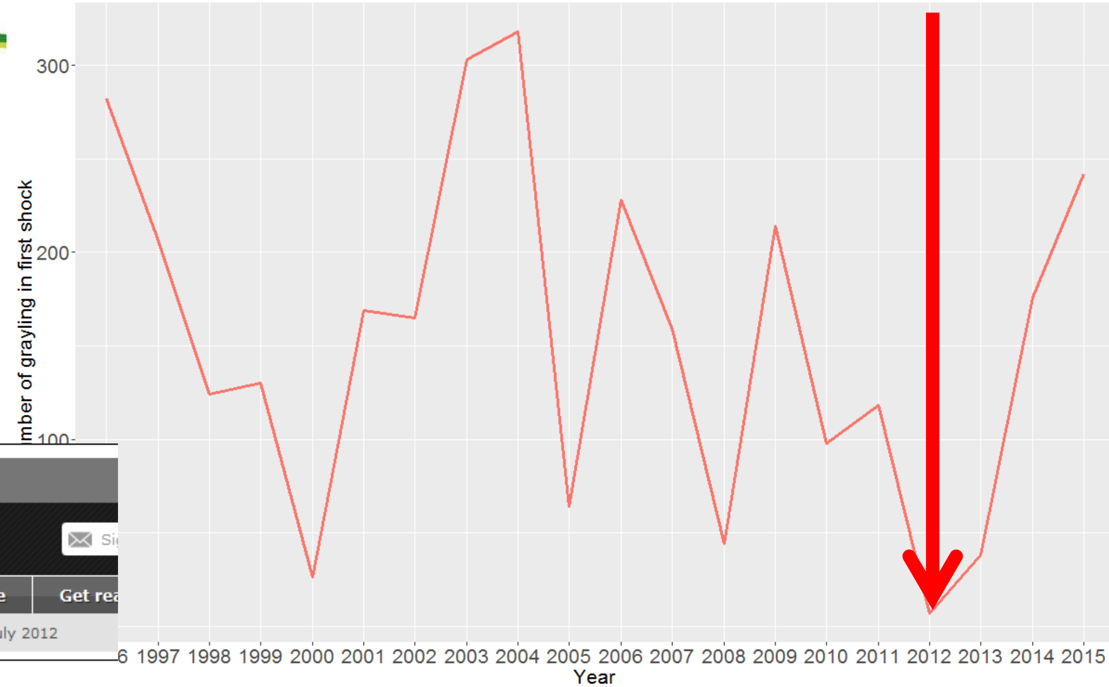
200
100
0
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Year

0+ only

April 2012



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Home ▸ Public ▸ Weather ▸ UK climate ▸ Past weather events ▸ Record rainfall - April to July 2012

Record rainfall - April to July 2012

From April to July 2012 the UK experienced a period of exceptionally wet weather, breaking previous rainfall records and resulting in several significant flood events.

The wet weather affected all of England, Wales and eastern Scotland. April, June, and the period April to July were each the wettest on record in the England & Wales precipitation series from 1766, while for the UK overall, summer 2012 (June, July and August) was the wettest since 1912. The record rainfall brought the 2010-12 England and Wales drought to an abrupt end. In contrast to the wet weather elsewhere, the far north-west of Scotland saw well below-average rainfall from March to October 2012.

The persistent wet weather was due to a shift in the jet stream to a much more southerly track than normal, bringing a succession of Atlantic low pressure systems and associated fronts across the southern half of the UK.

Impacts

After the drought, the wet weather was initially very welcome, bringing much-needed rain for farmers and growers. However, before long it brought new problems.

Waterlogging made access to land difficult, reduced yields and caused some crops to rot. Various flood incidents through the period caused widespread problems, particularly to the transport network. Surface water flooding and debris closed main roads. Railway lines were blocked by flooding and landslips. Birmingham airport diverted inbound flights in late June.

2011 – 2012

118 -> 7 =

94% decrease in 0+

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“Provisional” observations

- Patterns: not cause and effect
  - Needs closer examination, e.g., 2005, 2014
- Based on counts, <u>not</u> population estimates
- Alternative factors:
  - Temperature
  - Habitat loss
  - etc

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Questions

How might flooding affect grayling populations?

- Shared patterns in flow and grayling counts?

How might flooding affect grayling in the future?

- Forecast from observed population patterns

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Procedure: “matrix population model”

$$\begin{pmatrix} N_{t+l_1} \\ N_{t+l_2} \\ N_{t+l_3} \end{pmatrix} = \begin{pmatrix} F_1 & F_2 & F_3 \\ S_1 & 0 & 0 \\ 0 & S_2 & 0 \end{pmatrix} \begin{pmatrix} N_{t_1} \\ N_{t_2} \\ N_{t_3} \end{pmatrix} \quad .$$

