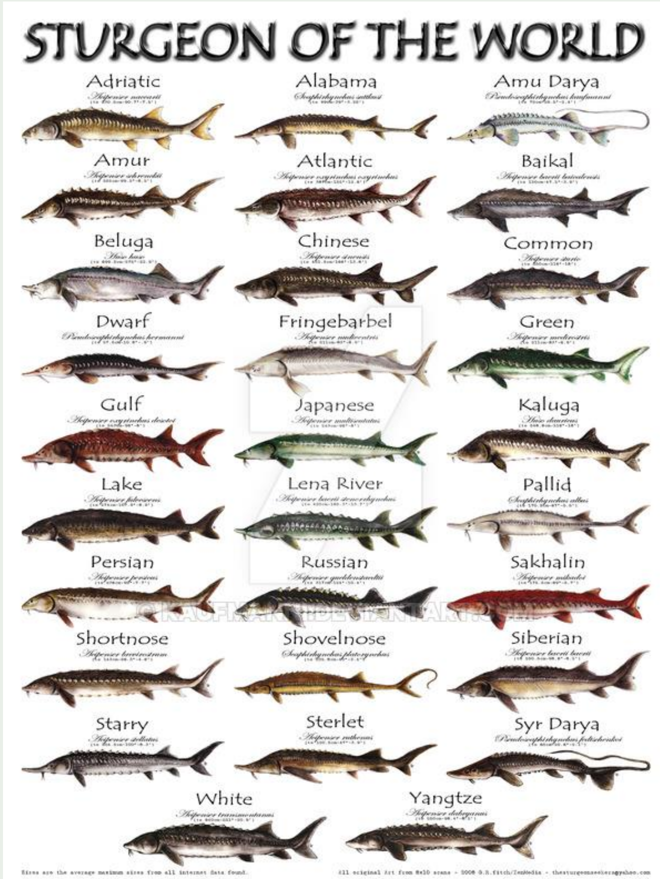
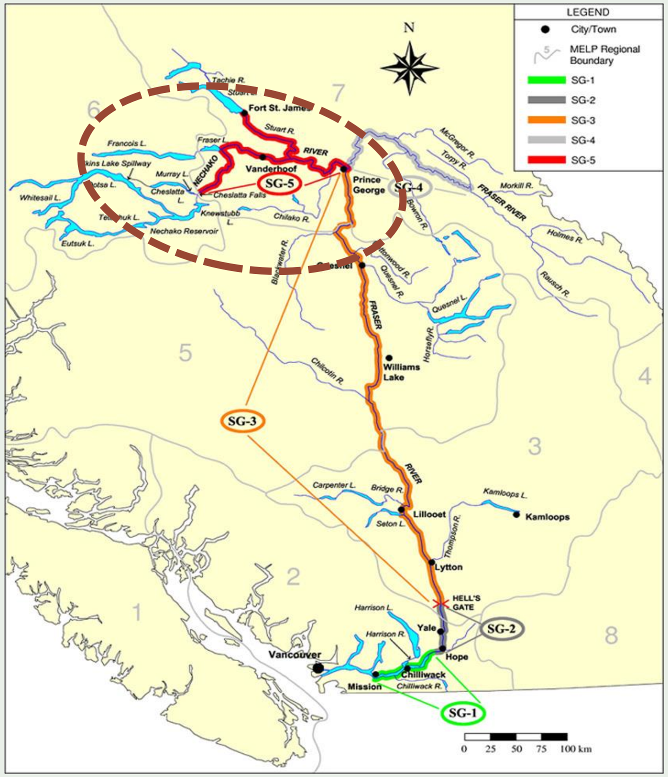


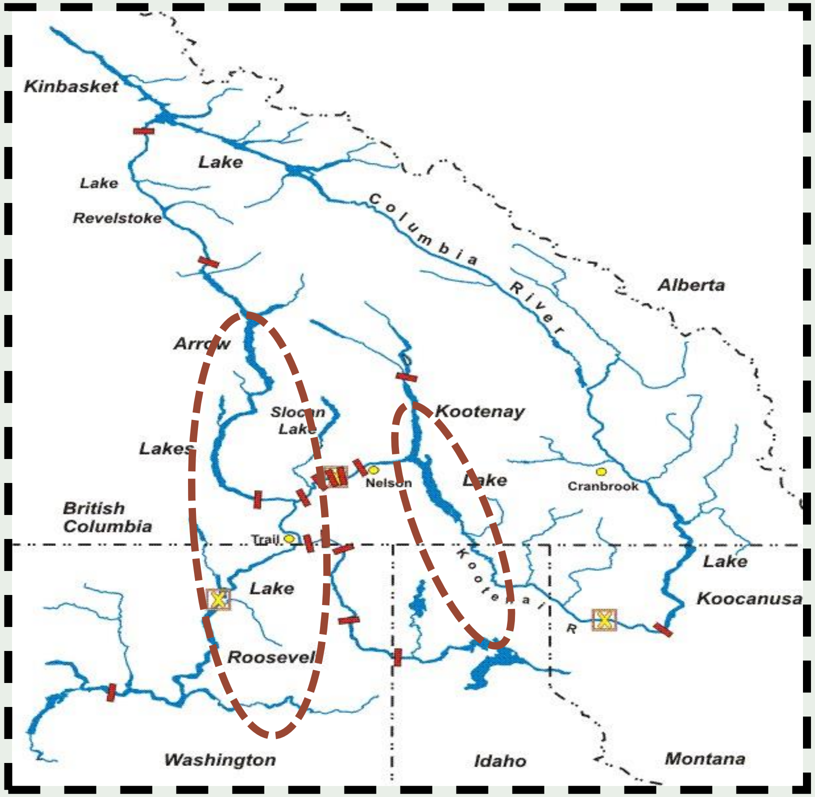
- **Most sturgeon species are of conservation concern due to harvest and habitat change**
- **River regulation is a common impact**

<u>Main themes</u>

- **White sturgeon general biology**
- **Nechako White sturgeon recruitment failure**
- **White sturgeon restoration**

