Resizing a river : using experimental management to develop a downscaled environmental flow regime for the Lower Bridge River
or
Does more water mean more fish?

Mike Bradford

Paul Higgins

Josh Korman

Alternative Perspectives on Flow Management:

Natural Flow Paradigm

- "Nature knows best"
- Flows for ecosystem health
- The magnitude of the impact is related to the "degree of hydrologic alteration"
- More water = more fish

Designer Flows

- Flows for target species or management goals
- River resizing
- More water ≠ more fish

Experimental Management as a management paradigm

- Substantial uncertainty in instream flow methodologies, most are not tested
- Variable and unpredictable responses of the ecosystem to flow changes

- Instead of flow modelling, empirically determine response of the river to flow by testing a range of flow regimes

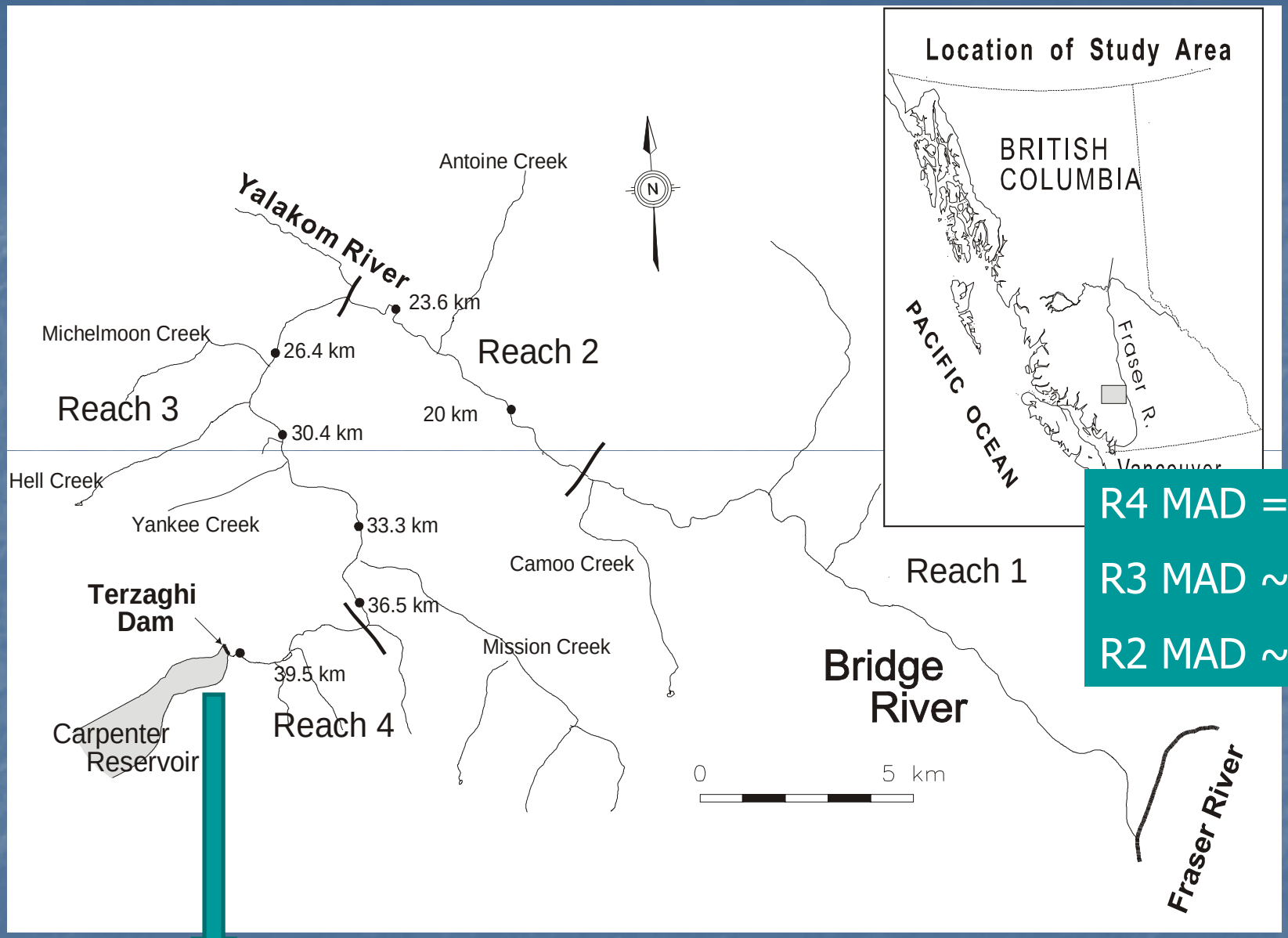
Bridge River, southwestern BC

Present location of Terzaghi Dam

MAD ~100 m^3s

Fish production in tributaries

Terzaghi Dam, ca 1958



R4 MAD = 0cms

R3 MAD ~ 0.6 cms

R2 MAD ~ 5.6 cms

100% diversion for power


Terzaghi Dam


Reach 4


Reach 3


Reach 2

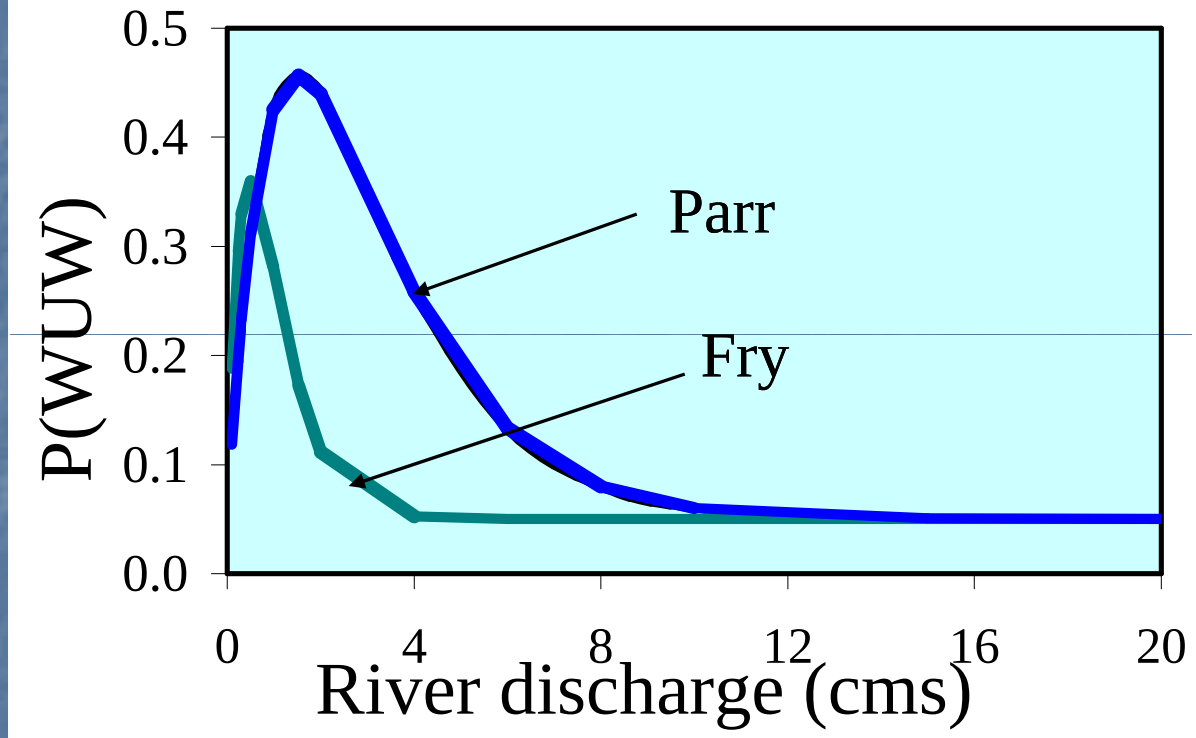
Mid 1990s: the reintroduction of flow from Terzaghi Dam

- Modification of the dam
- How much water to release?
- Water is worth 2-3 M$ per annualized m^3/s for power generation
- At the time, juvenile salmon were the primary environmental performance measure

Standard physical habitat simulation in Reach 3 predicted that a large flow release would reduce juvenile fish habitat

This is counter to standard setting approaches used by agencies

More water ≠ more fish!