1. Use observed data to calculate age-specific:
    - Death rate
    - Birth rate

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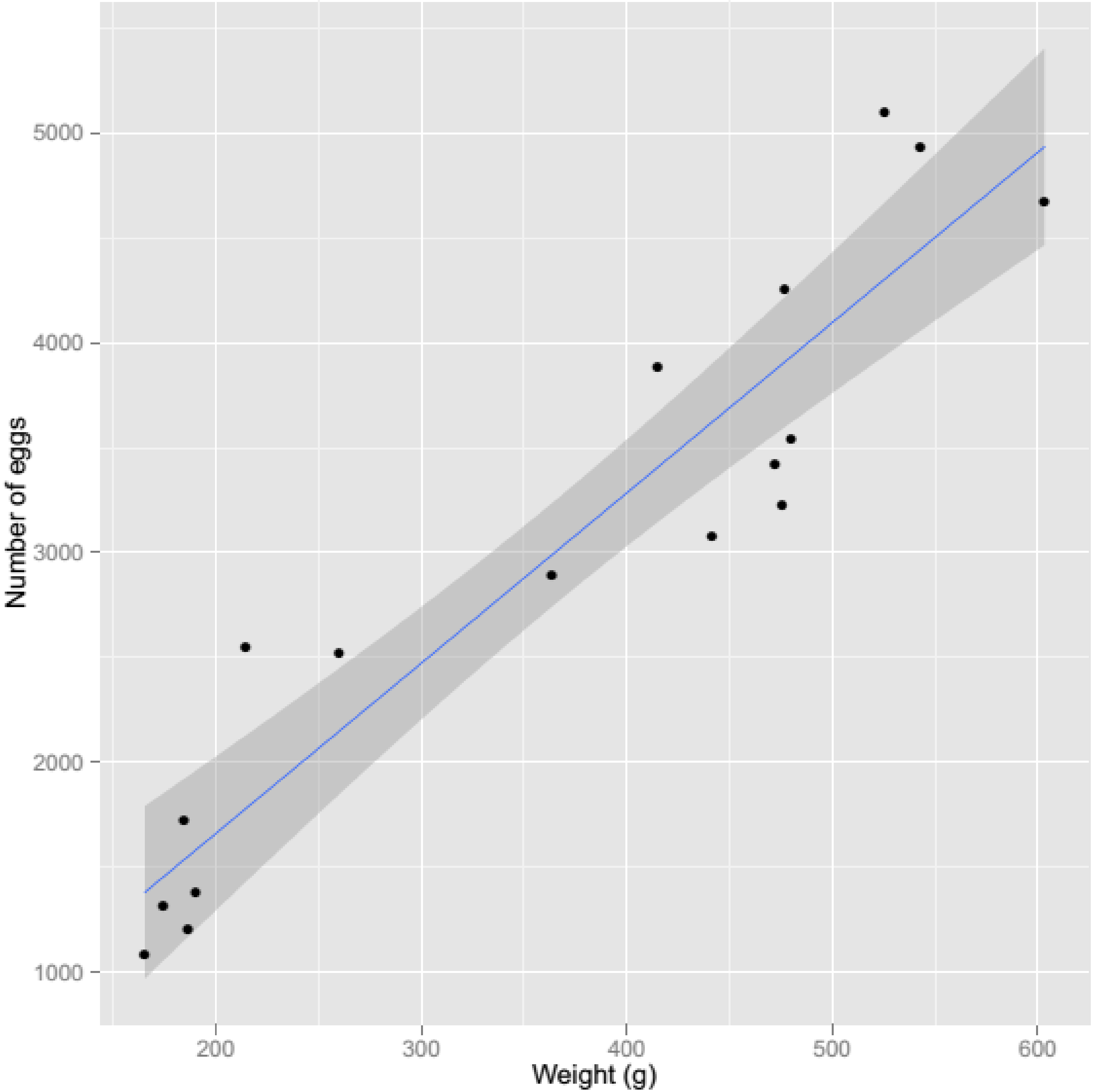

5000
4000
3000
2000
1000
Number of eggs
200
300
400
500
600
Weight (g)

Procedure: "matrix population model"

$$\begin{pmatrix} N_{t+l_1} \\ N_{t+l_2} \\ N_{t+l_3} \end{pmatrix} = \begin{pmatrix} F_1 & F_2 & F_3 \\ S_1 & 0 & 0 \\ 0 & S_2 & 0 \end{pmatrix} \begin{pmatrix} N_{t_1} \\ N_{t_2} \\ N_{t_3} \end{pmatrix} .$$

1. Use observed data to calculate age-specific:
   - Death rate
   - Birth rate
2. Competition for food among 0+ individuals

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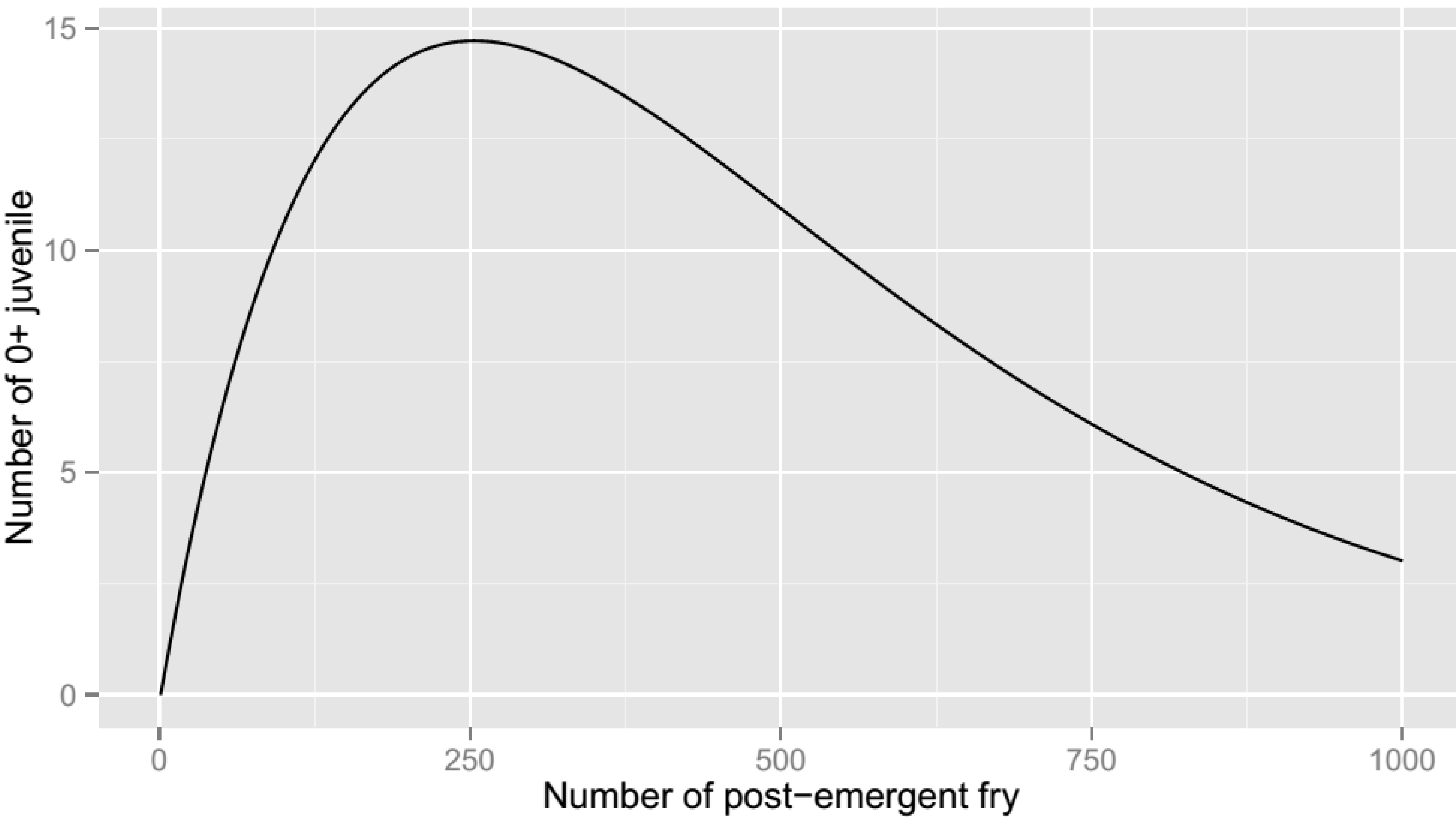