Canadian Distribution

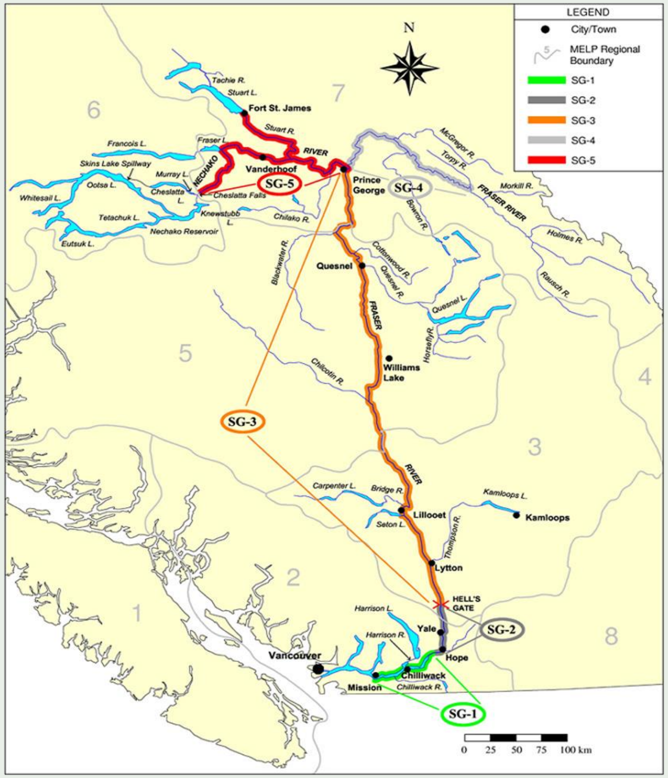




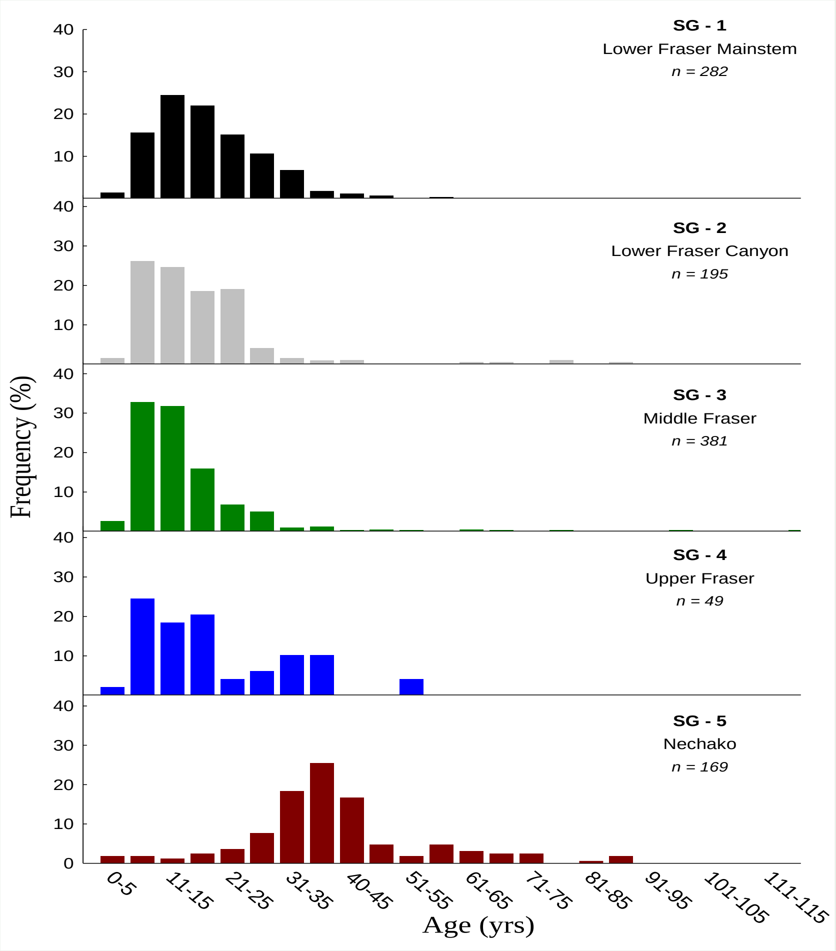
- Nechako (1967), Columbia (1969) and Kootenay (1974) populations undergoing recruitment failure (large dams on all three rivers)
- All three rivers have a ‘two-pronged’ recovery programs based on hatchery inputs and habitat restoration

Scientific Designation and SARA Listing

- Four populations legally listed as endangered under the Species at Risk Act (SARA-2006)
    - Nechako
    - Upper Fraser
    - Kootenay
    - Columbia
- Three populations above Hell's Gate combined (2012) and called the Upper Fraser Designatable Unit (scientific recommendation= endangered)
- SARA review of Upper Fraser DU is ongoing



Identifying Recruitment Failure



- Fraser Basin study 1995-99
- Juveniles more abundant in other Fraser populations
- Limited juveniles in Nechako shows recruitment failure
- Similar to Columbia, Kootenay rivers

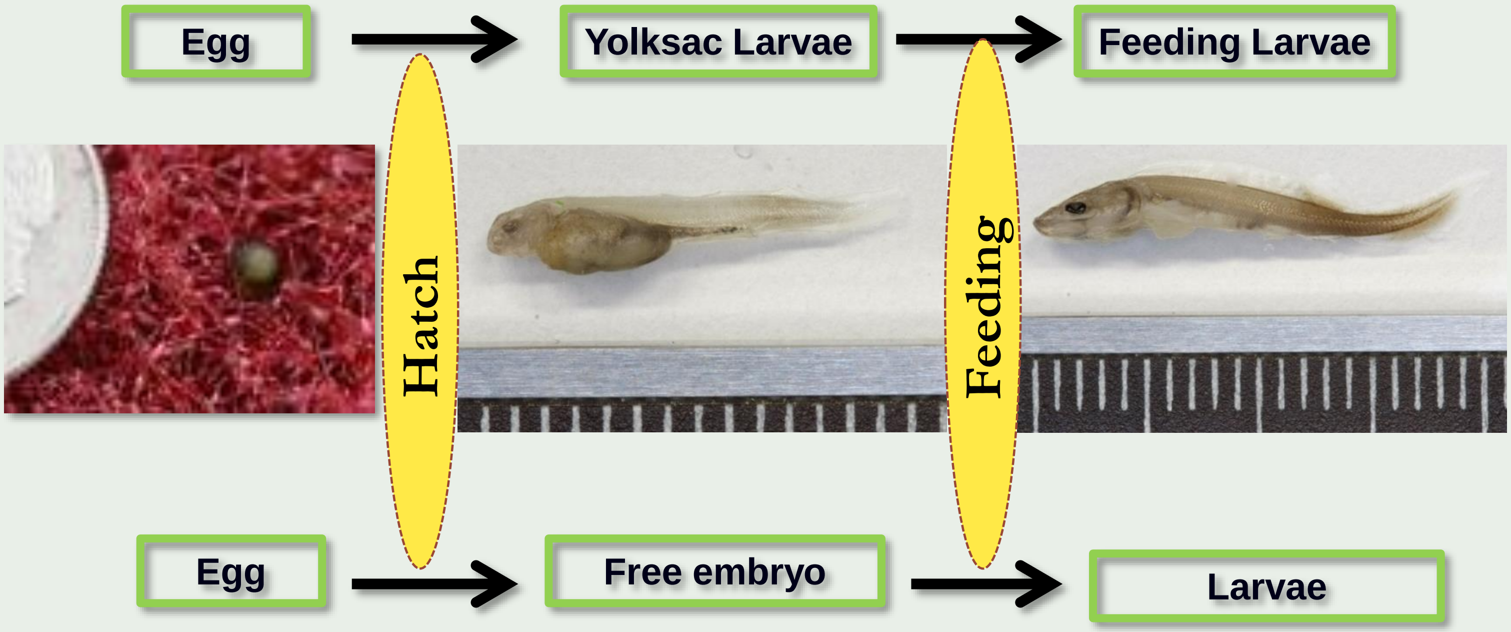
White Sturgeon Life Cycle*

Spawning interval:
males 2 - 3 years, females 3- 4 years

Mature Adult Population

Spawning → Egg (~9 days) → Yolksac larvae (~12 days) → Feeding Larvae (~40 days) → Juveniles Less than 1-m → Sub-Adults 1-m to maturity → Mature Adult Population → Spawning

