# Nearshore Ecology of Juvenile Native Fish in Grand Canyon:

## Central Objectives and Key Challenges

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# Central Study Objective and Research Questions

- Understand how river flow, through its interaction with physical habitat structure, influences mainstem survival rates of juvenile native fish in Grand Canyon.
- RQ1: Do steadier flows during summer and/or fall increase survival rates?
- RQ2: To what extent does physical habitat (sand bars and backwaters), in conjunction with flows during this period, influence survival rates.

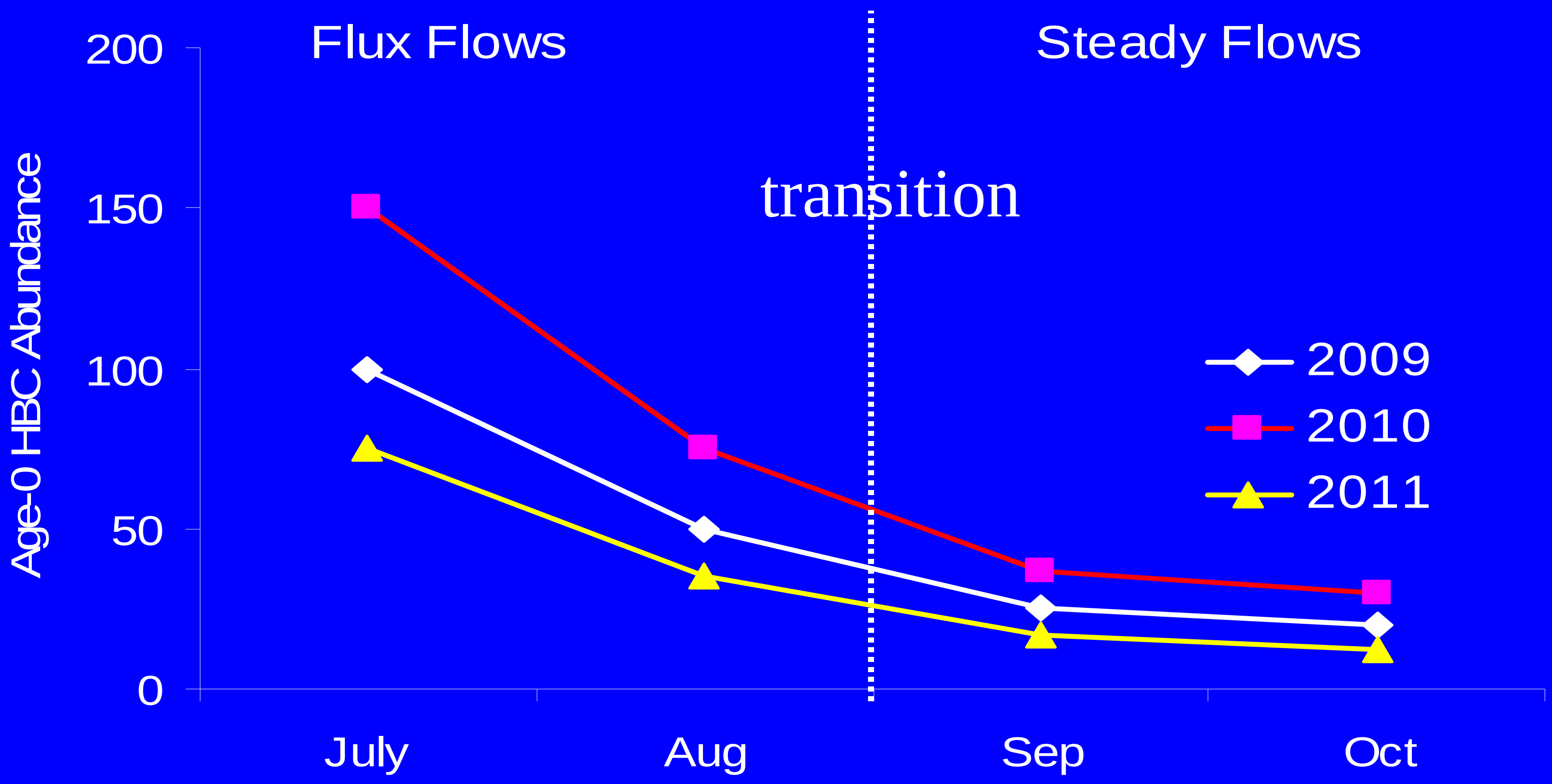
# Approach

- Estimate site occupancy (pres/abs) and reach-wide abundance of juvenile natives over four sampling trips (July, Aug, Sept, Oct).

- Survival and growth can then be estimated over 3 intervals:
  - July-Aug: summer flows (high Q flux)
  - Aug-Sep: transition from flux to steady
  - Sep-Oct: steady flow

- Examine relationships between occupancy and physical site characteristics. Do relationships vary with flow regime?

# Approach (con’t)



# Challenges

1. Estimates of growth, occupancy, abundance, and survival rate may be uncertain due to sparse data (low numbers and low detection probability).

2. Very limited replication (n=3 yrs), single relatively modest flow treatment (steady 10 kcfs), no data under fall ‘control’ (ROD) flow (ca. 5-10 kcfs).

3. Uncertainty in relating flow-dependent habitat use to meaningful demographic parameters like survival.

4. Change in mainstem abundance through time is not solely dependent on physical factors influencing mainstem survival rate
   - recruitment from LCR (otolith microchemistry and LCR marking)
   - density-dependence in mainstem survival rates
   - non-native abundance in mainstem

5. Timing of summer-fall flow changes coincides with changes in other factors that will influence growth and survival
   - Fish growth declines through time (water temp. and fish size)
   - Densities decline through time, which will increase survival rate

# What Can be Learned Over Three Years?

- Will define accuracy and precision of estimates of habitat use (occupancy), abundance, and survival rates. Necessary for establishing efficacy of long-term monitoring.

- Improved understanding about growth and fate of LCR emigrants to mainstem via otoliths and tagging (e.g., do very young/small emigrants survive?).

- Improved understanding about habitat use through high spatial and temporal sampling intensity (e.g., backwater use under fluctuating and steady flows).

# Long-Term NSE Monitoring Embedded within Sensible Long-Term Experimental Design

- Real value of an NSE-type project comes from monitoring growth, occupancy, abundance, and survival over a much longer time period under contrasting conditions.

- Although the nature of future experiments is uncertain, there will likely be differences in  mainstem physical conditions due to purposeful experiments or natural variation (e.g., drought).