Prediction: Optimal flows at 1-3 cms (1-3% MAD)

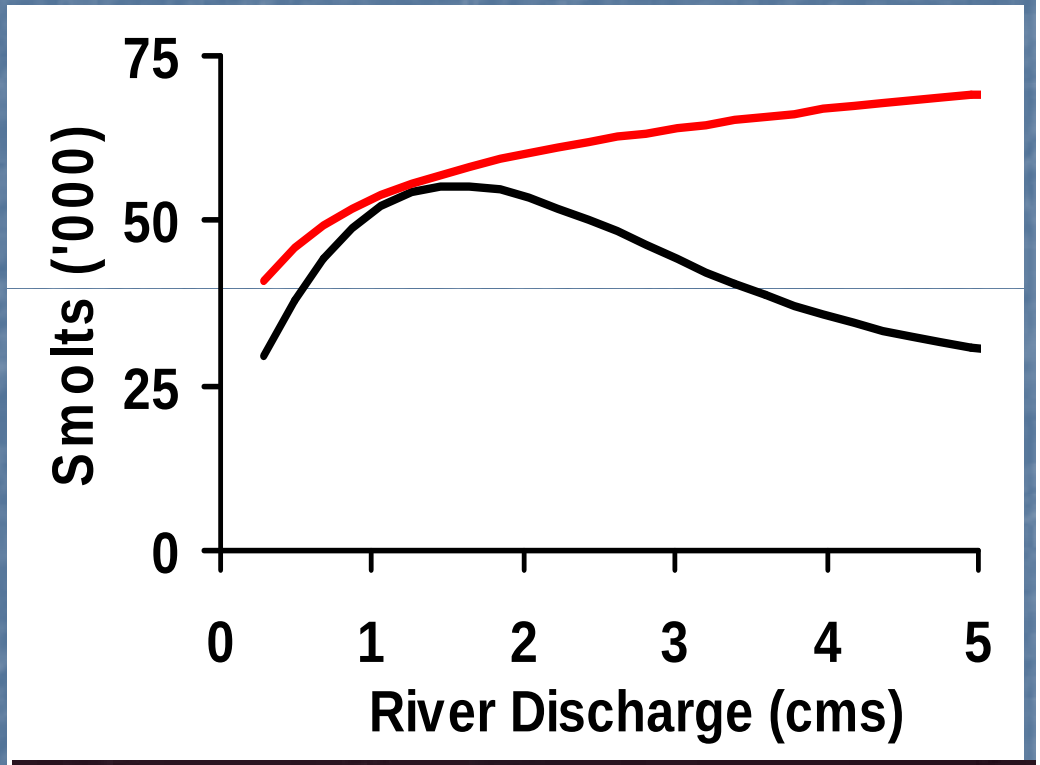
A flow experiment was recommended to arbitrate between competing hypotheses

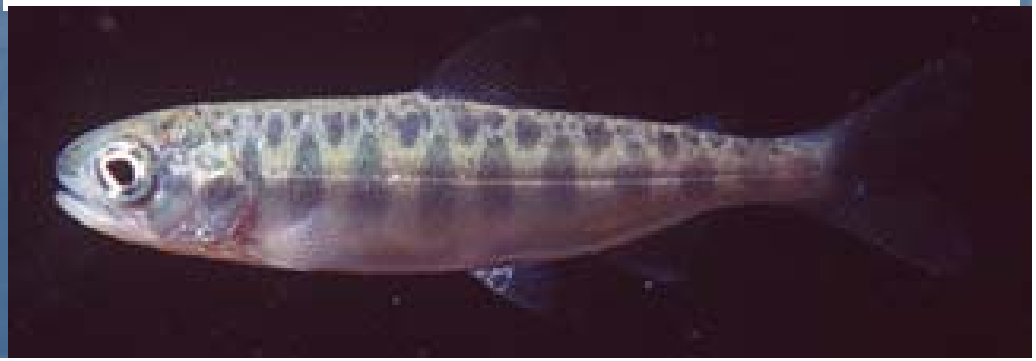
H_1: "More flow produces more fish"

Fish production is direct function of the relationship between wetted area and flow

H_2: "More flow will not produce more fish"

Habitat quality changes with flow, and after some threshold point this causes a net reduction in fish production