Early life history (lab studies)



Eggs: adhesive, sink and adhere at spawning site

Yolksac larvae: hide in substrate interstitial spaces, drift if they can’t hide

Feeding larvae: nocturnal drift, some may be resident

Recruitment failure – identifying and reversing the causes

Diagnosis → Analysis → Restoration

Identify potential mechanisms

Case studies:

Nechako River
Upper Columbia River

Verify apparent mechanisms

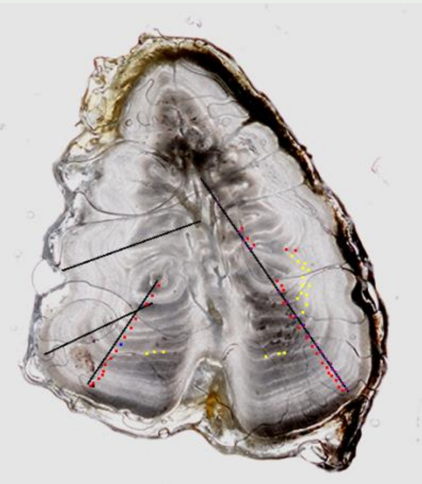
Laboratory study:

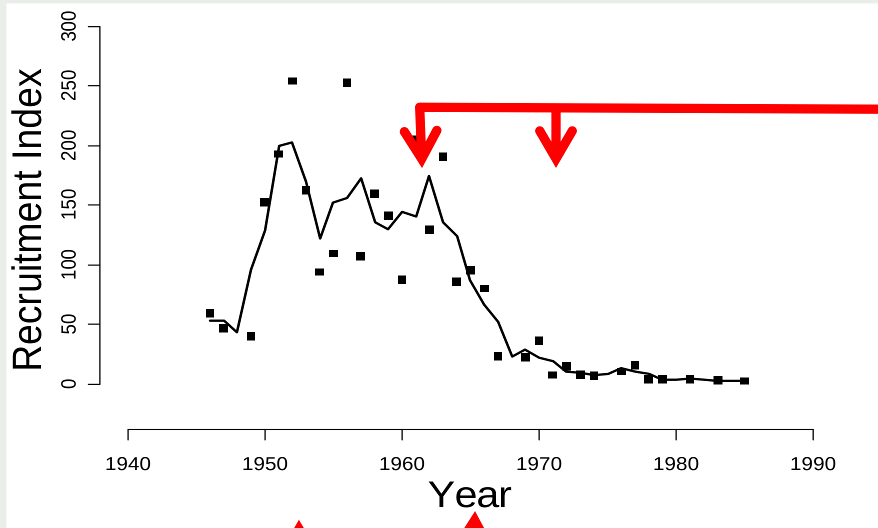
Effects of substrate on yolksac larvae behaviour and survival

Reverse apparent mechanism

Field study:
In situ effects of substrate augmentation (medium and large scale)

Nechako River: retrospective analysis of recruitment failure (Trans. Am. Fish. Soc. 134: 1448-1456) (Diagnosis)





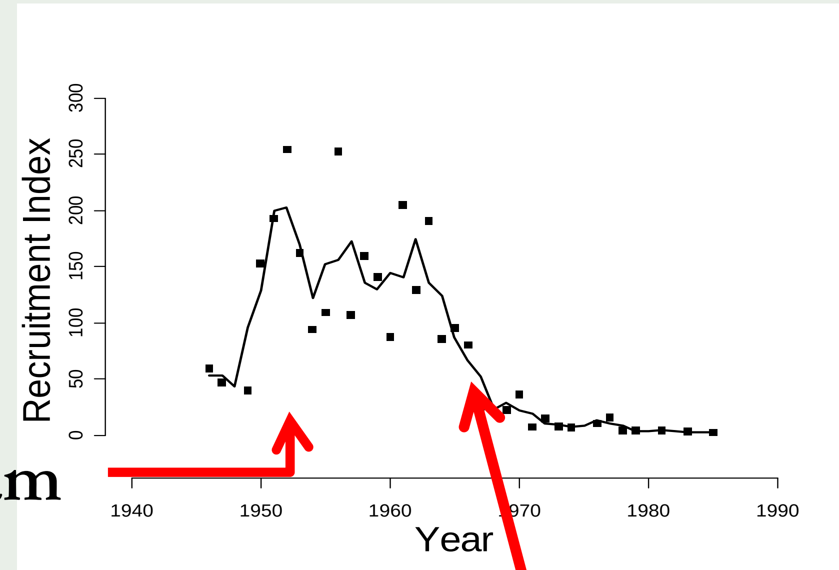
Sediment inputs

Dam

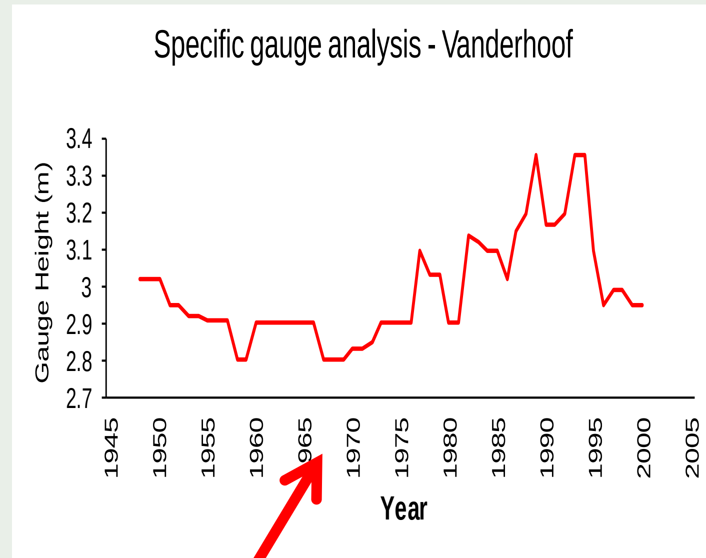
Recruitment failure

- Recruitment failure coincided with an influx of fine sediment
- Links **substrate change** at spawning site and recruitment failure