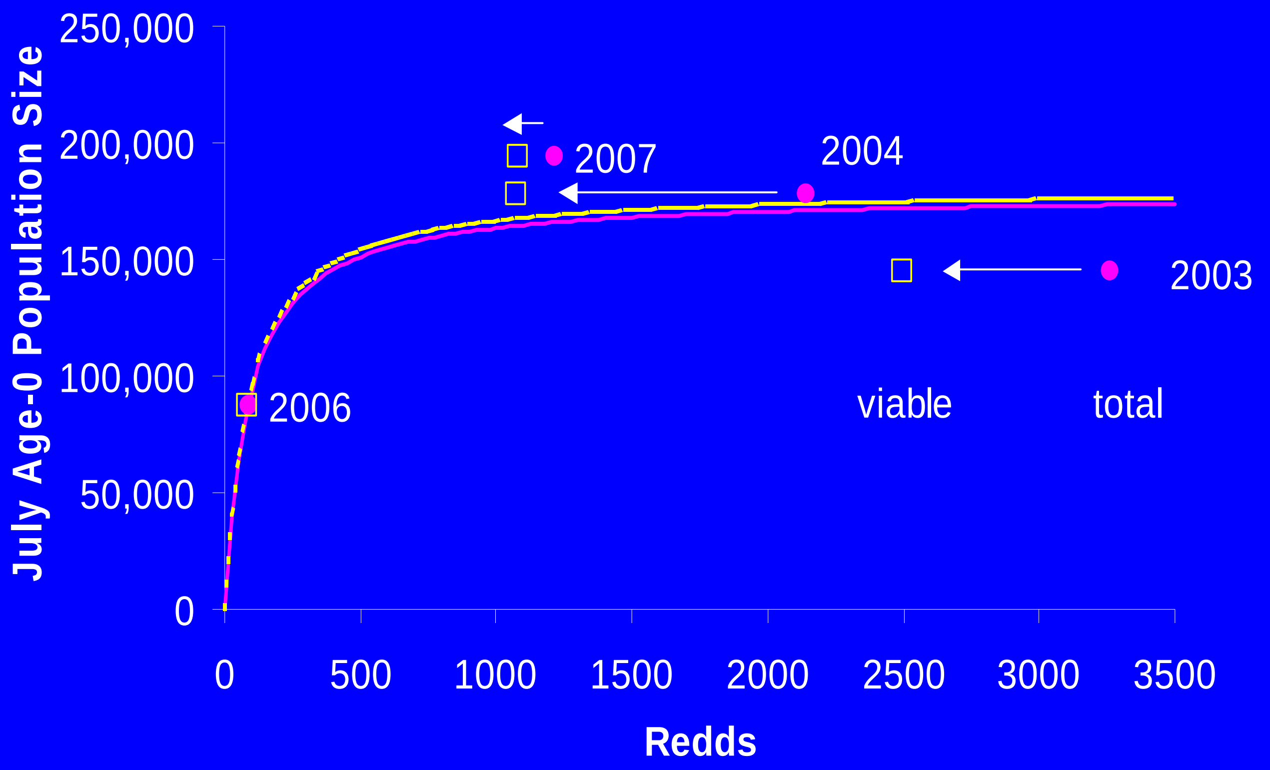
- Initial insights from current NSE project may help shape future experiments and increase the probability of conducting more informative experiments.

- Although the scope of this type of long-term project is significant, it is essential to relate changes in adult HBC abundance to conditions in the mainstem.

# Common Characteristics of NSE Project and Monitoring of Early Life Stage Survival of Rainbow Trout in the Lee's Ferry Reach (RTELSS)

- Two well-supported assumptions justify monitoring early life stages:
  - Early life stages are more sensitive to changes in habitat than adults
  - Survival of early life stages determines abundance of adult population
- Similarities in flow-habitat hypotheses (flow-habitat stability)
- Many similarities in sampling and analytical methods and experimental design challenges
- Long-term versions of these projects could be used to evaluate effects of both purposeful and natural flow experiments (e.g., not specific to any one test)
- Both efforts should be considered core projects if the objective is to understand effects of dam operations on fish populations

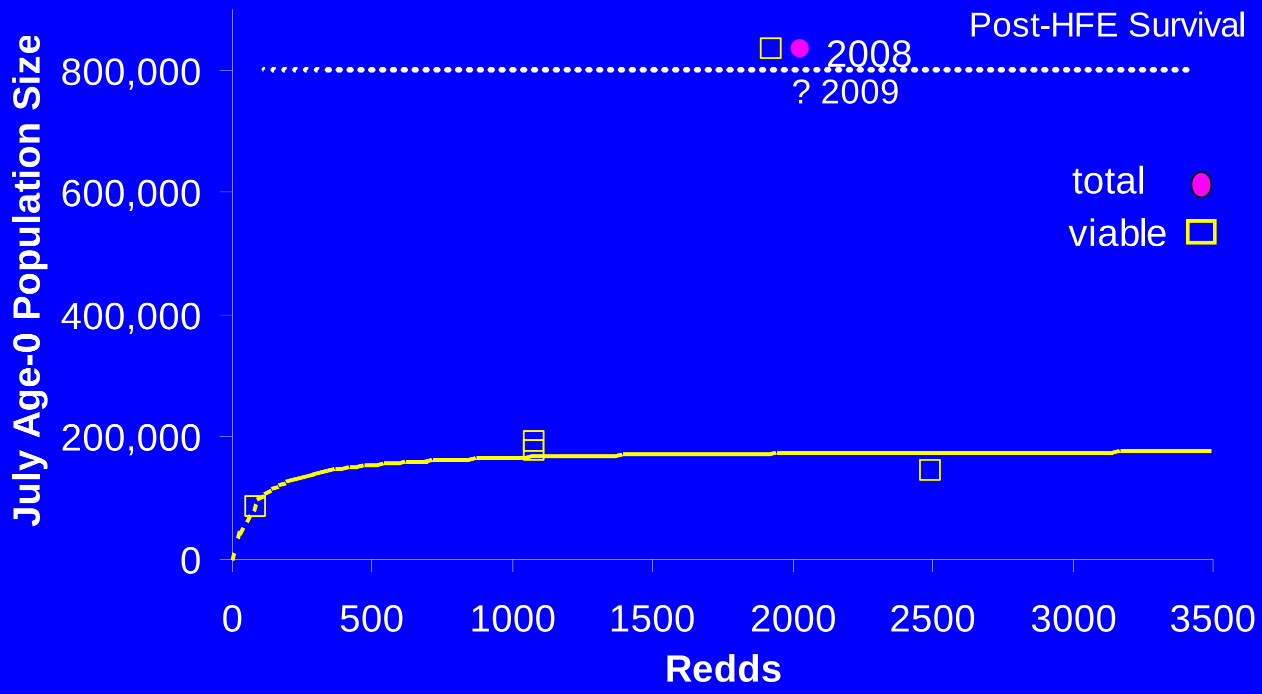
# Effects of Density Dependence in Survival Rate




- High winter fluctuations killed 25 and 50% of egg deposition in experimental years 2003 and 2004, respectively.

- Strong compensation in early survival rates (e.g., 2006) suggests that this flow-dependent mortality at moderate levels of egg deposition (# redds) will not effect juvenile abundance.