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Procedure: matrix population model

$$\begin{pmatrix} N_{t+l_1} \\ N_{t+l_2} \\ N_{t+l_3} \end{pmatrix} = \begin{pmatrix} F_1 & F_2 & F_3 \\ S_1 & 0 & 0 \\ 0 & S_2 & 0 \end{pmatrix} \begin{pmatrix} N_{t_1} \\ N_{t_2} \\ N_{t_3} \end{pmatrix} .$$

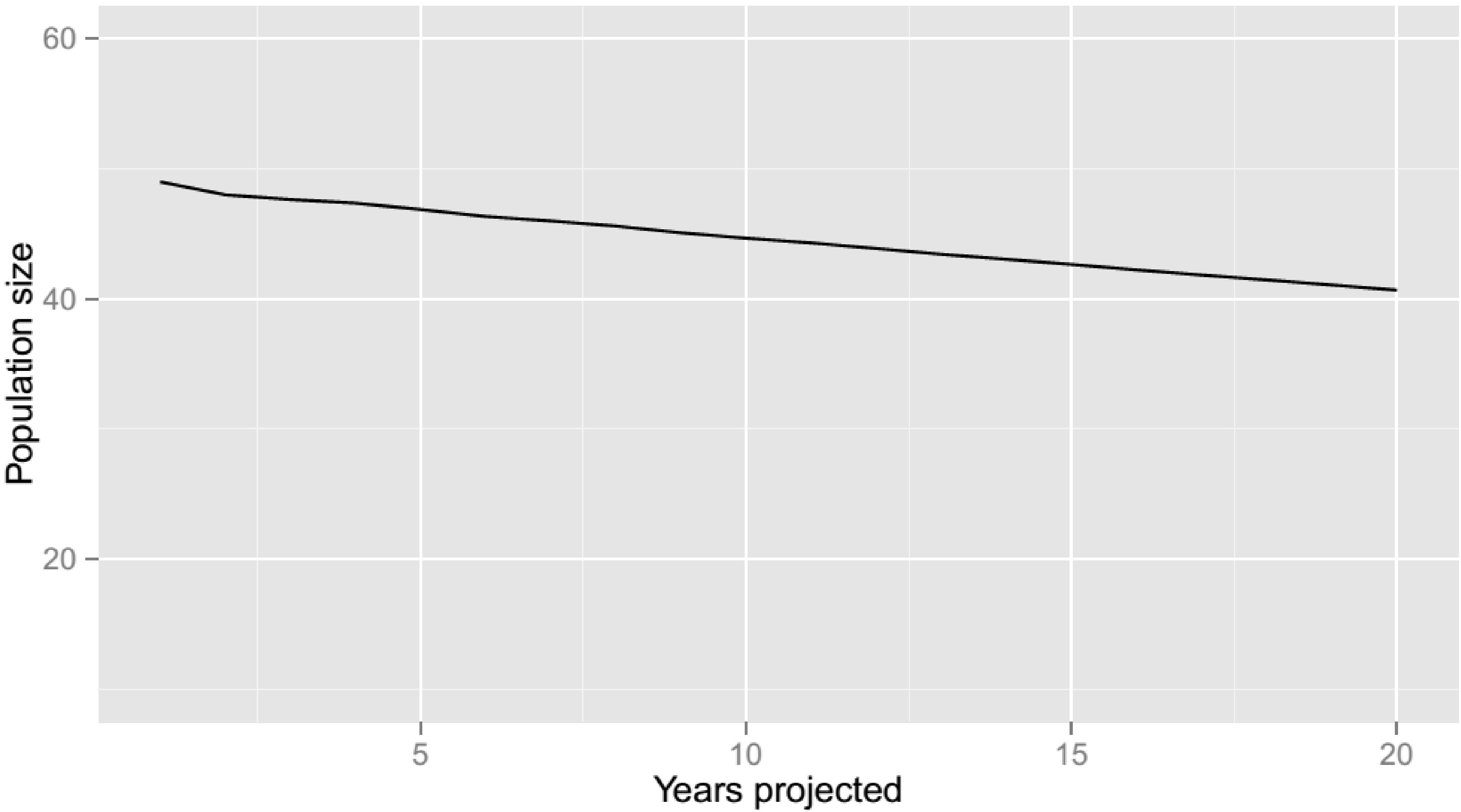
1. Use observed data to calculate age-specific:
    - Mortalities
    - Fecundities
2. Competition for food among 0+ individuals
3. Calculate “population projection matrix”