Recruitment failure: links to substrate change



Dam



Recruitment Failure

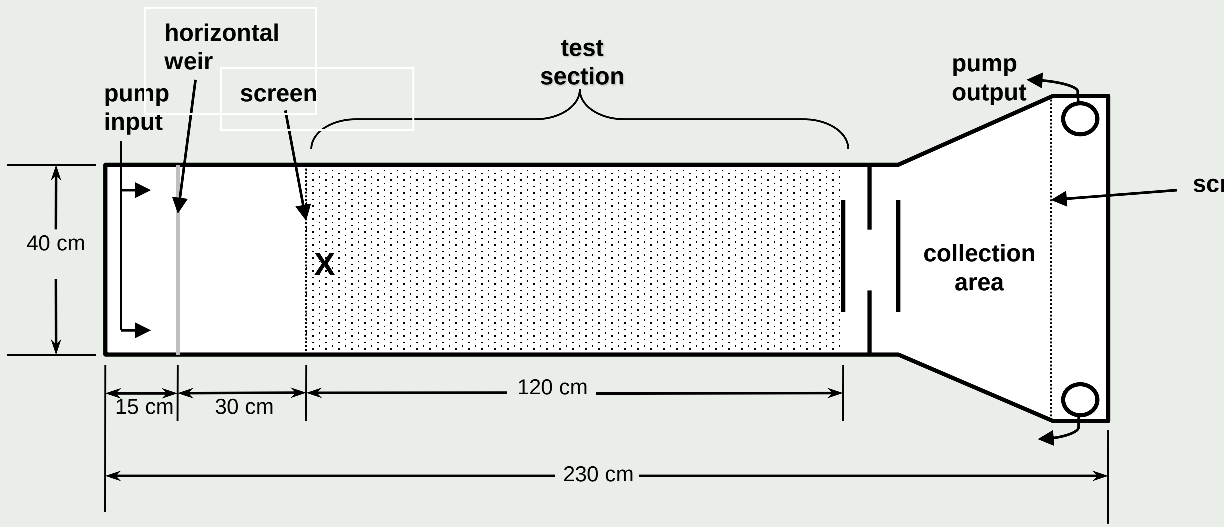
Increased Riverbed Elevation

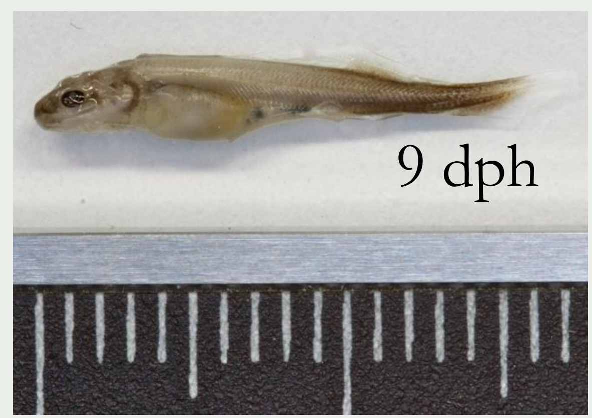
- Recruitment failure coincided with substrate alteration, i.e. a shift to aggradation

Analysis: what is the link between substrate change and recruitment failure?

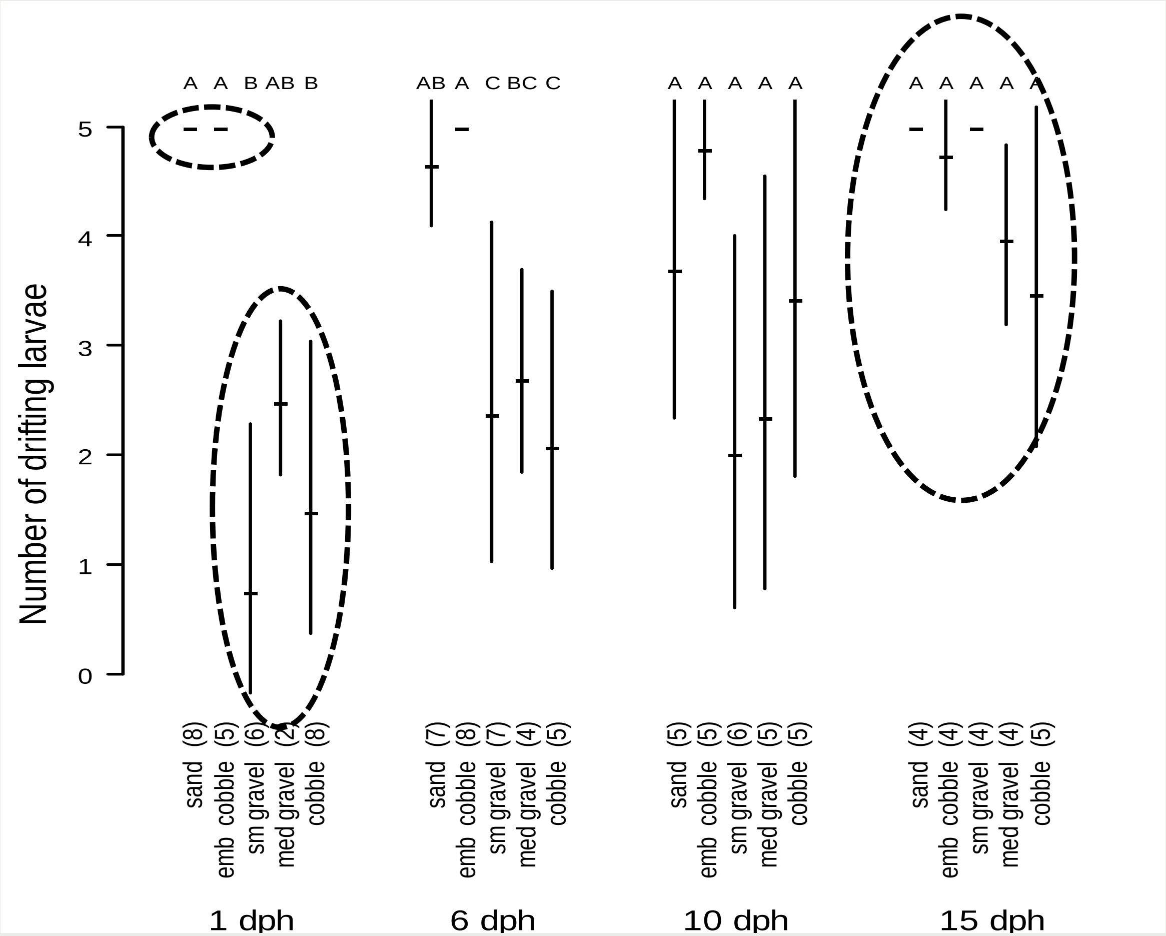
- Prior beliefs suggested drift at hatch in many sturgeon

- Bennett et al. (2007) preference for small gravel





(Can. J. Fish. Aquatic Science 68: 812-822)



- Larvae hide in the presence of suitable interstitial habitat (contradicts prior identification of YSL drift)
- Hiding increased survival

Physiological effects of substrate rearing (lab studies)