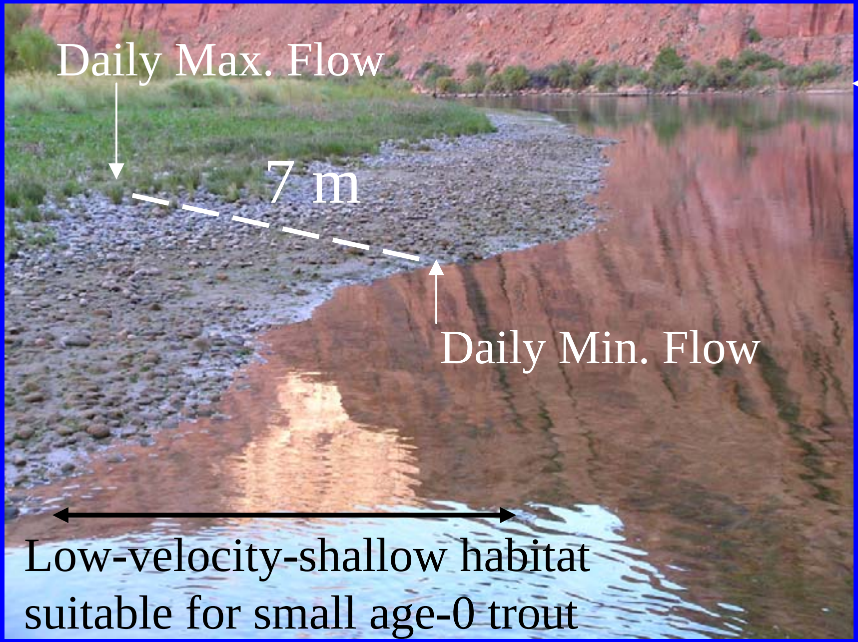
# Robust Monitoring Tool to Evaluate a Variety of Flow Experiments




- Survival of age-0 rainbow trout in the few few months from hatch (to 30-40 mm) in the Lee's Ferry Reach after the 2008 HFE (08-09) was ca. 5-fold higher than before (03-07).

- In the absence of juvenile monitoring, would be uncertain whether large 2008 and 2009 cohort seen in adult monitoring was due to steady flows, the HFE, or higher egg deposition.