Procedure: matrix population model

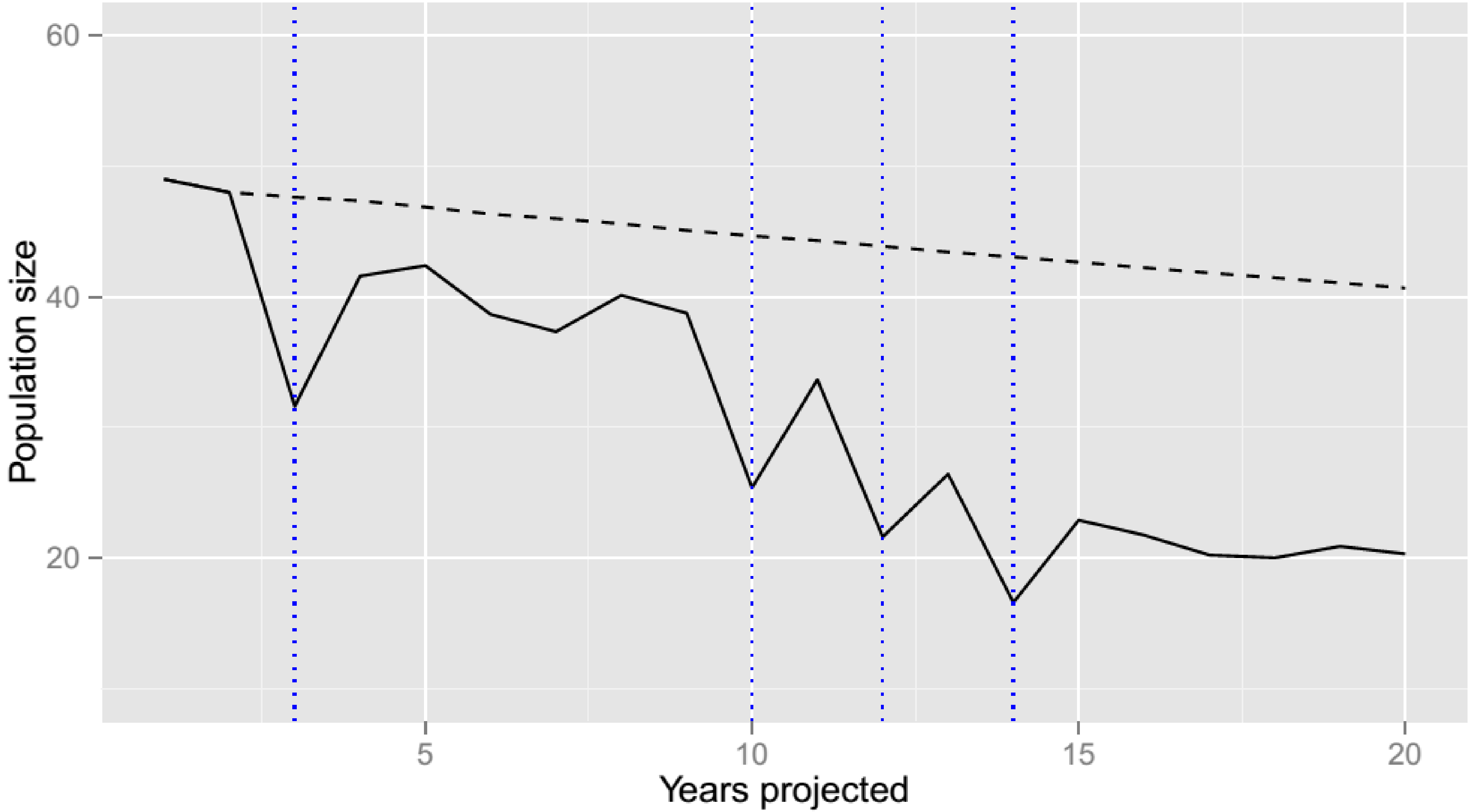
$$\begin{pmatrix} N_{t+l_1} \\ N_{t+l_2} \\ N_{t+l_3} \end{pmatrix} = \begin{pmatrix} F_1 & F_2 & F_3 \\ S_1 & 0 & 0 \\ 0 & S_2 & 0 \end{pmatrix} \begin{pmatrix} N_{t_1} \\ N_{t_2} \\ N_{t_3} \end{pmatrix} .$$

1. Use observed data to calculate age-specific:
   - Mortalities
   - Fecundities
2. Competition for food among 0+ individuals
3. Calculate "population projection matrix"
4. Forecast future population changes