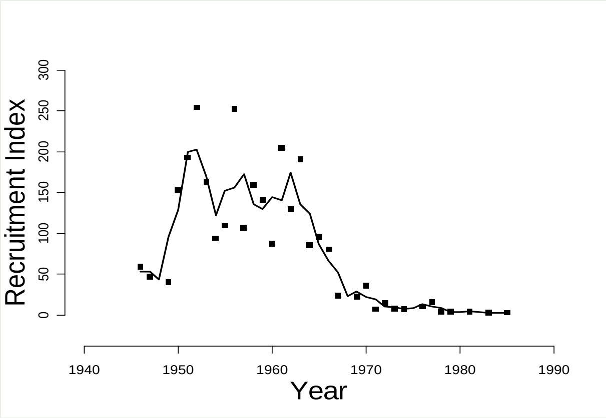
Boucher et al. (2014)

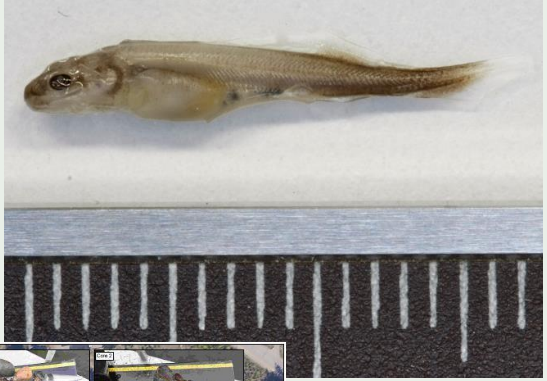
Gravel rearing of yolksac larvae affects:

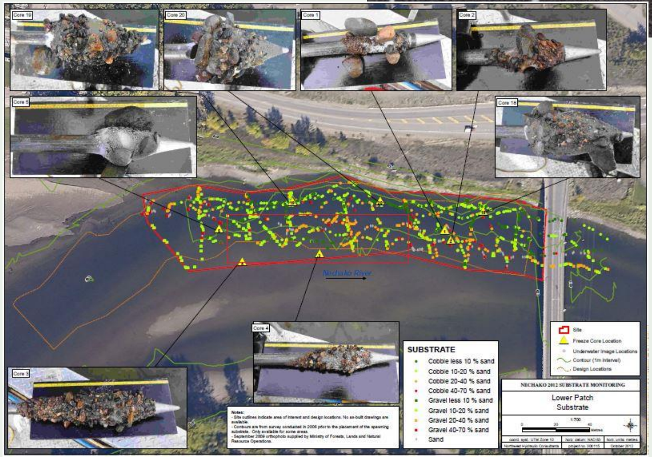
- growth and morphometry
- gut development
- survival
- swimming ability
- metabolism
- stress hormones

Summary of recruitment failure causation

- Data analysis – diagnosis of recruitment failure
- Lab studies – substrate quality negatively affects early life stages
- Fluvial geomorphology – in-river substrate changes



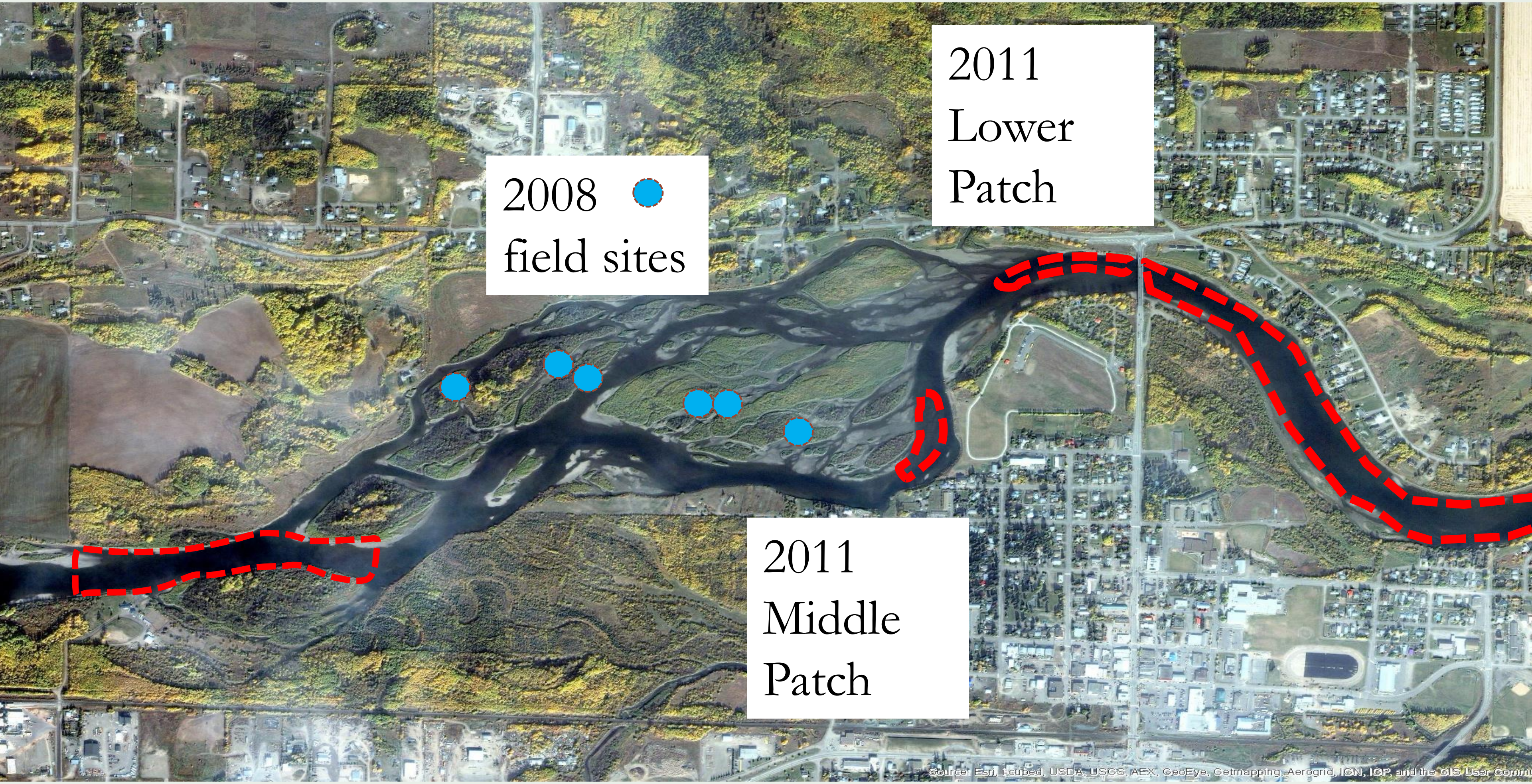




Medium scale habitat restoration (Restoration: 2008)

- **Increased scale of restoration experiments**
- **In-river investigation of medium scale restoration**
- **Gravel placed in side channels (thanks Wayne)**
- **1 day old larvae released**
- **Monitoring to detect larval retention and drift**
- **Provided 'proof-of-concept'**