# Hypotheses of habitat use and flow sensitivity in large rivers




**Low-angle habitat**

Preferred by smaller age-0 trout

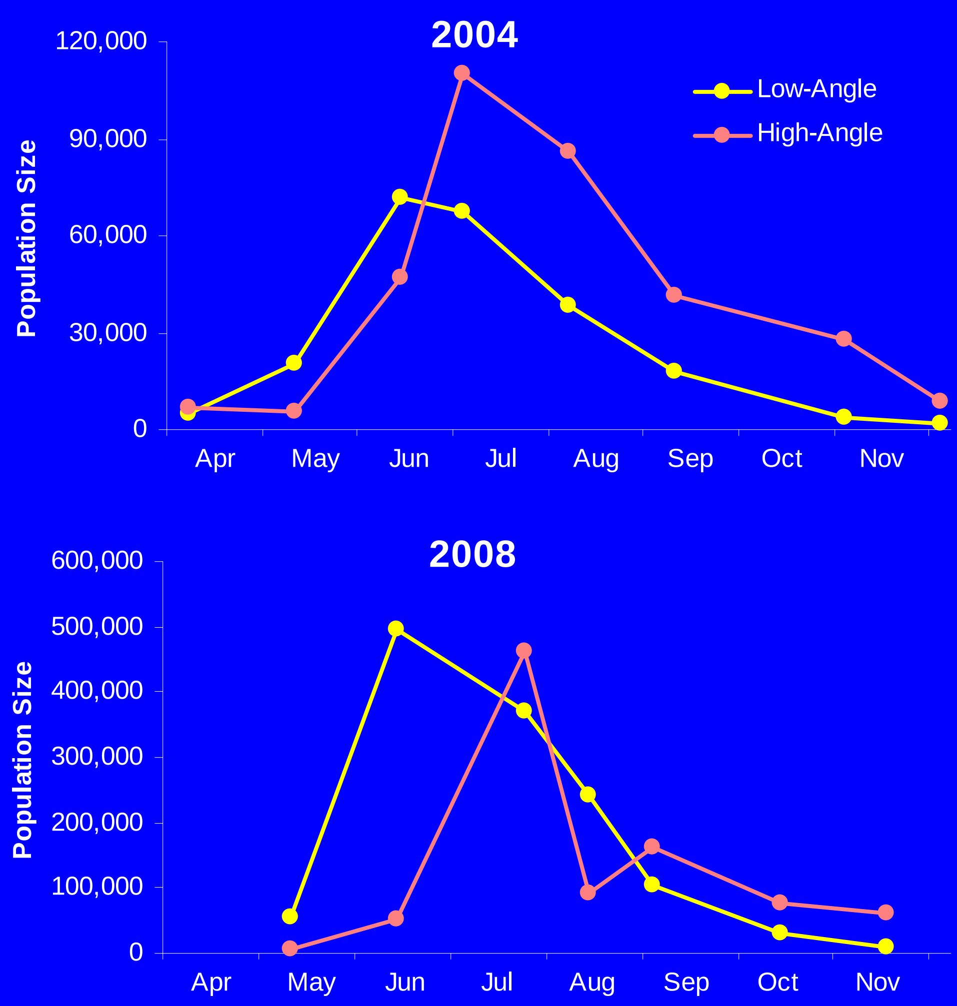
More sensitive to variation in flow

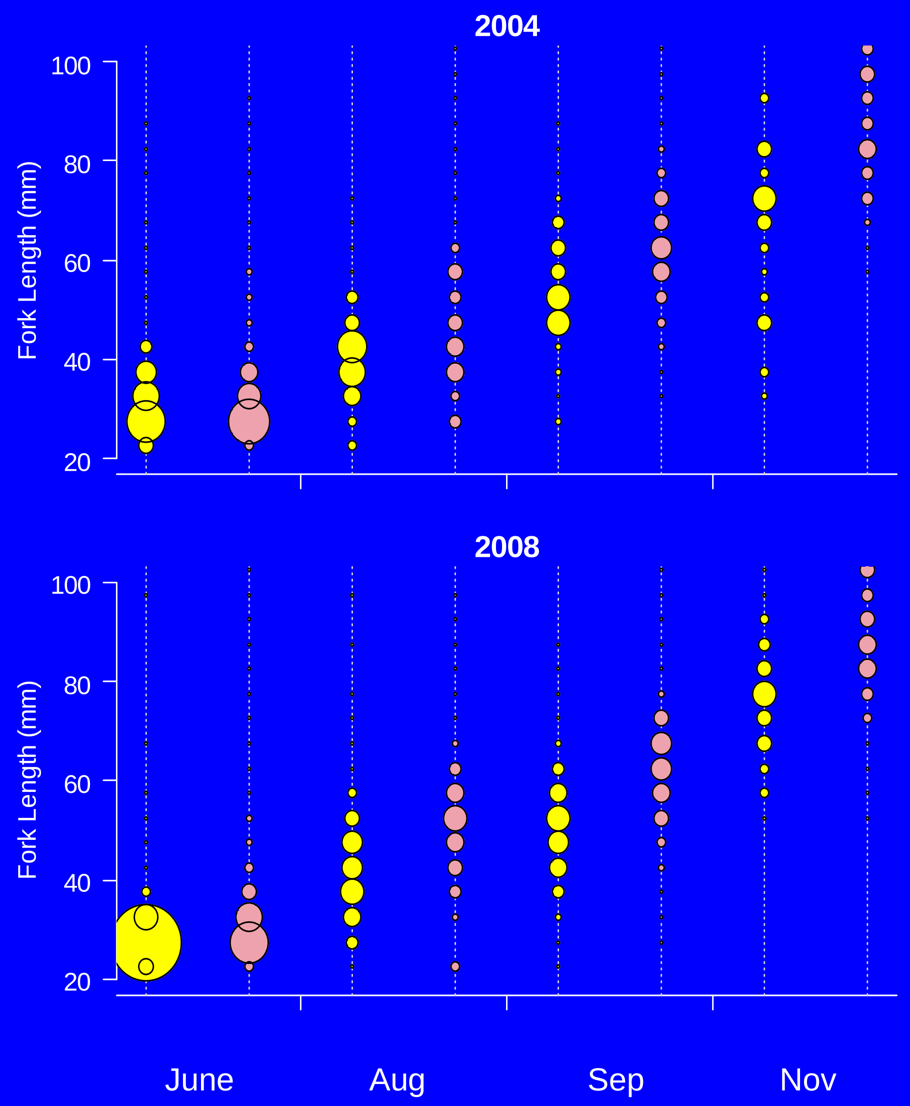