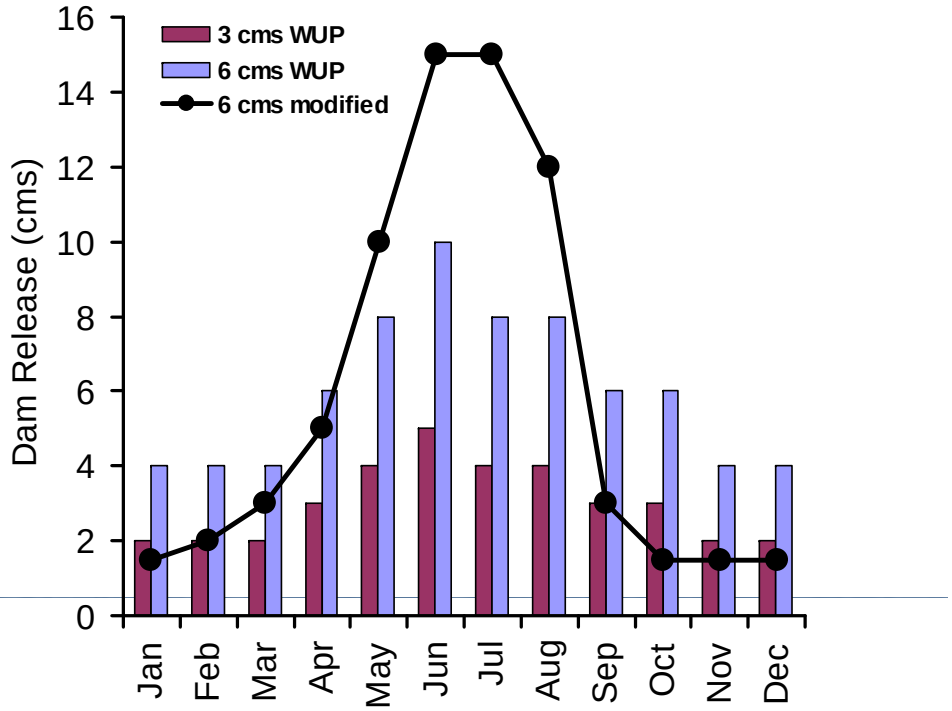


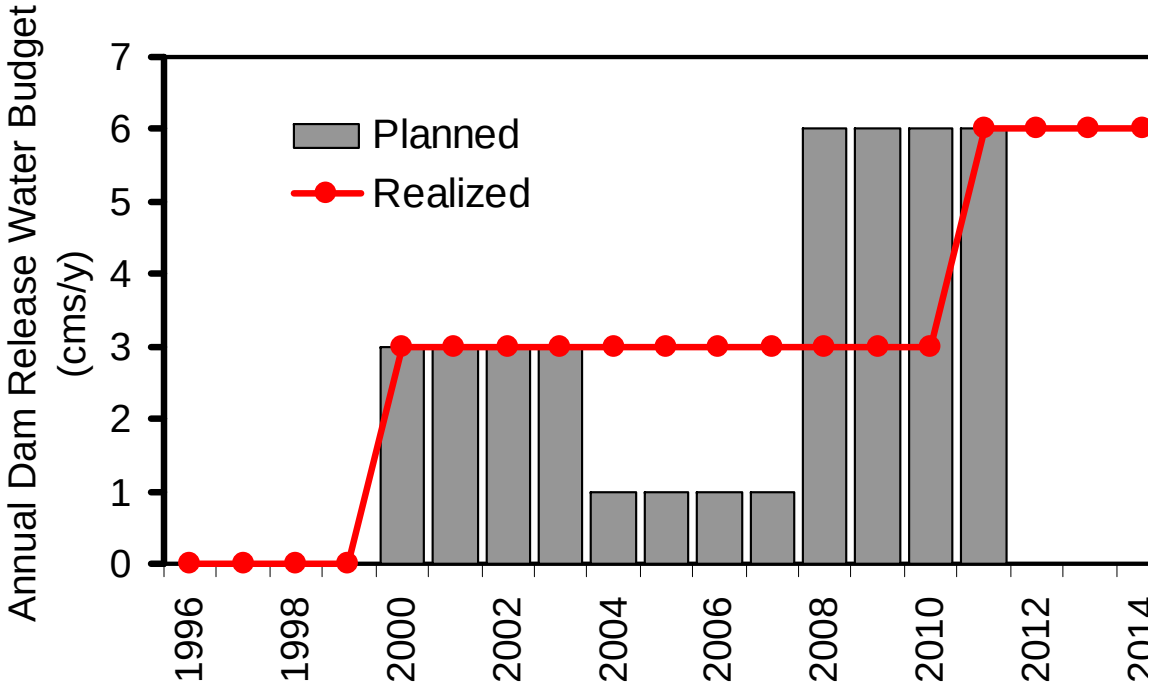


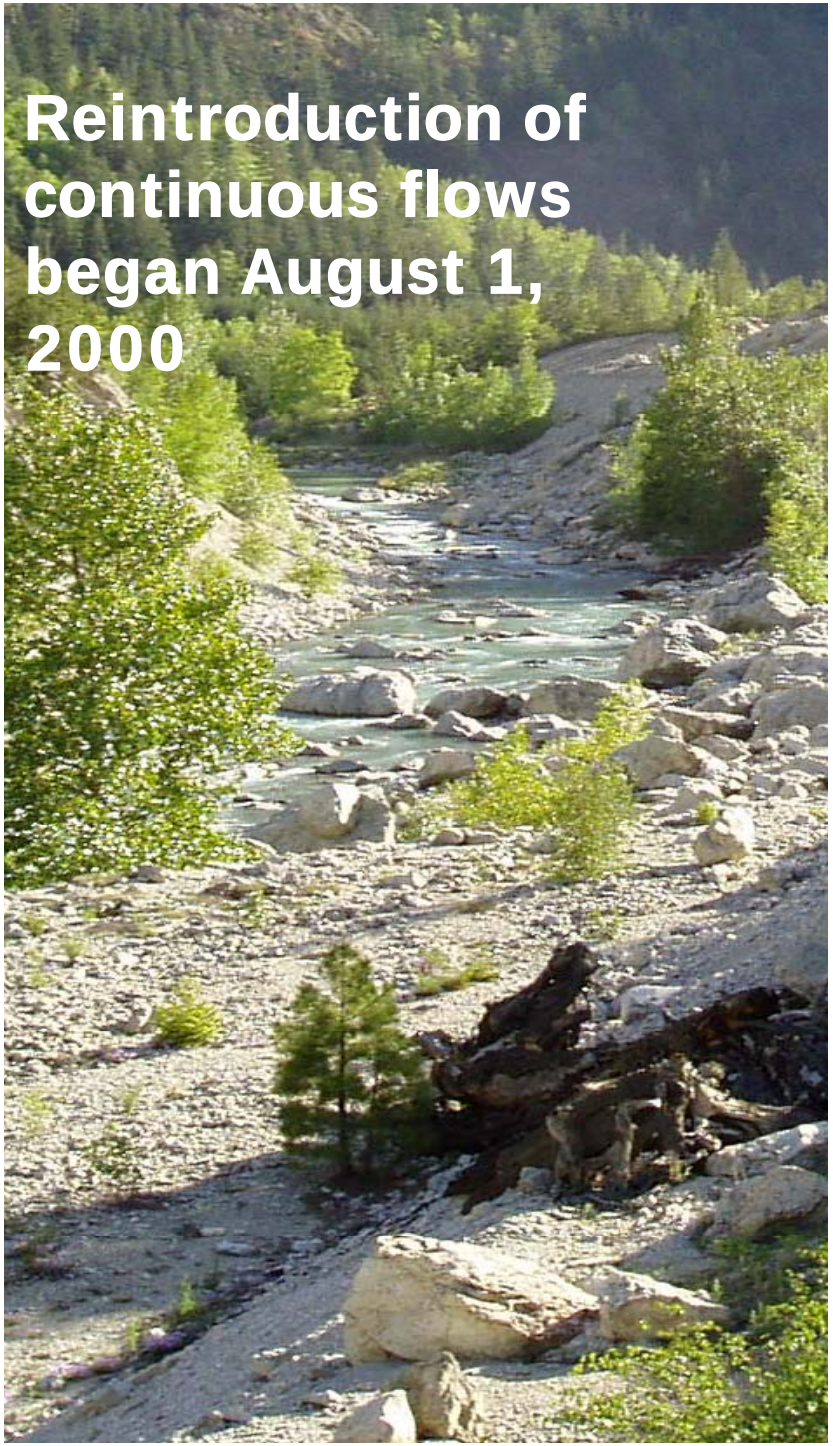
Recommended planned flow treatments:

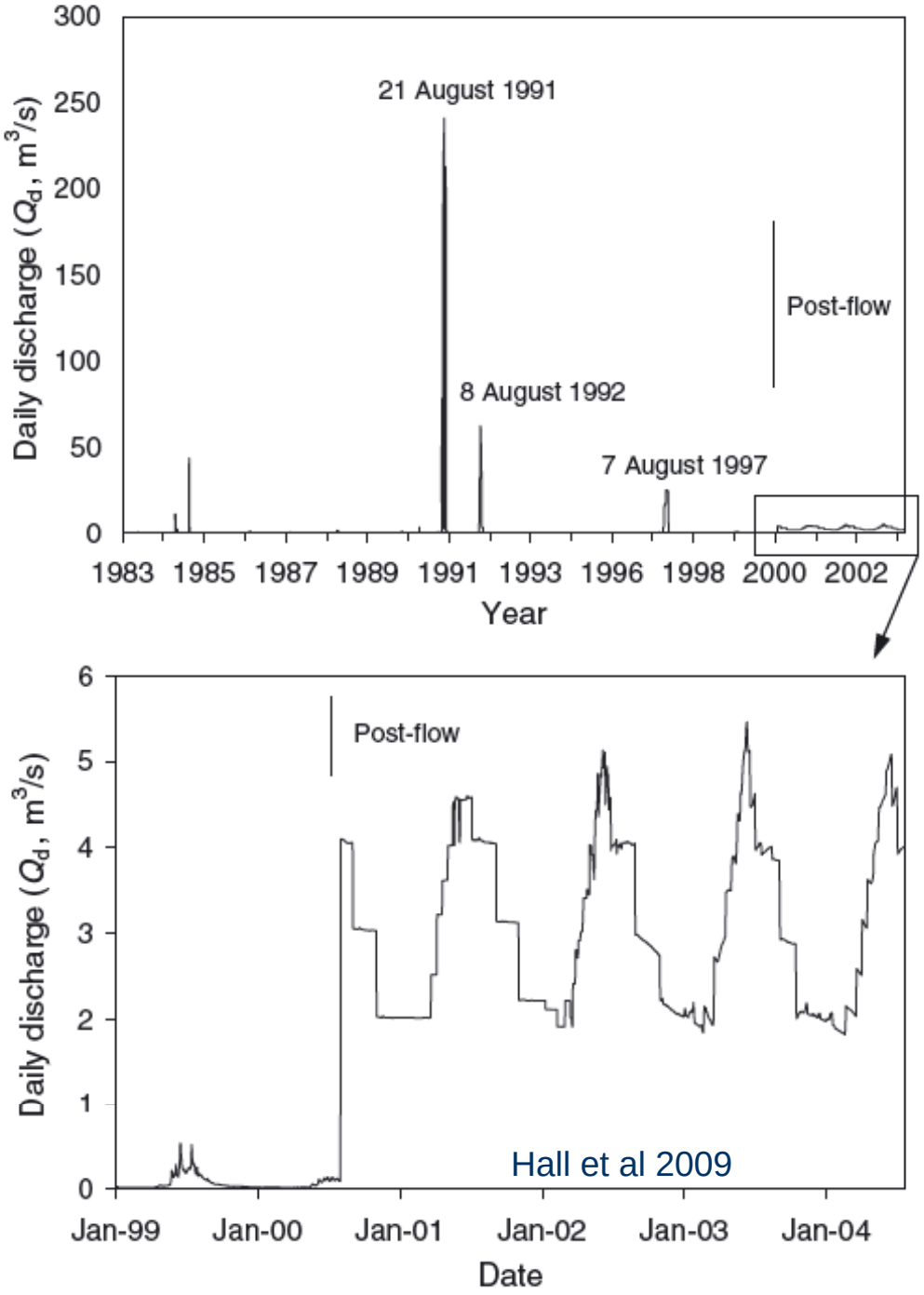
Seasonal flow variation “semi-natural flow”