Nechako: medium and large scale restoration (field experiments)



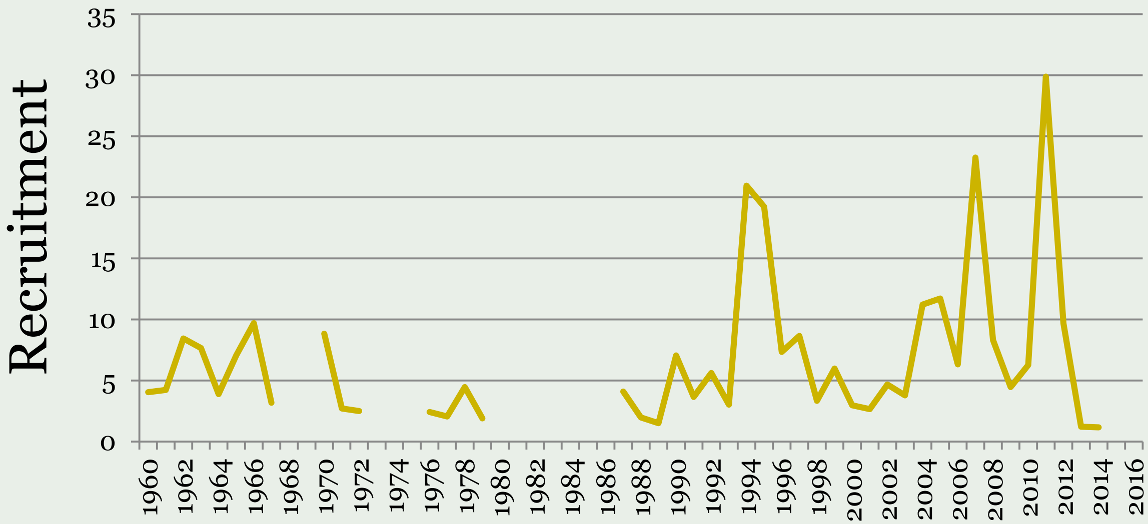
Meso-scale restoration: identified benefits of larval hiding under natural conditions
Large-scale restoration: can we stimulate detectable recruitment?

2011 - 2100 m³ gravel-cobble added at two spawning sites

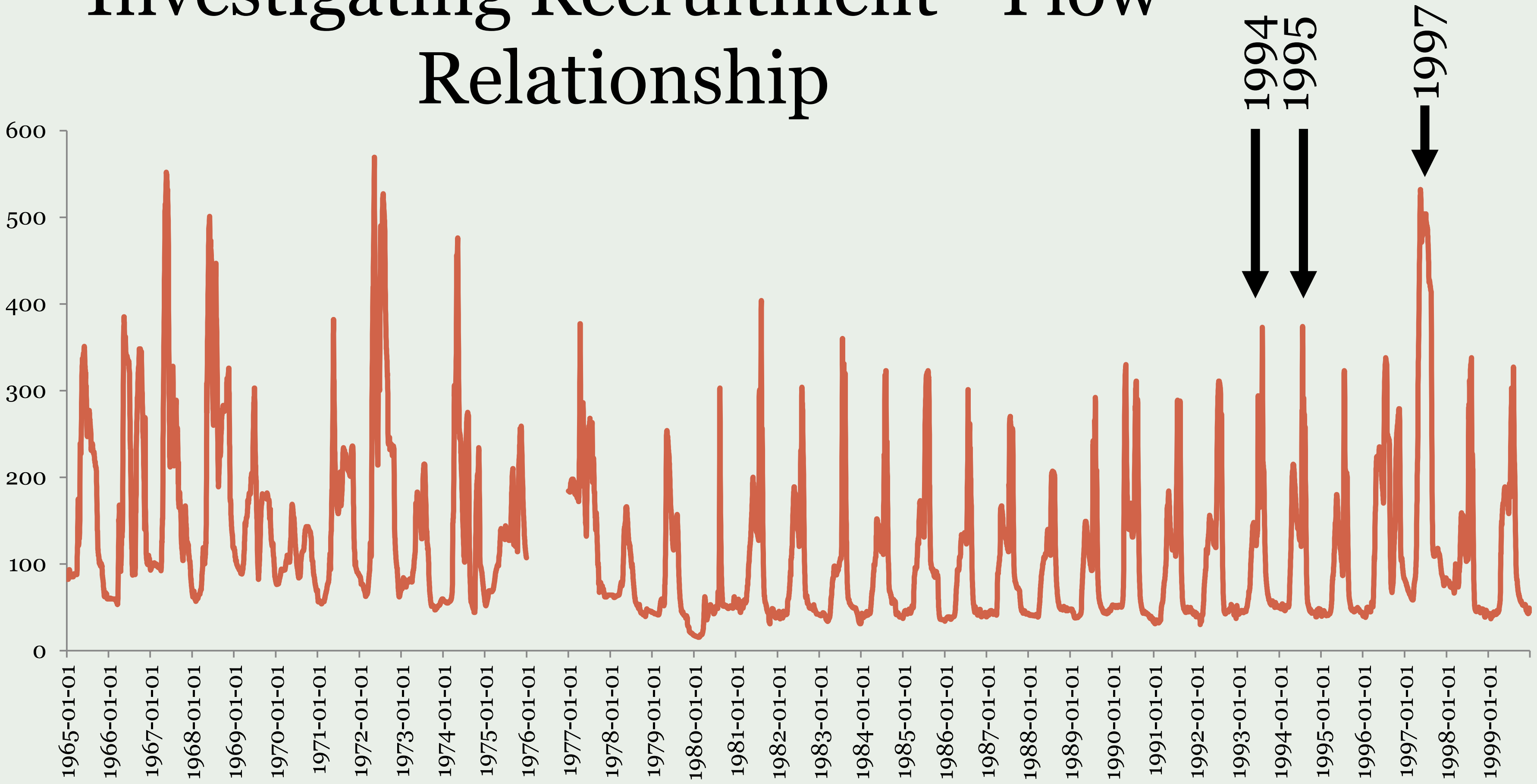
Biological responses

- Spawning over pads confirmed in 2012, 2014, 2016 (egg mat sampling)
- Increased capture of wild juveniles
- Age of wild juveniles supports link to 2007 (high flow) and 2011 (restoration)
- Genetic parentage evaluation indicates success