**High-angle habitat**

Preferred by larger age-0 trout

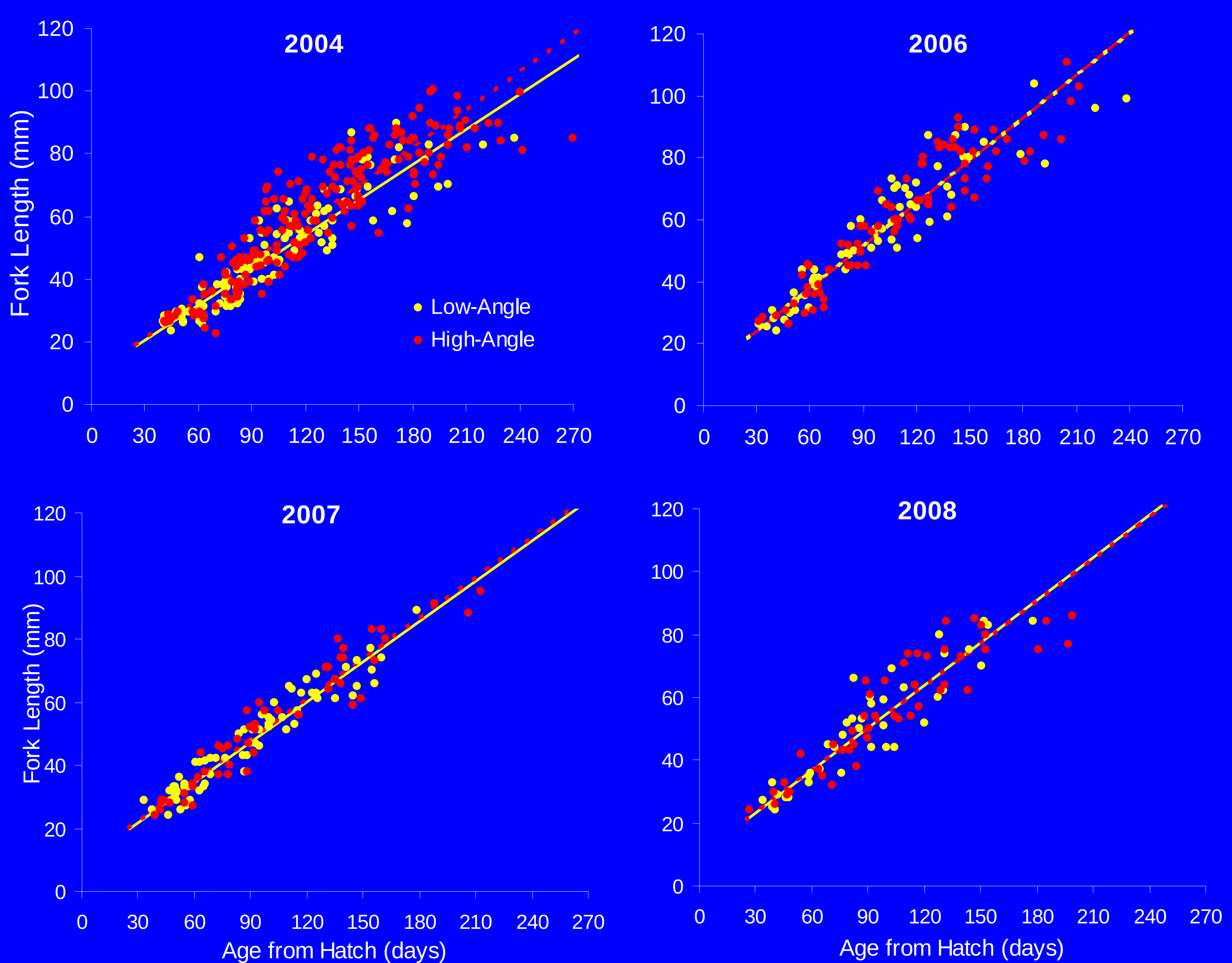
Less sensitive to variation in flow

# Age-0 habitat use and movement

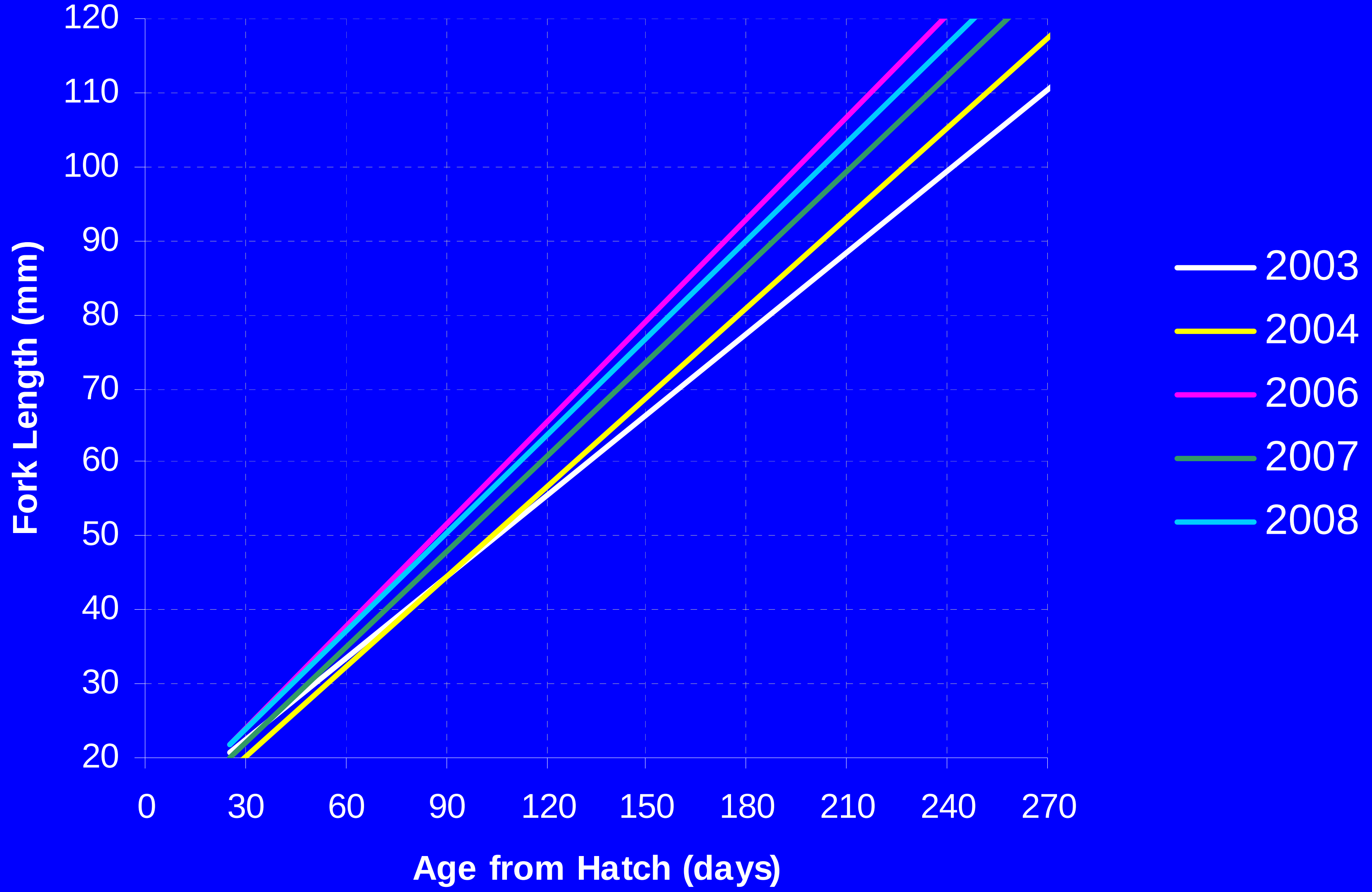