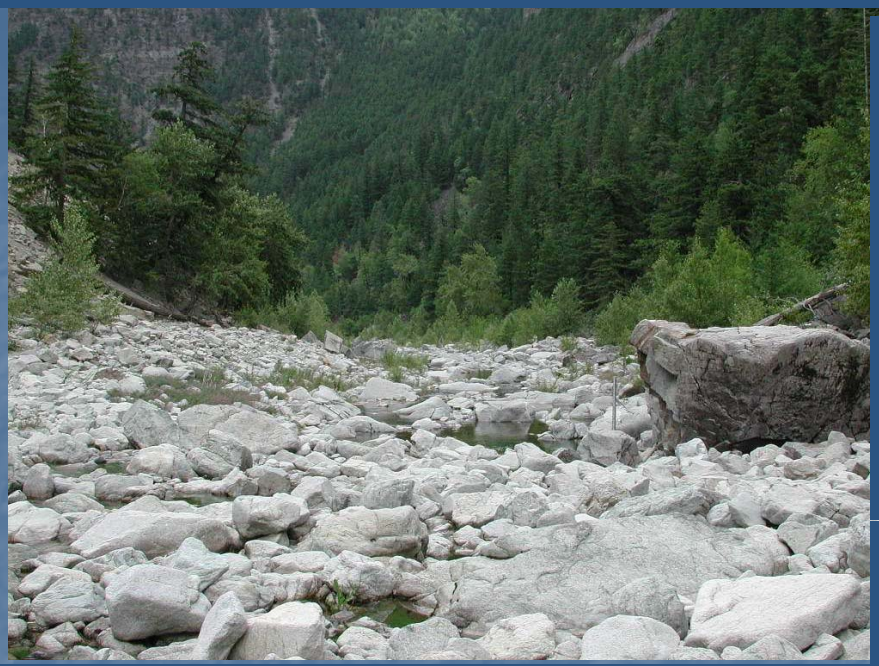
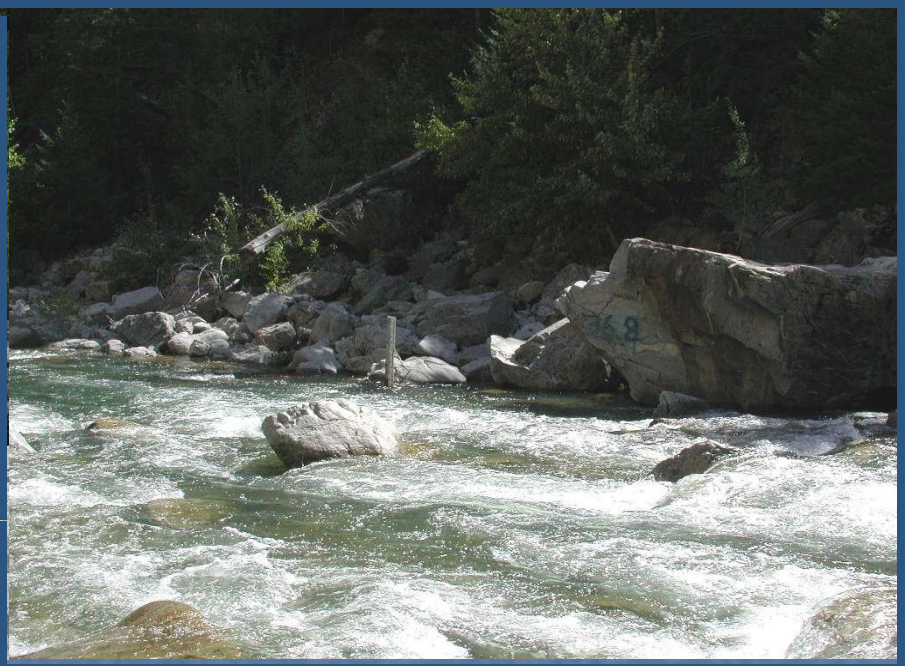
4-year treatment blocks





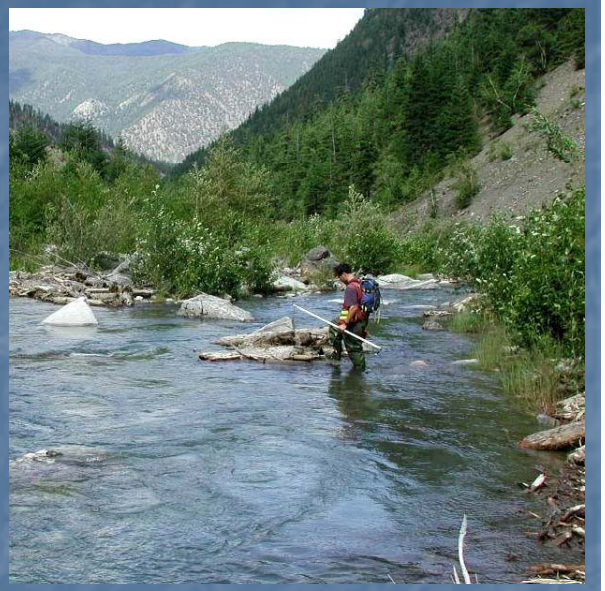

Reintroduction of continuous flows began August 1, 2000


Daily discharge (Q_d, m^3/s)
300
250
200
150
100
50
0
21 August 1991
8 August 1992
7 August 1997
Post-flow
1983 1985 1987 1989 1991 1993 1996 1998 2000 2002
Year
Post-flow
6
5
4
3
2
1
0
Jan-99 Jan-00 Jan-01 Jan-02 Jan-03 Jan-04
Date
Hall et al 2009