300,000 Eggs Placed in 2011

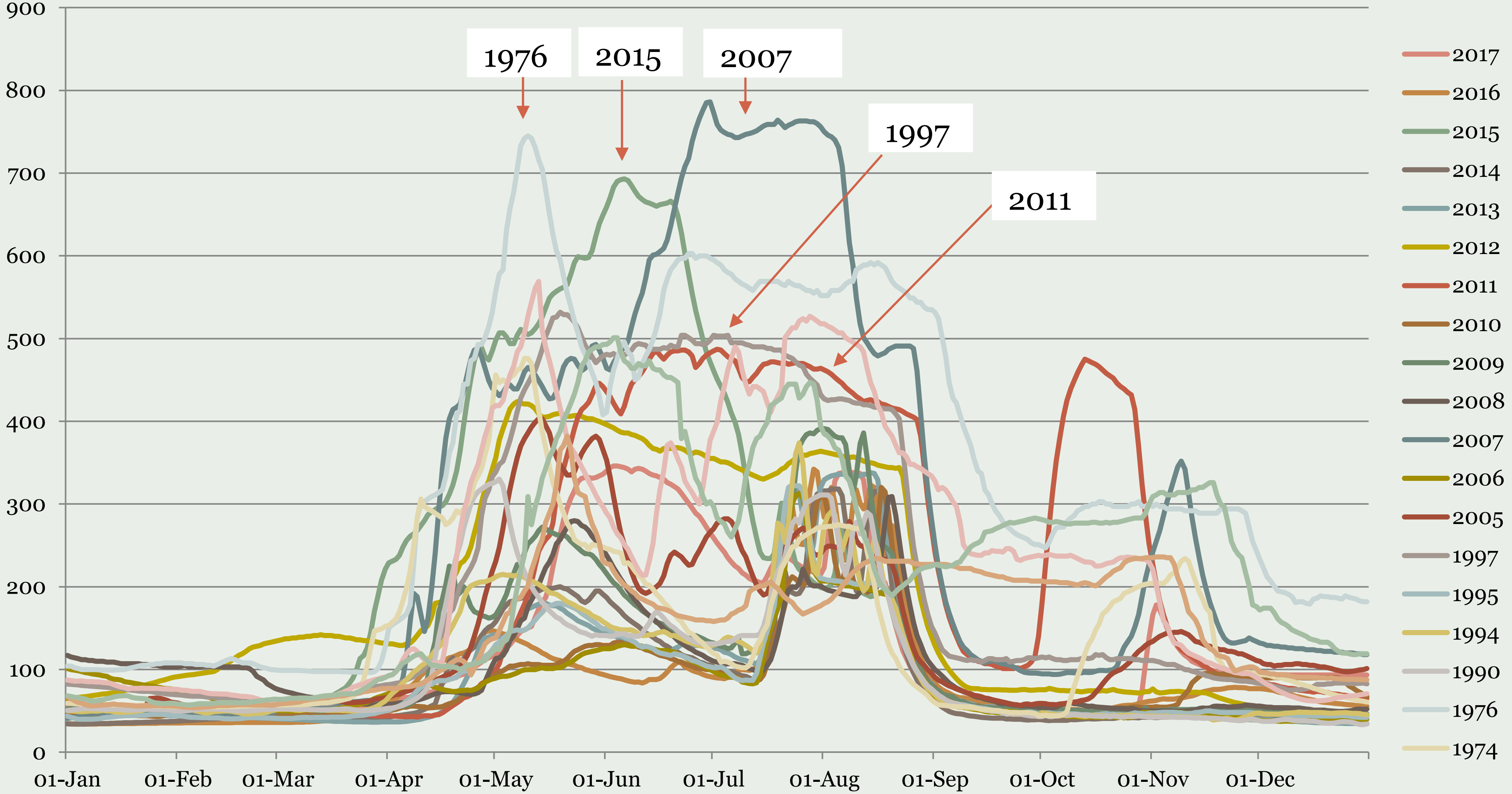


Investigating Recruitment - Flow Relationship



- 1978 to 1996 was an extended low flow period
- Recruitment in 1994/95 during low flow period
- No recruitment detected for 1997

Flow Regime



- High spring discharge in some years
- For high discharge years, recruitment in 2007 and 2011 (substrate restoration)

year	Recruitment pulse (Y/N)	Days Q > 300 in April / May	Q >300	Q >400	Q >500	Summary score (Recruitment 0/1 – High Q 0/1)	Comment
1968	N	20	y	y	y	0-1	
1971	N	9	y			0-1	
1972	N	38	y	y	y	0-1	
1974	N	26	y	Y		0-1	
1976	N	51	y	Y	Y	0-1	
1990	N	9	y			0-1	
1994	Y	0				1-0	1994/95 was the end of multi-year low freshet period
1995	Y	0				1-0	1994/95 was the end of multi-year low freshet period
1997	N	34	Y	Y	Y	0-1	
2005	N (minor?)	27	y	y		0-1	
2007	Y	46	y	y	y	1-1	
2011	Y	14	y	y		1-1	Substrate restoration
2012	N	35	y	y		0-1	
2015	N	45	y	y	y	0-1	
2016	? (2018/19)	0				?-1	Substrate cleaning

High discharge / low recruitment	Low discharge / recruitment	High discharge / recruitment
10	2	2 (2011)

Habitat restoration: next steps

- Substrate cleaning (2020/2021)
  - Can we remove fine substrates at spawning sites to improve habitat quality during the spawning period?
  - If yes – identify substrate conditions required to support recruitment
- Long term solutions?
  - Can river flow be used to maintain substrate quality?
  - Requires understanding of how river discharge affects river bed substrates
  - Vanderhoof Reach is hydraulically complex

Conservation fish culture – two pronged recovery approach

Hatcheries present on the Kootenay, Columbia and Nechako Rivers

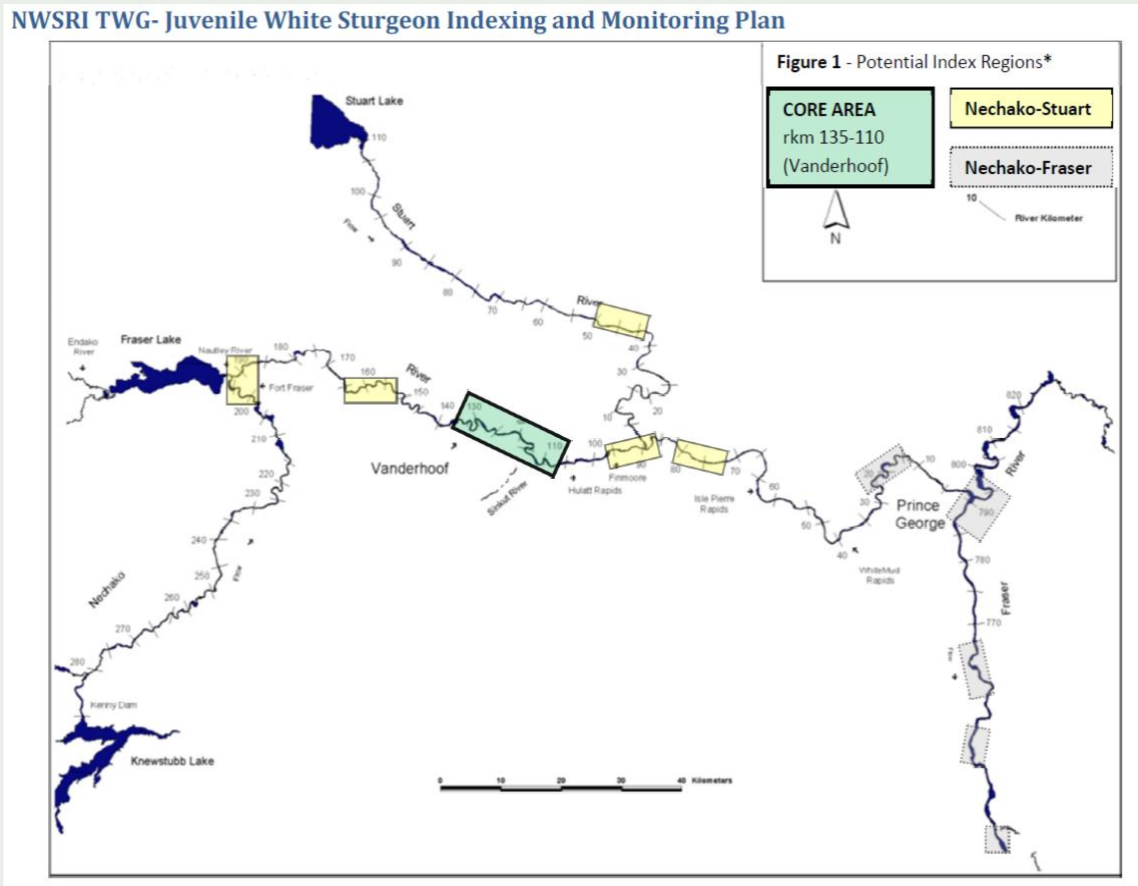
Challenges:
Unknown survival rate – hard to determine numbers to be released