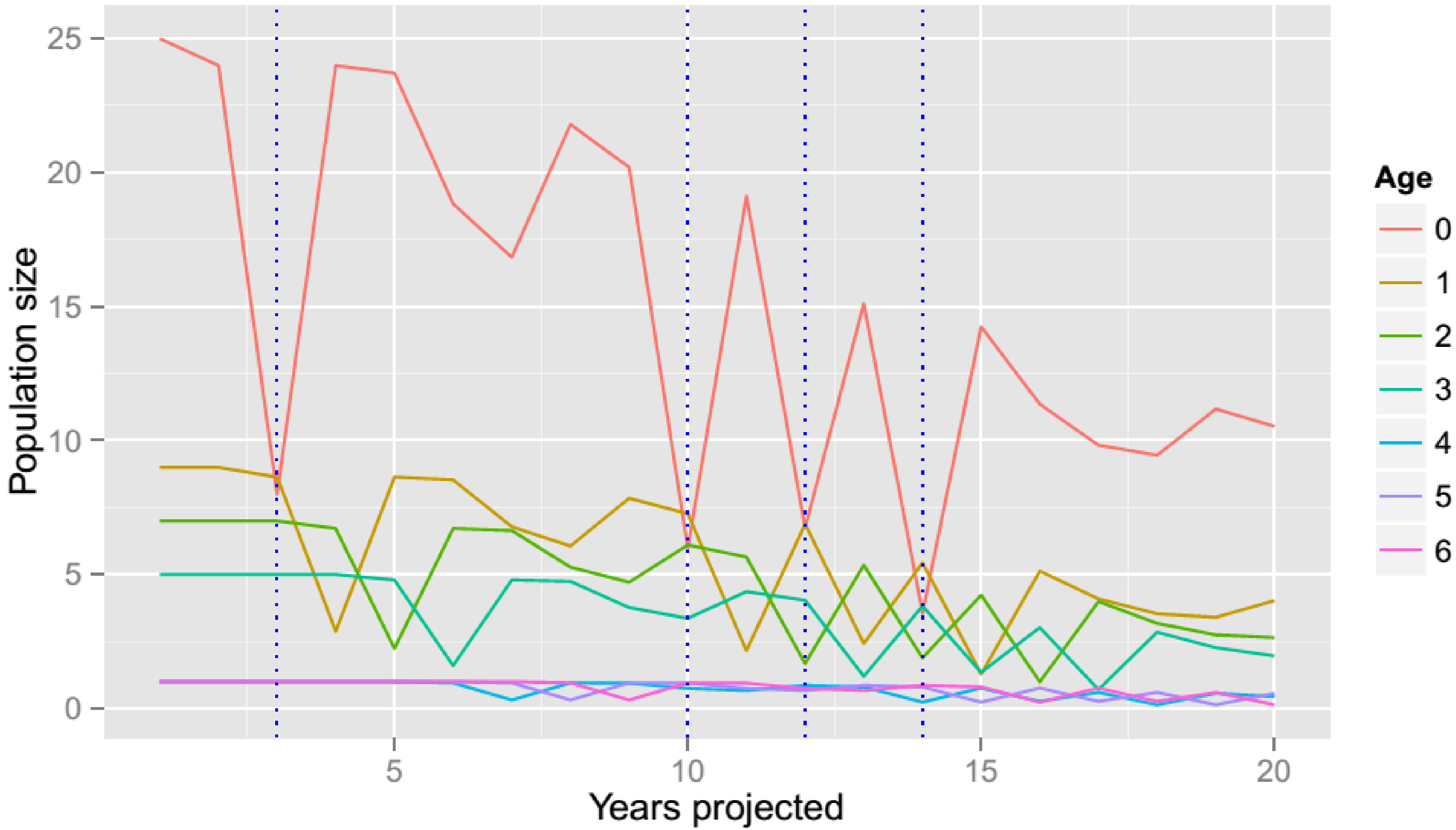
Population forecast without floods



Population forecast with floods



Population forecast with floods



What does this mean?

- Floods *could* cause population decline
- Juvenile (0+) fish will be most affected
- Sensitivity analysis of model parameters:
  - Identify information gaps
  - Guide additional data collection

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What can be done?

- Consider management options
  - Habitat alterations
  - Woody debris
- Test possible implications of management
- Catchment-based water management
- Extend investigation to other species?

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Next steps

- Compare effects of flow to other factors:
  - river temperature
  - etc
- Grayling population & climate change
- Individual analyses