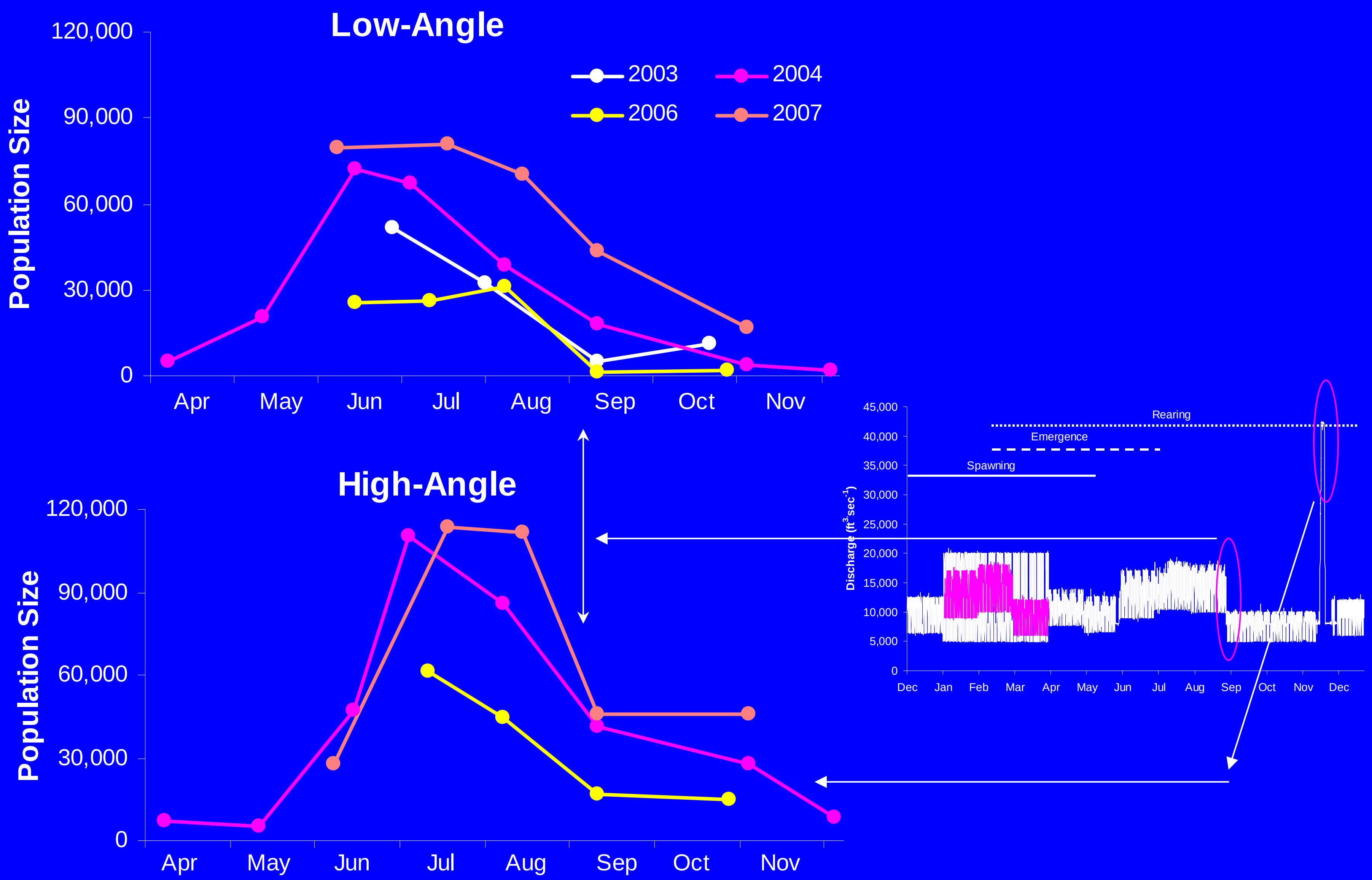
# Age-0 growth – habitat effects



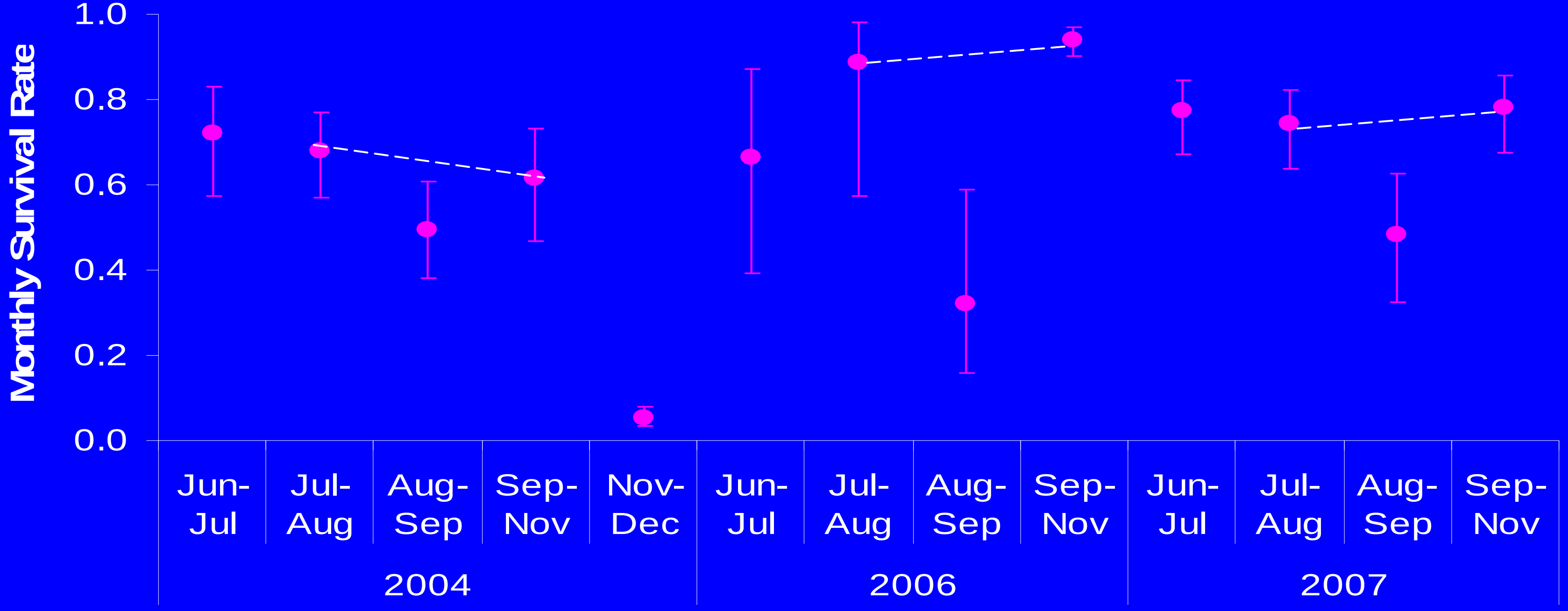
# Age-0 growth – year effects



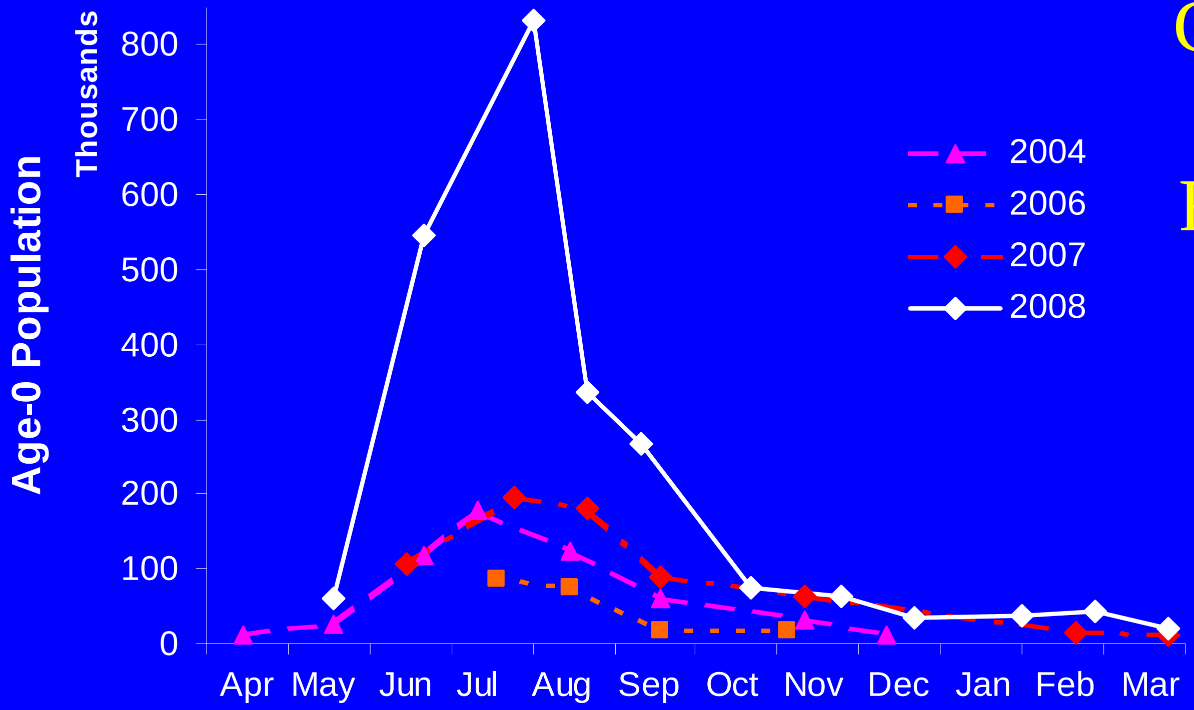
# Age-0 mortality estimated from abundance trends