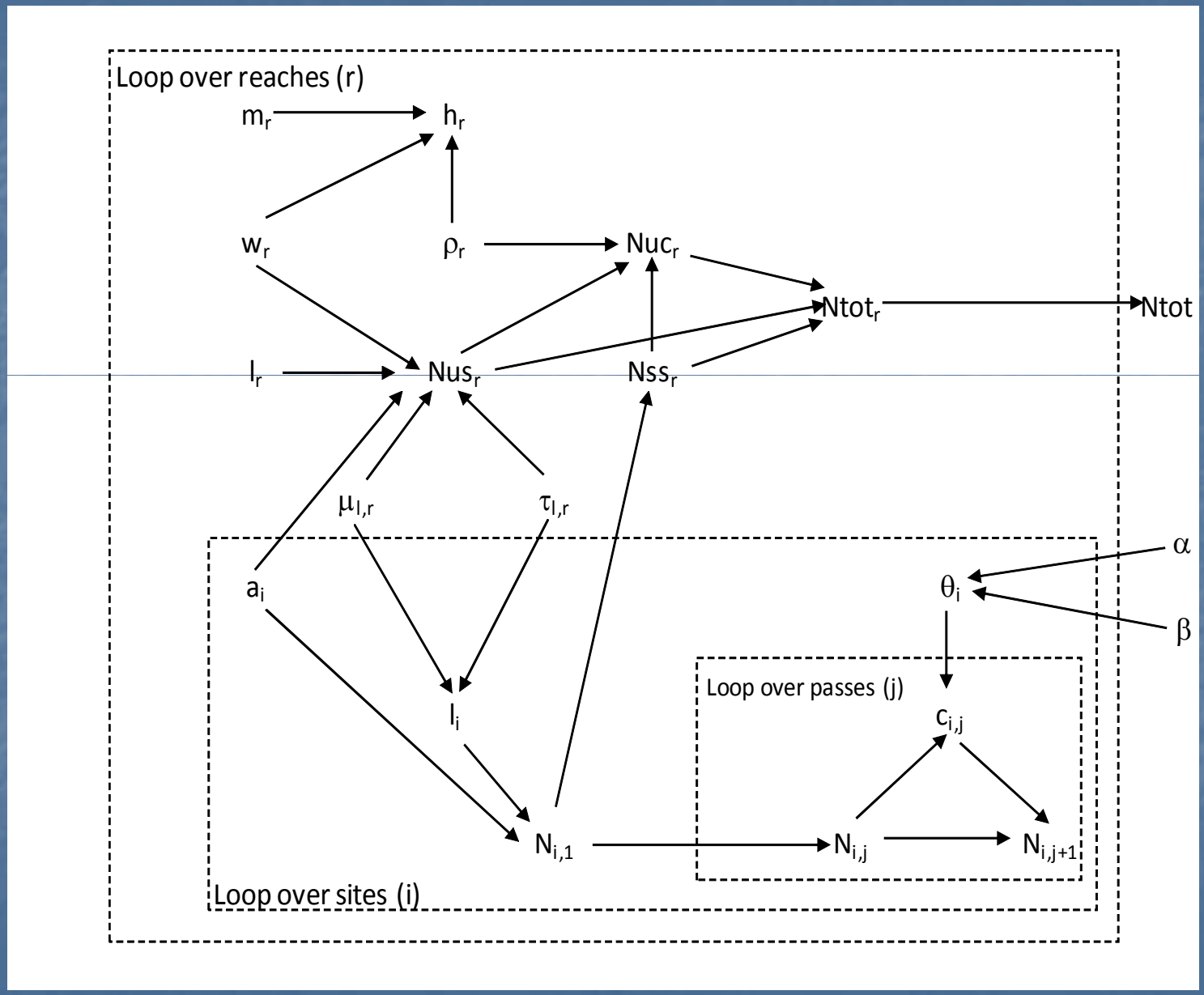
	Before	After
Reach 4		
Reach 3		

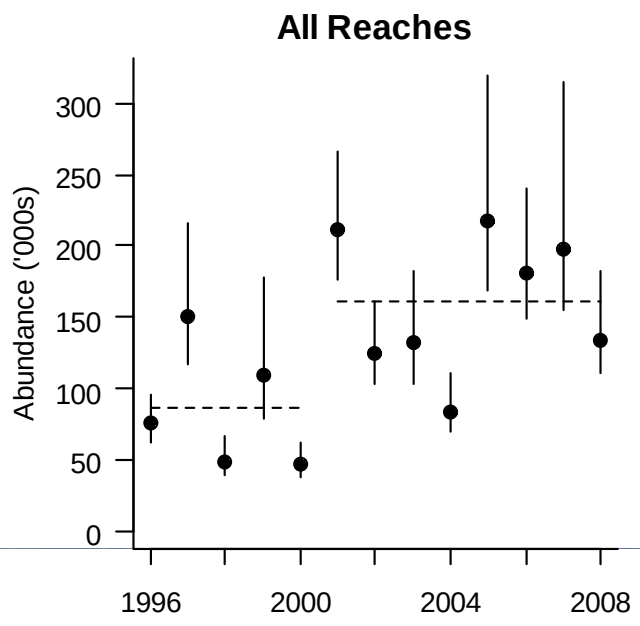
Monitoring Design

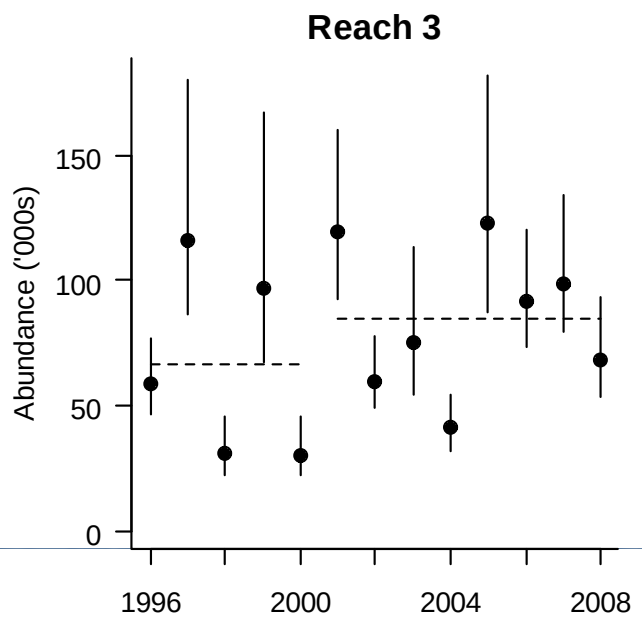
- Pre-release: 1996-1999
- Release year: 2000
- Post release: 2001-2008
- Basic unit- 3 pass backpack E/f
- 12-18 sites in each of 3 reaches
- Additional indicators:
  - Fish condition
  - Lower trophic levels
  - Physical and chemical monitoring

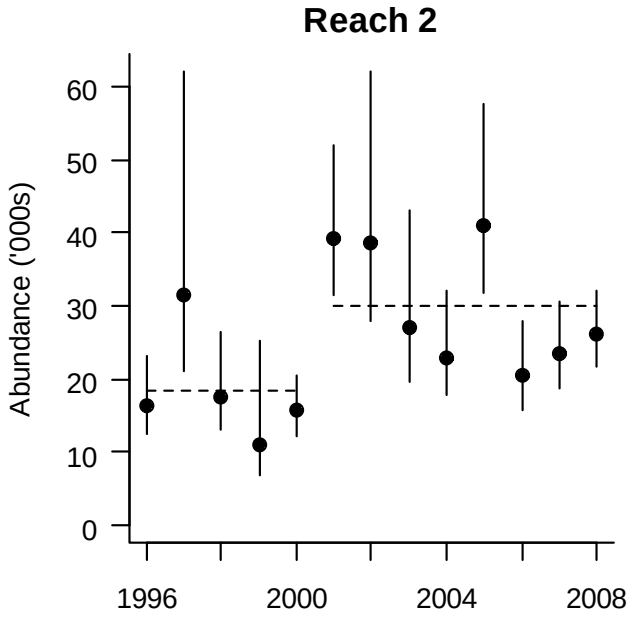


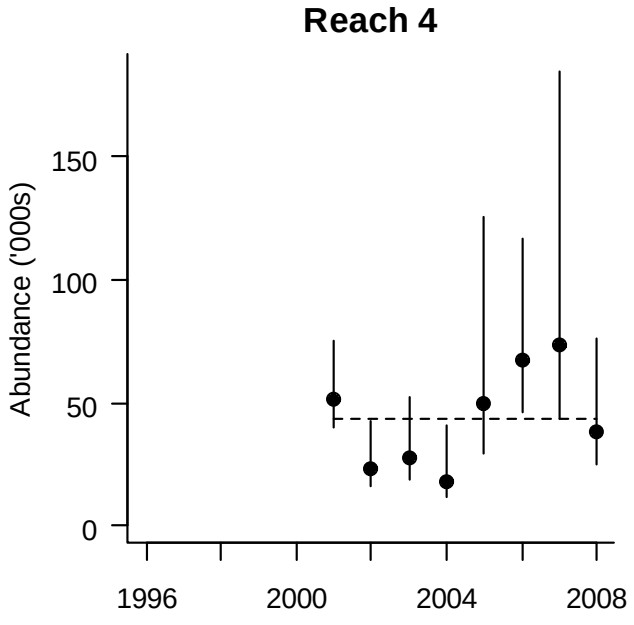
Hierarchical model for analyzing electrofishing data