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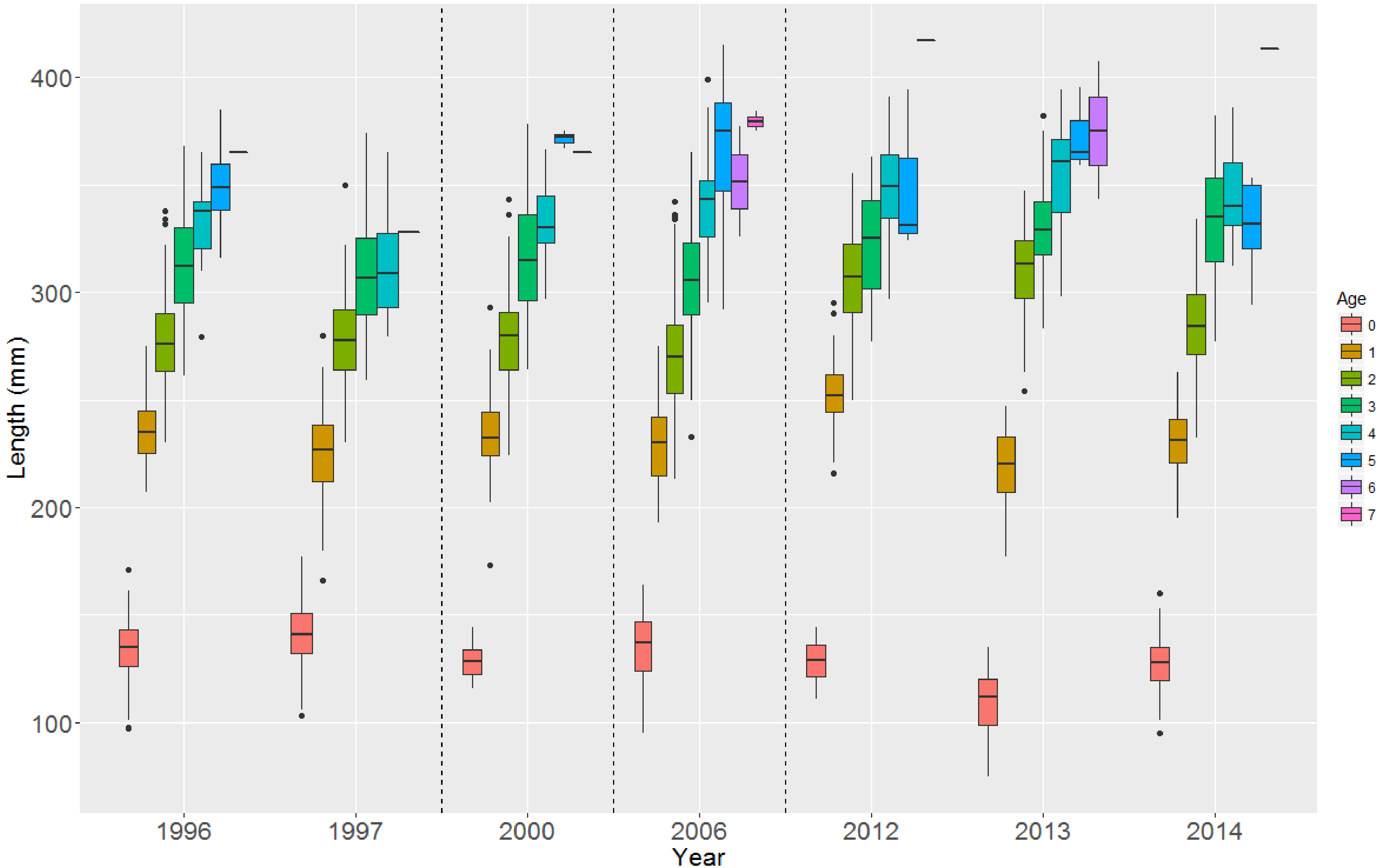
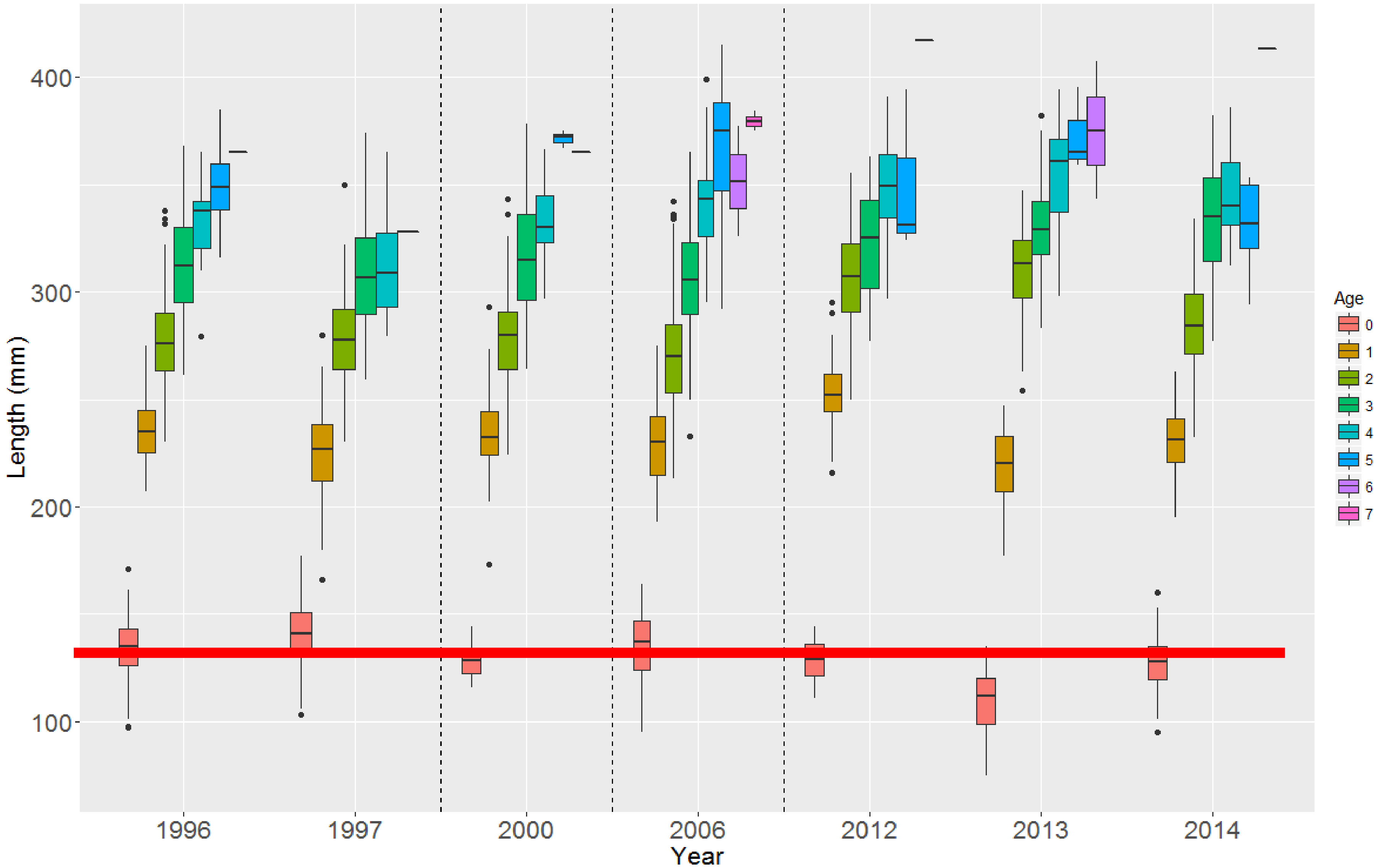
Further work

- Grayling growth ~ environmental conditions

Length: poor 0+ growth 2013?



Length: poor 0+ growth 2013?



Further work

- Grayling growth ~ environmental conditions

- Grayling and trout coexistence

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Trout!

Trout!

- Three shock survey 2009 : 2016

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Trout!

- Three shock survey 2009 : 2016
- Six sites

Trout!

- Three shock survey 2009 : 2016
- Six sites
- ~7500 individual length & weight records

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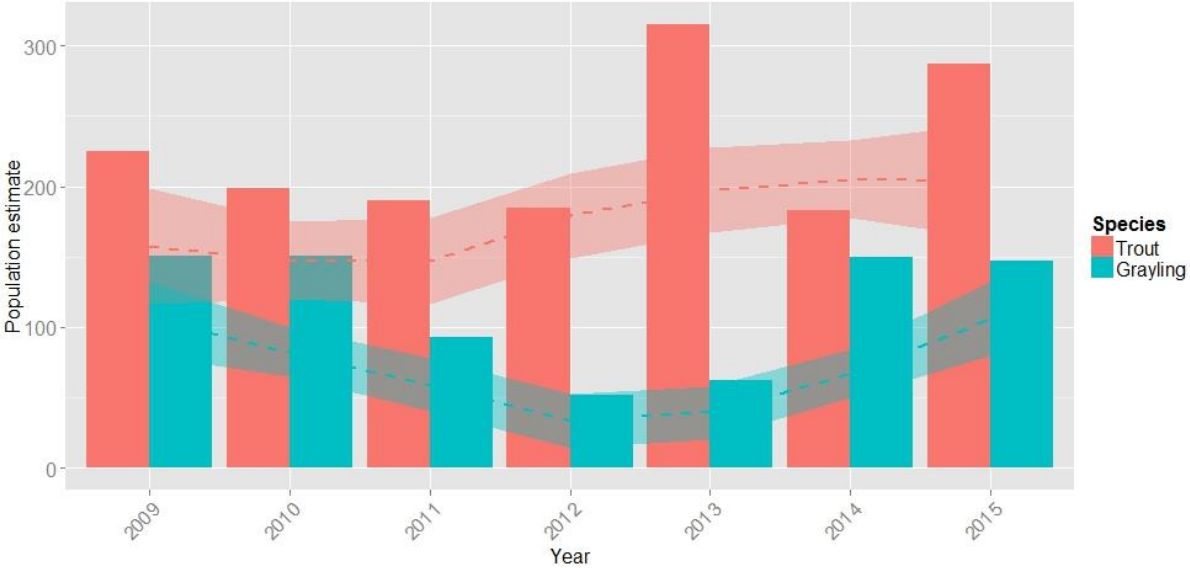
Coexistence between grayling & trout