# Model-based estimates of temporal variation in age-0 survival



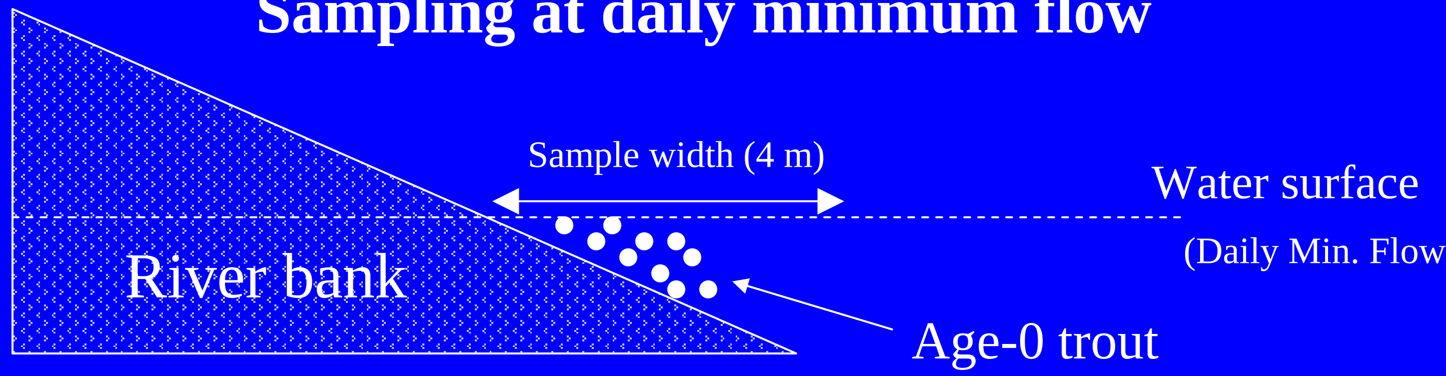
# Confounding of density and Fall steady flow effects




- High abundance in 2008 was apparent by summer, well before steady flows.
- Age-0 survival rate over fall was actually lower in 2008, but this was likely caused by higher density, rather than by steady flows.
- Need comparable densities to ROD period to evaluate effects of steady flows on age-0 survival rate.

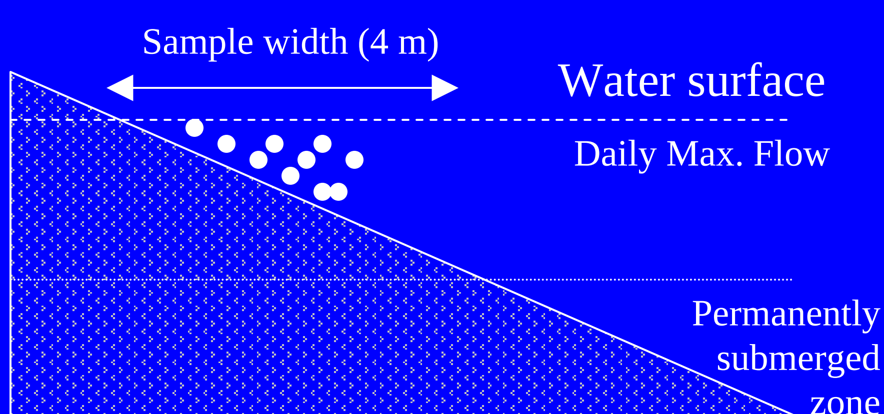
# Unanticipated gains in knowledge resulting from high spatial and temporal sampling resolution