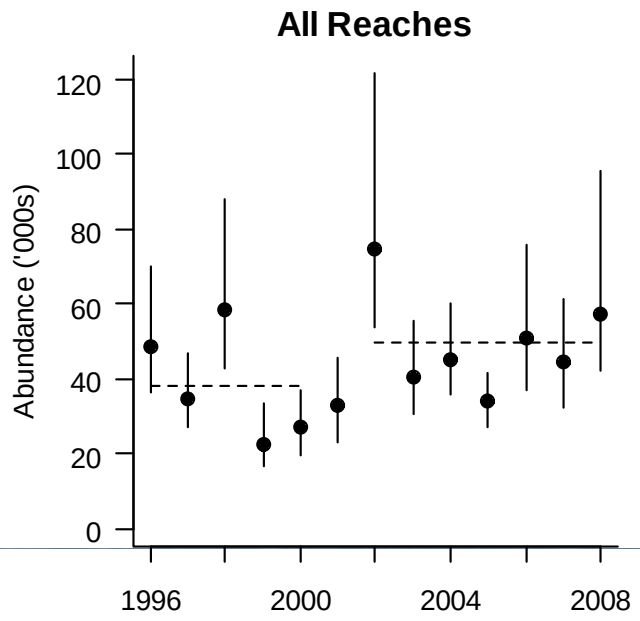


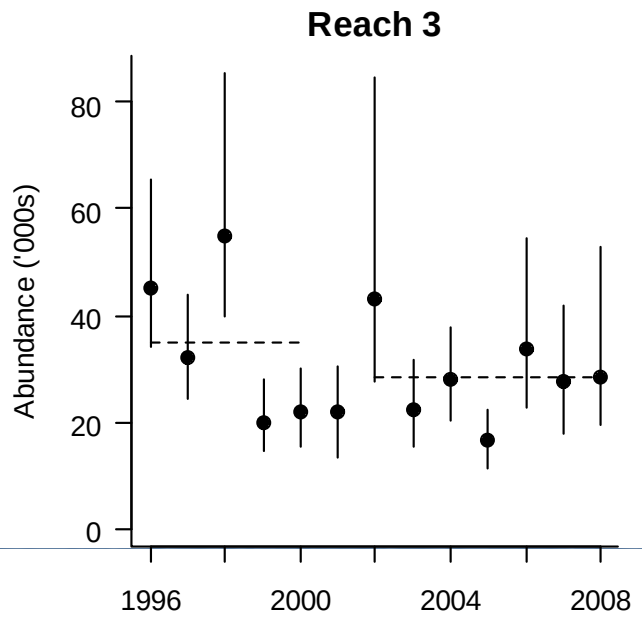


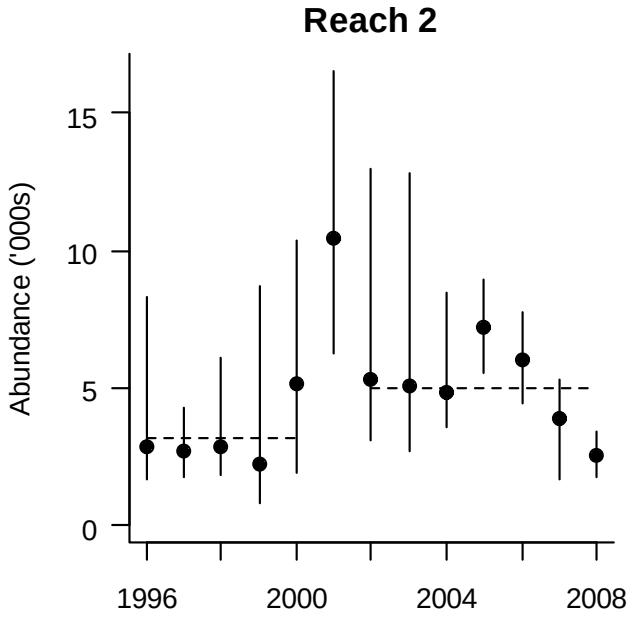
Age-0 rainbow trout

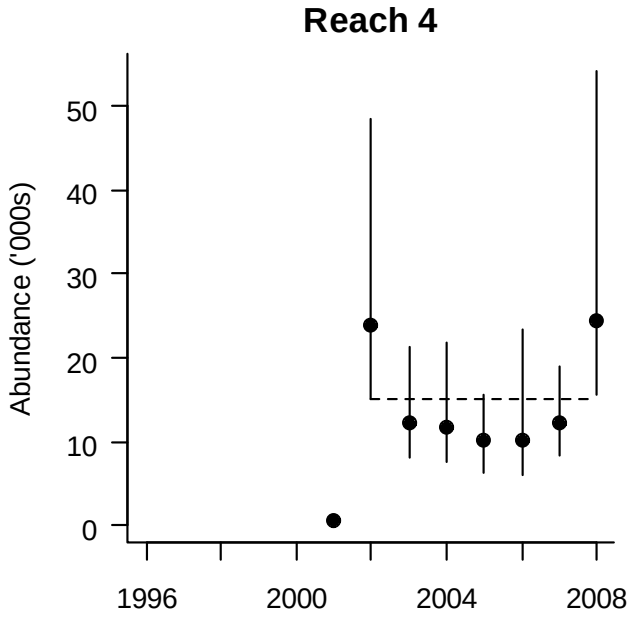
Median abundance and 95% credible intervals of abundance by year and reach.

Dashed horizontal lines show the average abundance pre- and post-flow release







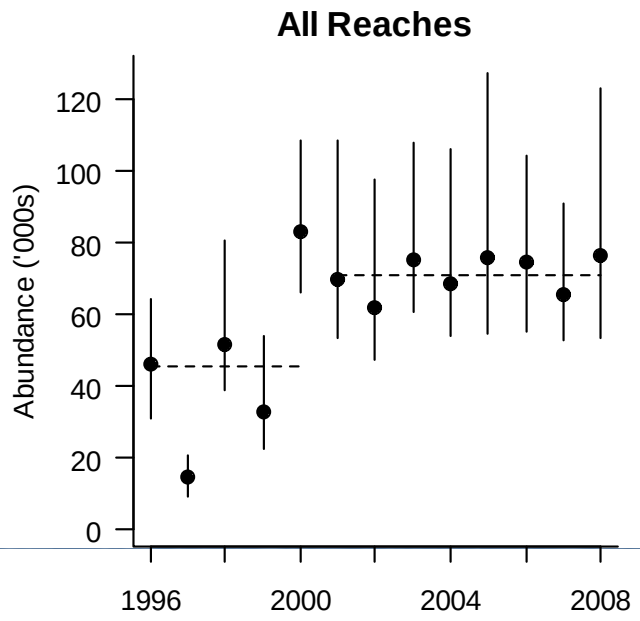


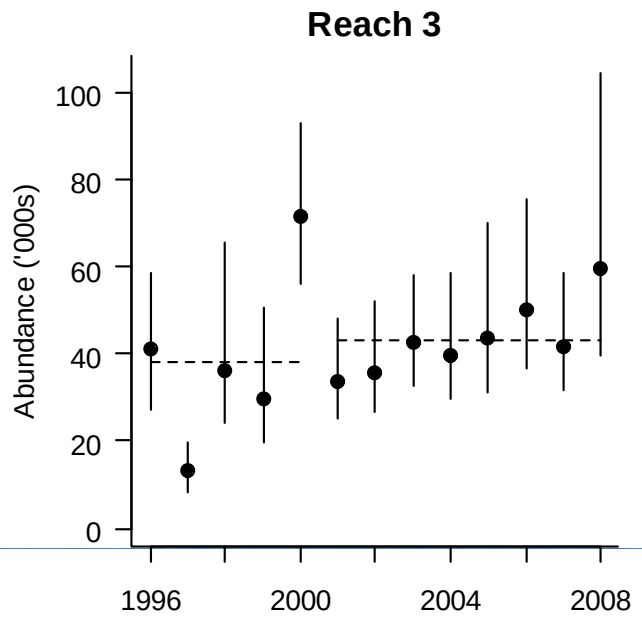
Age-1 rainbow trout

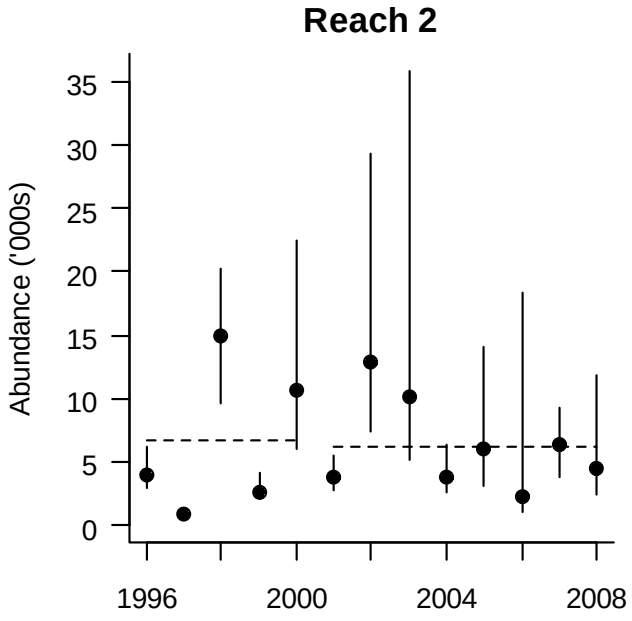
Median abundance and 95% credible intervals of abundance by year and reach.

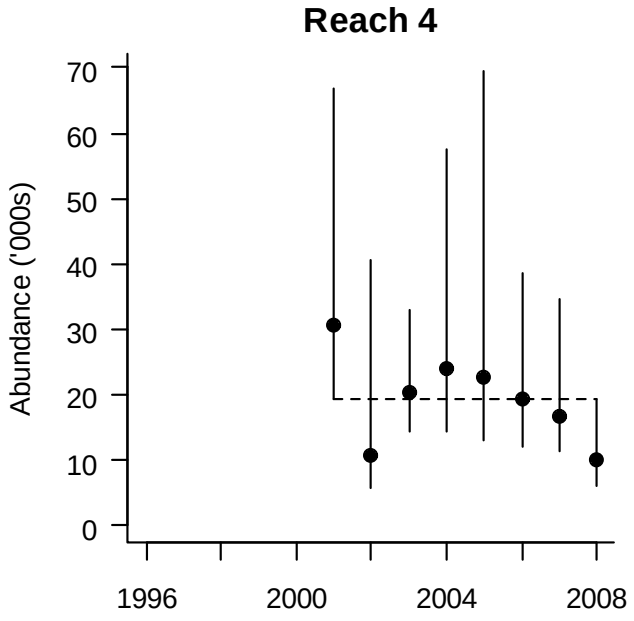
Dashed horizontal lines show the average abundance pre- and post-flow release