- Populations



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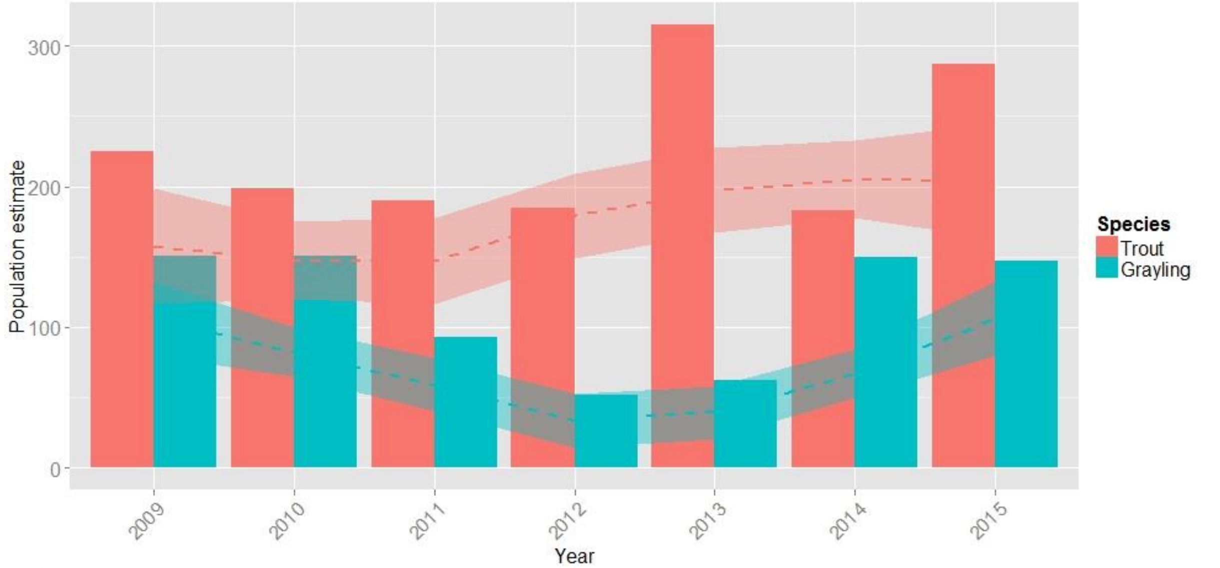
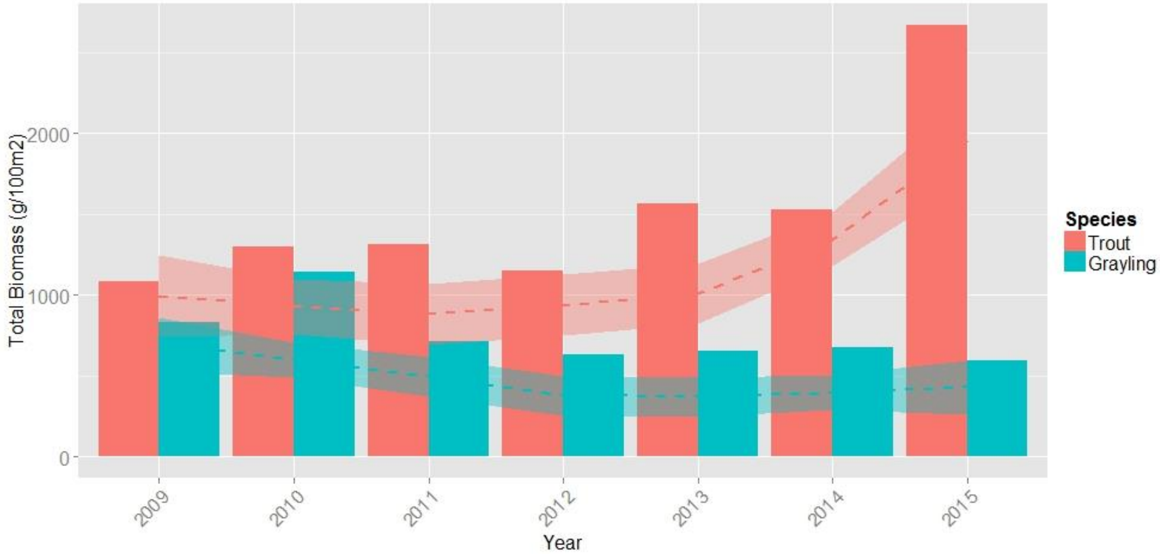
Coexistence between grayling & trout

- Populations
- Biomass





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Further work

- Grayling growth ~ environmental conditions
- Grayling and trout coexistence
- Grayling population dynamics

Grayling: an indicator of river health

- Salmonid ~ similar needs to salmon & trout

Ibbotson, A., Cove, R. et al. (2001) A Review of Grayling Ecology, Status and Management Practice; Recommendations for Future Management in England and Wales. Environment Agency.