Evidence of movement in the middle Fraser River – how to handle mixing with neighbour populations

2014 – Nechako conservation hatchery

- Sited within a known spawning reach
- River water intakes (temperature and imprinting benefits)
- Substrate rearing of yolksac larvae

2018 & 2019 Juvenile Monitoring



- Juvenile monitoring critical to evaluate effectiveness of both hatchery inputs and habitat restoration (survival rate, movement, growth)
- Need to monitoring throughout the watershed

River Otter predation study

- Predation by otters and others (raptors) and emerging concern
- >520 PIT tags recovered in latrine & feeding sites
- Radio tag recovery confirms mortality (perhaps 50%)
- Largest fish consumed by otter >70cm
- Shifted to releasing fewer larger fish

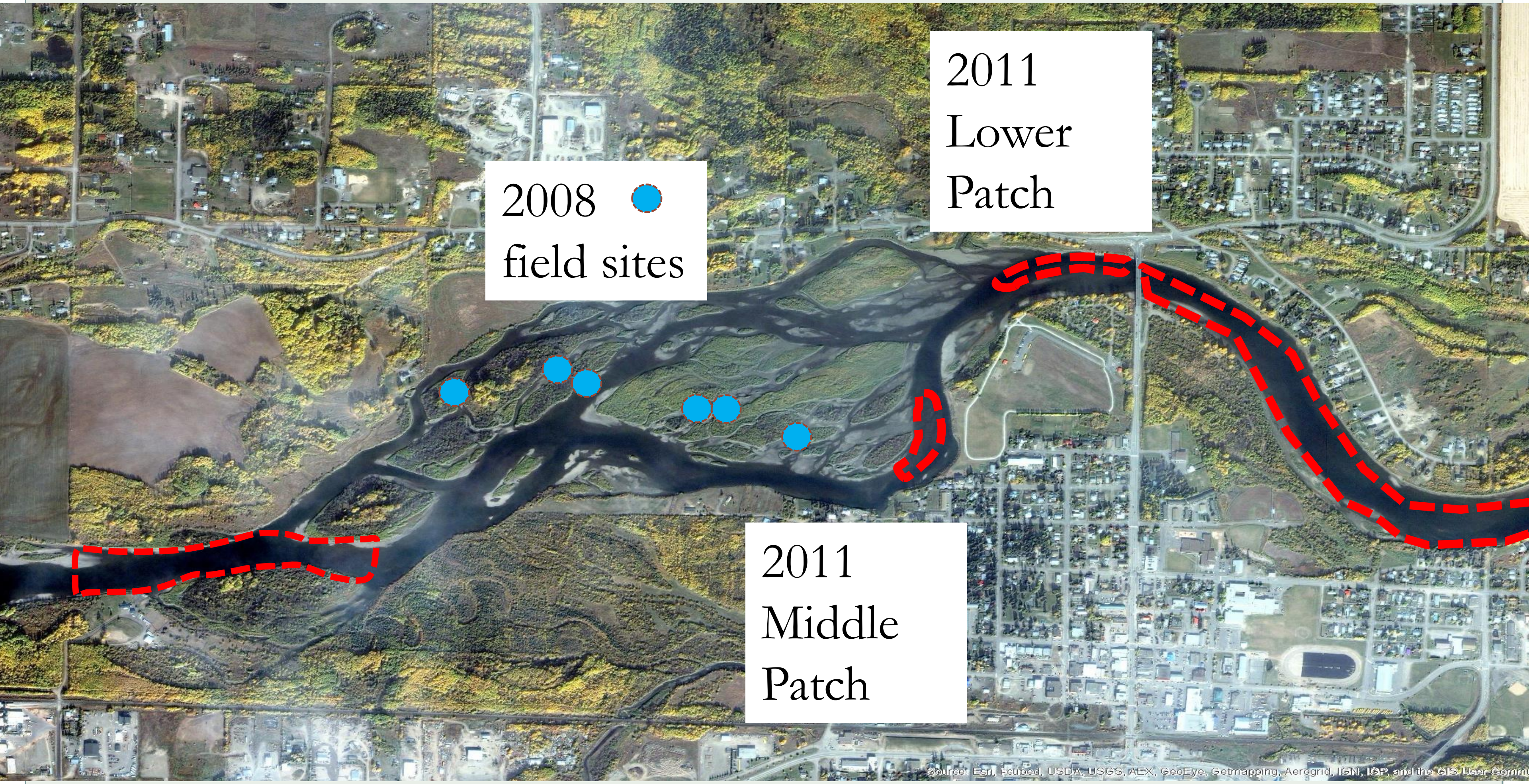
Summary and Questions

- **Simultaneous pursuit of hatchery and habitat based restoration**
- **Spawning habitat restoration**
  - **requires detailed knowledge of spawning site selection, egg and larval habitat requirements, and fluvial geomorphology**
- **Conservation fish culture**
  - **Successful short term measure, spring releases essential to success, establishing survival rates an important early priority, fish movement a current challenge**

Acknowledgements

- Many partners on sturgeon recovery programs
- Nechako White Sturgeon Recovery Initiative
- (MOE, FLNRO, DFO, CSTC, FFSBC, RTA)
- District of Vanderhoof

Nechako: medium and large scale restoration (field experiments)



Key question is how to ensure long term maintenance of restored habitats