Age-0 Coho salmon

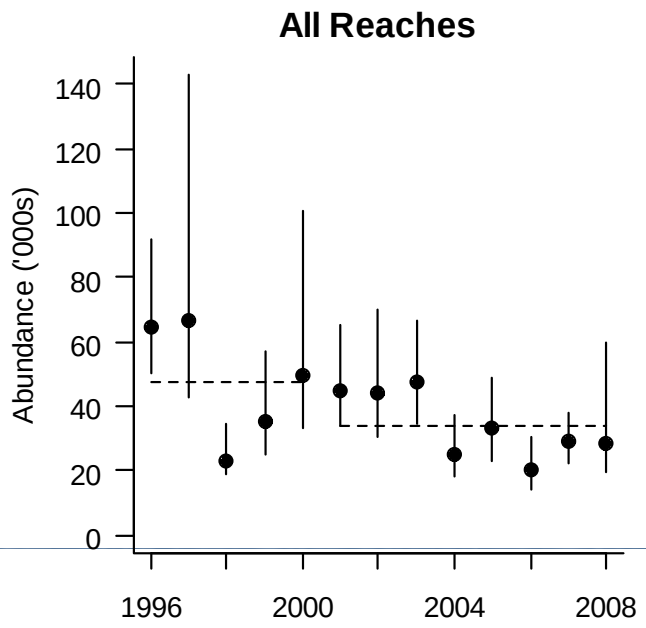


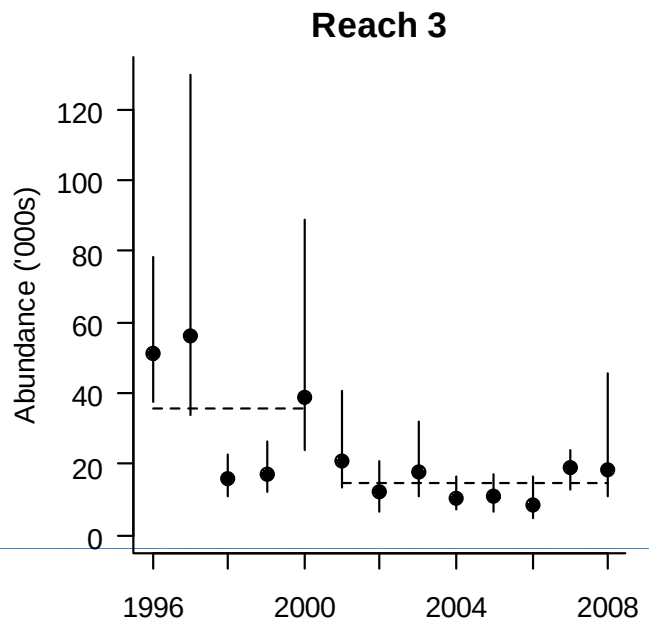


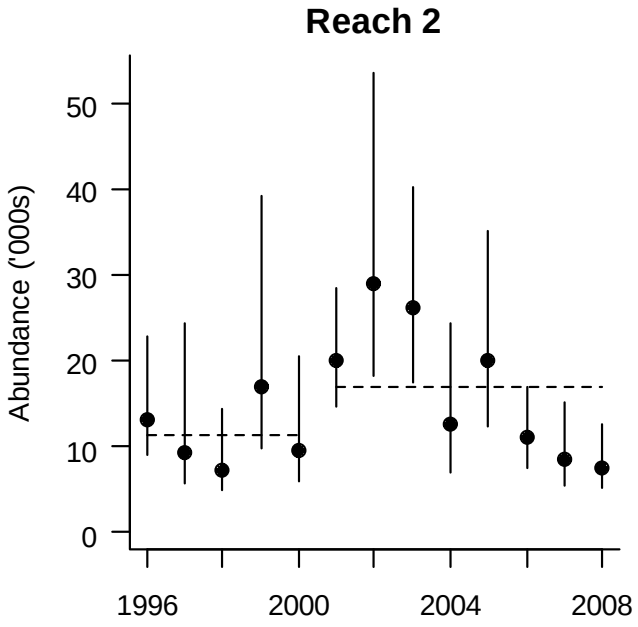


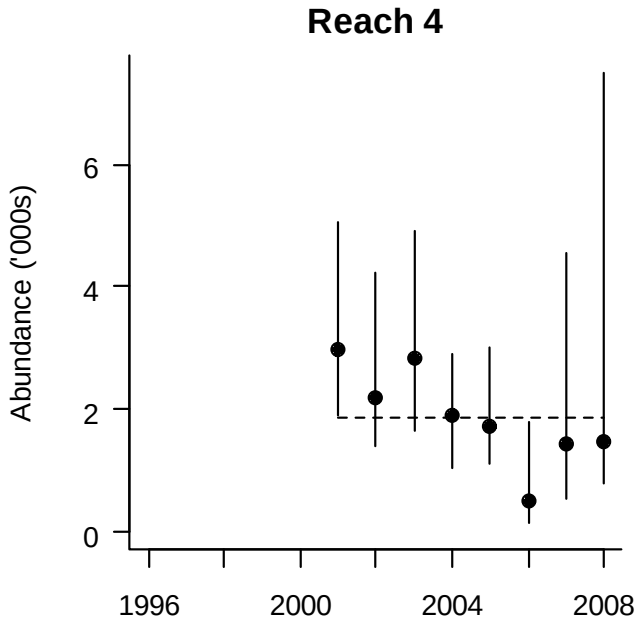


Posterior distributions of abundance of pre- and post-flow release





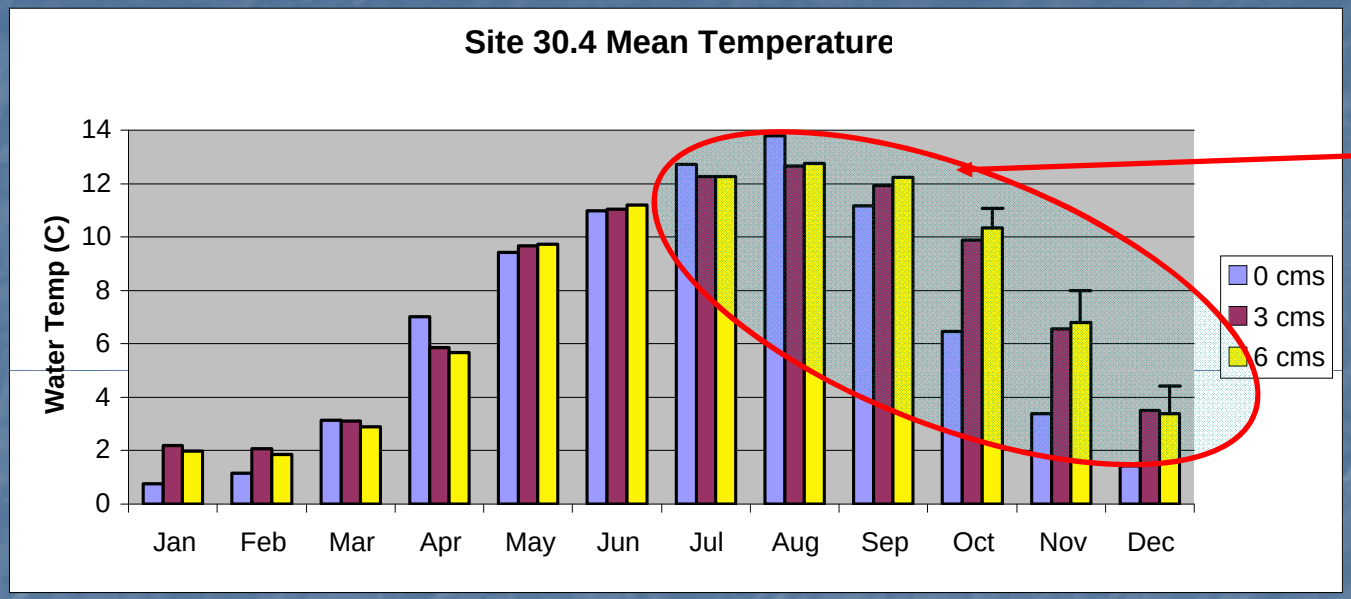




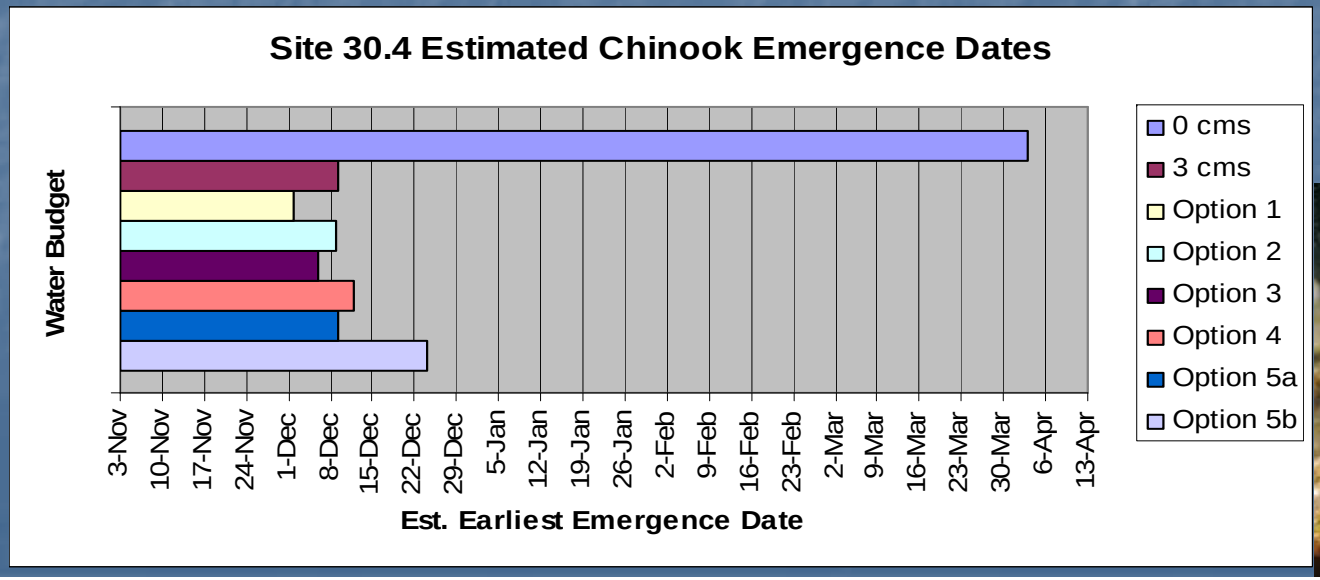
Age-0 chinook salmon

Median abundance and 95% credible intervals of abundance by year and reach.

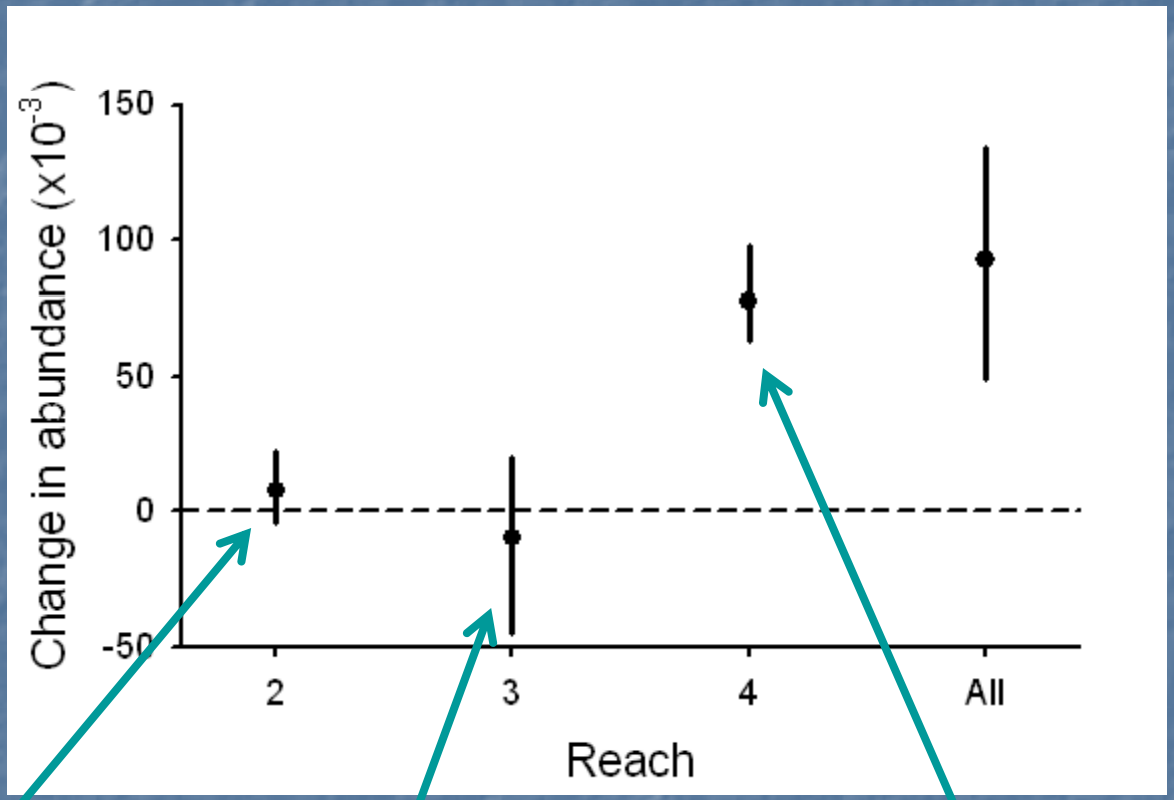
Is the chinook salmon decline caused by the impact of the altered thermal regime on abundance?



0+ Chinook abundance: decline due to change in life history caused by increased larval development rates



Summary of change over all 4 fish taxa



Little change

3x increase

Rewetted

Is habitat in the Bridge River too complex to model or predict?

What have we learned?

1. Biology

   • Prior to the flow release the Bridge River was a productive salmon river