Grayling: an indicator of river health

- Salmonid ~ similar needs to salmon & trout
- Most sensitive to environmental change:

	Temperature (oC)		
	Salmon	Trout	Grayling
Lower	0 – 6	0 – 4	0 – 4
Optimum	6 – 20	4 – 19	4 – 18
Upper	20 – 34	19 – 30	18 – 25

Ibbotson, A., Cove, R. et al. (2001) A Review of Grayling Ecology, Status and Management Practice; Recommendations for Future Management in England and Wales. Environment Agency.

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Grayling: an indicator of river health

- Salmonid ~ similar needs to salmon & trout
- Most sensitive to environmental change:

	Temperature (oC)		
	Salmon	Trout	Grayling
Lower	0 – 6	0 – 4	0 – 4
Optimum	20 – 34	19 – 30	18 – 25
Upper	6 – 20	4 – 19	4 – 18

- Most sensitive reproductive strategy

Ibbotson, A., Cove, R. et al. (2001) A Review of Grayling Ecology, Status and Management Practice; Recommendations for Future Management in England and Wales. Environment Agency.

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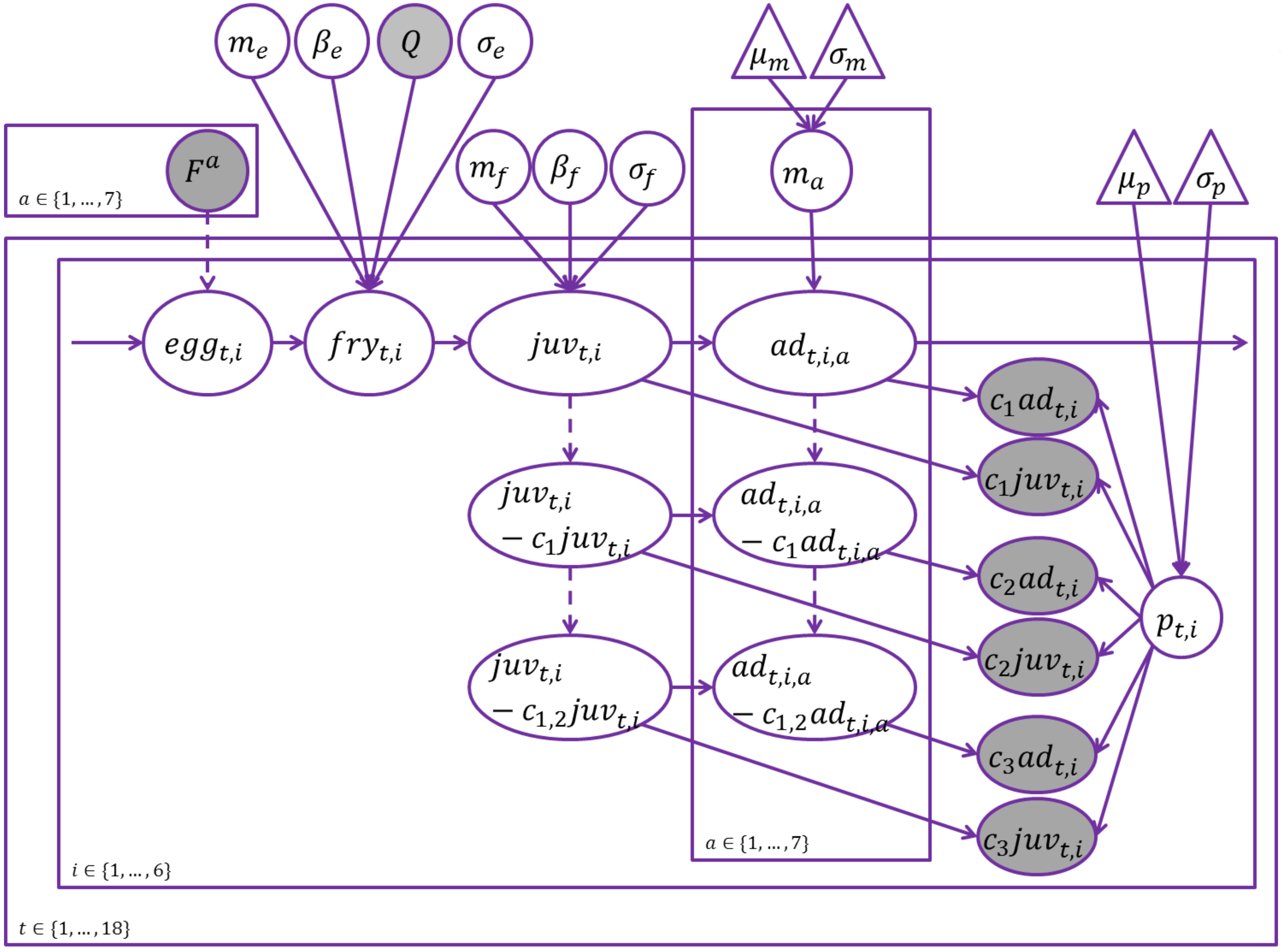

m_e
β_e
Q
σ_e
μ_m
σ_m
F^a
$a \in \{1, \dots, 7\}$
m_f
β_f
σ_f
m_a
μ_p
σ_p
$egg_{t,i}$
$fry_{t,i}$
$juv_{t,i}$
$ad_{t,i,a}$
$c_1 ad_{t,i}$
$c_1 juv_{t,i}$
$juv_{t,i} - c_1 juv_{t,i}$
$ad_{t,i,a} - c_1 ad_{t,i,a}$
$c_2 ad_{t,i}$
$p_{t,i}$
$c_2 juv_{t,i}$
$juv_{t,i} - c_{1,2} juv_{t,i}$
$ad_{t,i,a} - c_{1,2} ad_{t,i,a}$
$c_3 ad_{t,i}$
$c_3 juv_{t,i}$
$a \in \{1, \dots, 7\}$
$i \in \{1, \dots, 6\}$
$t \in \{1, \dots, 18\}$

Photos: Dick Hawkes

Thank you

Cyfoeth Naturiol Cymru
Natural Resources Wales

The Piscatorial Society

Game & Wildlife Conservation Trust

The Grayling Research Trust

The Grayling Society
Promoting Awareness, Conservation & Angling for Grayling, Worldwide