## Sampling at daily minimum flow

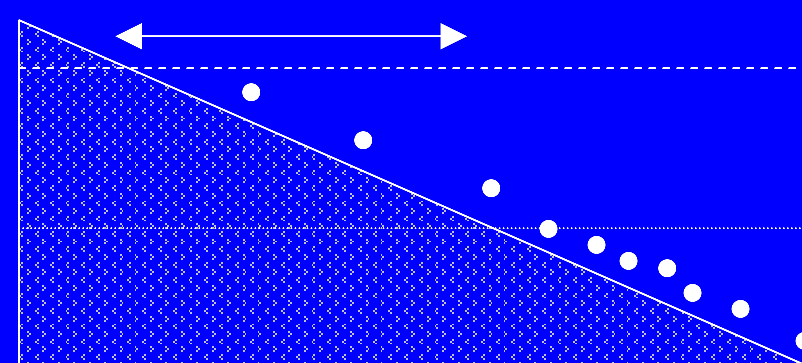



## Sampling at daily maximum flow

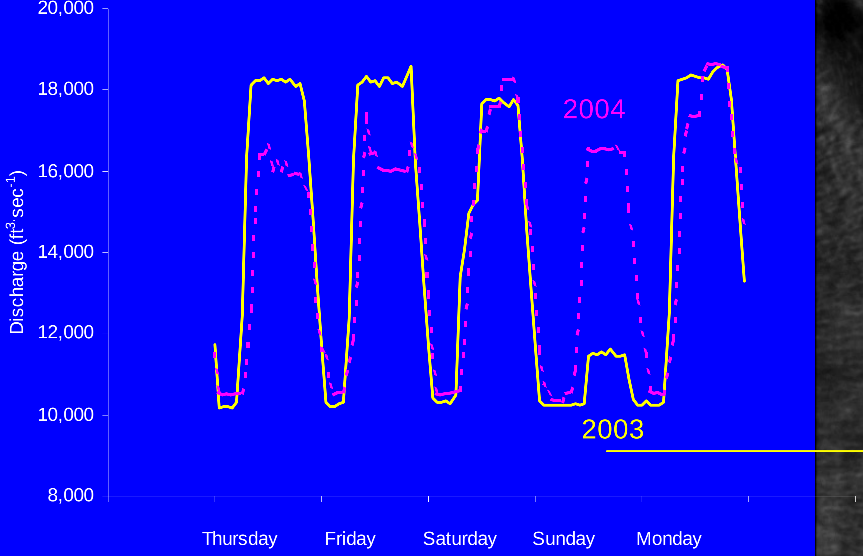
### 1) Shoreline-tracking

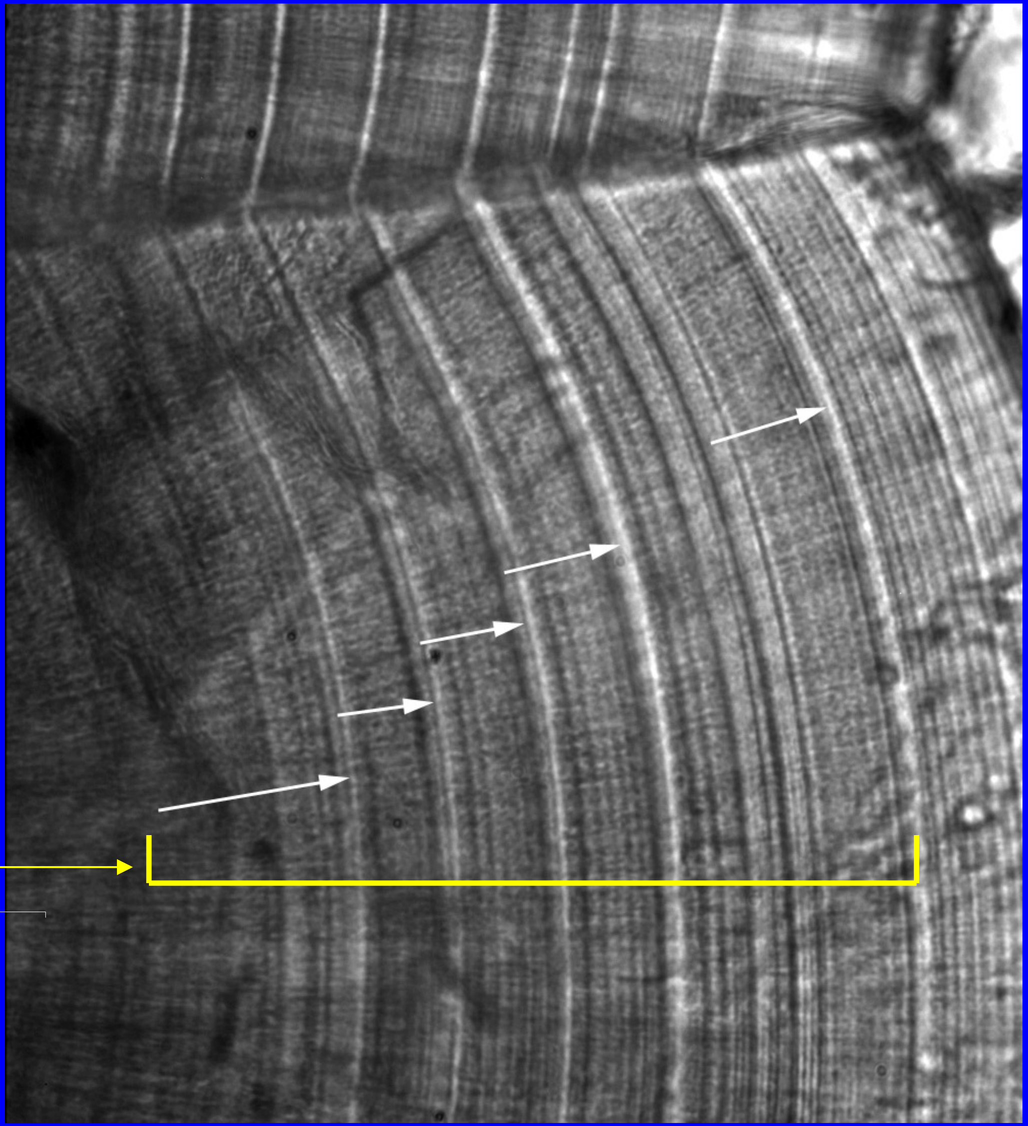



### 2) Restricted-Movement



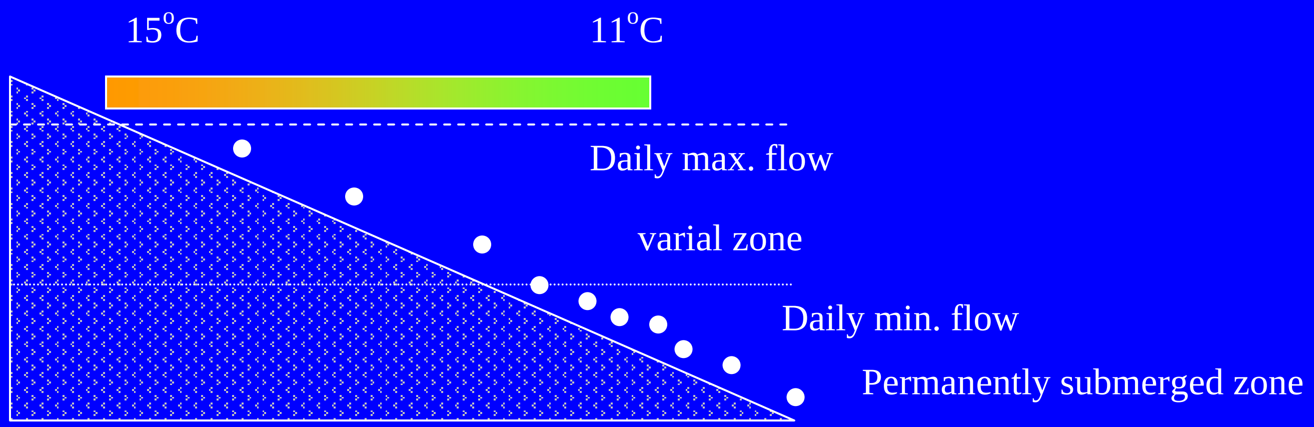
# 25% Increase in otolith growth on Sundays in 2003 when flow was low and steady



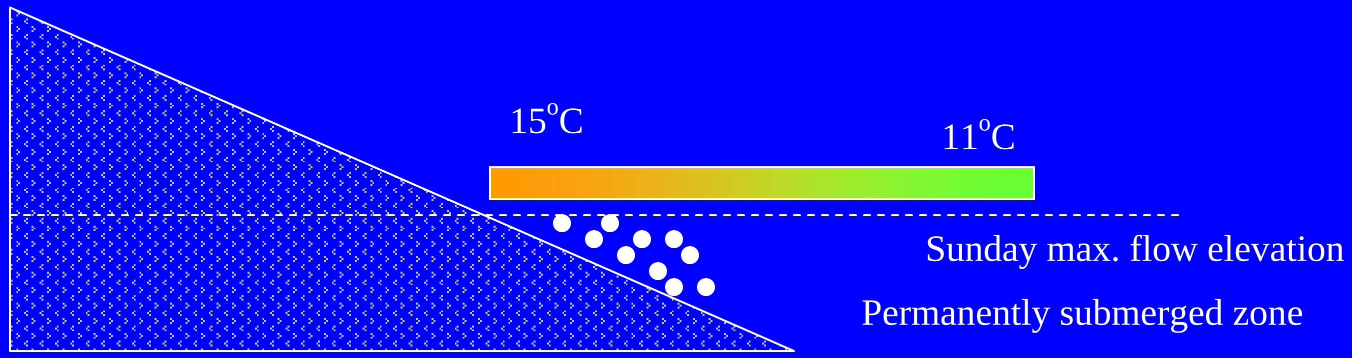



# Otolith growth - nearshore habitat use

## Daytime – Monday through Saturday




## Daytime – Sunday (2003 only)



# Summary

1. Flow-dependent incubation losses of 25-50% in experimental flow years likely not large enough to reduce abundance of age-0 trout because of strong compensation.

2. Some age-0 trout migrate from low- to high-angle shorelines. Use of high-angle shorelines is considerable, and may buffer impacts of flow variation.

3. Age-0 growth over the summer and fall was very similar across habitat types, reasonably similar across years, and showed little density-dependence.

4. Apparent age-0 mortality rates over summer and fall were similar between 2003-2007, but were much higher in 2008. Density-dependent mortality displacement?

5. Apparent age-0 mortality was highest during periods when sudden changes in flow occurred (Aug-Sep, Nov. '04). Flow-dependent mortality or displacement?

6. More years of data are needed to better separate effects of flow, density, and natural variation on early survival rates.