   • Increasing the flow to the wetted reach had no effect on salmon abundance- this was contrary to predictions based on habitat and hydraulic modelling

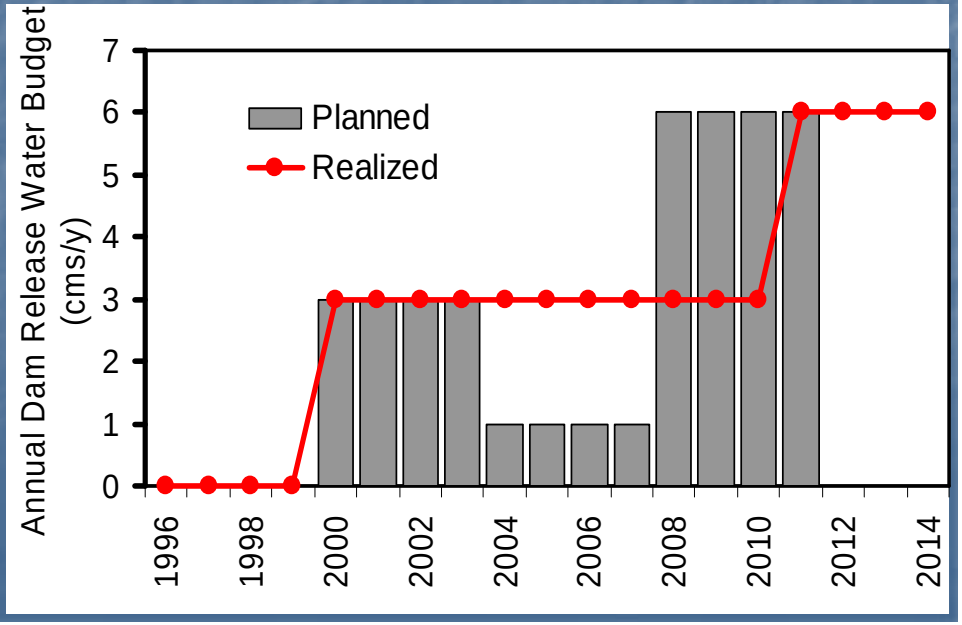
   •Each fish taxa responded differently

   • Possible to "resize the river"- a smaller flow release would likely provide similar benefits

What have we learned, con't

2. Resource management

- The river is not a "scientist's sandbox"
- We did not capture the important values to stakeholders
- Esthetic and cultural values strongly support higher flows



Is monitoring and adaptive management an efficient method of resource management decision making?

- Long trials are difficult to sustain in today's world ($$, time, shifting social environment)
- Key questions may be less relevant by the end
- Lower requirement for accurate biological information in complex decision environments where many factors are in play.
- Value of information analysis at local and regional scales

See you in 2016 for the final chapter!