Knowledge assessment October 2011

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Objectives

- **Justification for talking today**
  - Many policy actions in Grand Canyon are directed at maintaining/restoring habitat YET we have little understanding if habitat relationships exist and whether they are important to population persistence.
  - We often look at associations between where fish are found and the types of habitat present in those areas
  - However, these associations rarely provide insight into the absolute requirement for a particular habitat
  - A habitat is required if it is necessary for the persistence of individuals or the population

Objectives

- **Justification for talking today**
  - When making decisions about habitats it is essential to accurately identify the subset of critical habitats which the species requires to persist.
  - "Without this knowledge managing habitat either defaults to educated guesswork, which often fails, or an overly conservative strategy of protecting everything, which often has economic and social consequences that are difficult to justify" (Rosenfeld 2003)

Objectives

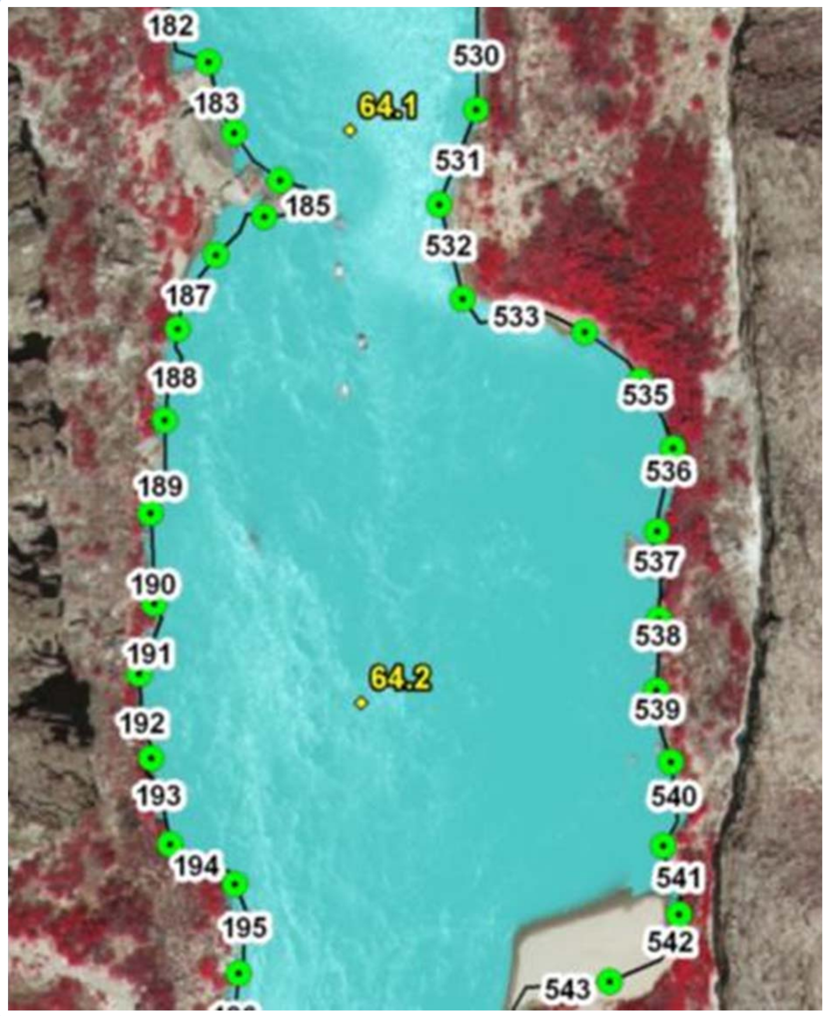
- **Justification for talking today**
  - "Although the importance of defining habitat relationships of endangered or managed species is widely recognized, information on habitat use is often collected in a haphazard way, correlative habitat associations are often confused with habitat requirement, and the significance of habitat relationships from field studies is often unclear or mis-interpreted" (Rosenfeld 2003)

Objectives

- **Justification for talking today**
  - I’m going to talk today about habitat use of juvenile humpback chub in Grand Canyon – basically what habitats do we find juvenile humpback chub
  - And I’m going to talk a little bit about habitat selection, whether humpback chubs are choosing to use some habitat types more than others
  - BUT I’m not going to talk about habitat requirements because I don’t know which (if any) of these habitats *in the mainstem, in our study reach* are required by juvenile humpback for populations of humpback chub to persist in Grand Canyon (this is something we can talk about)

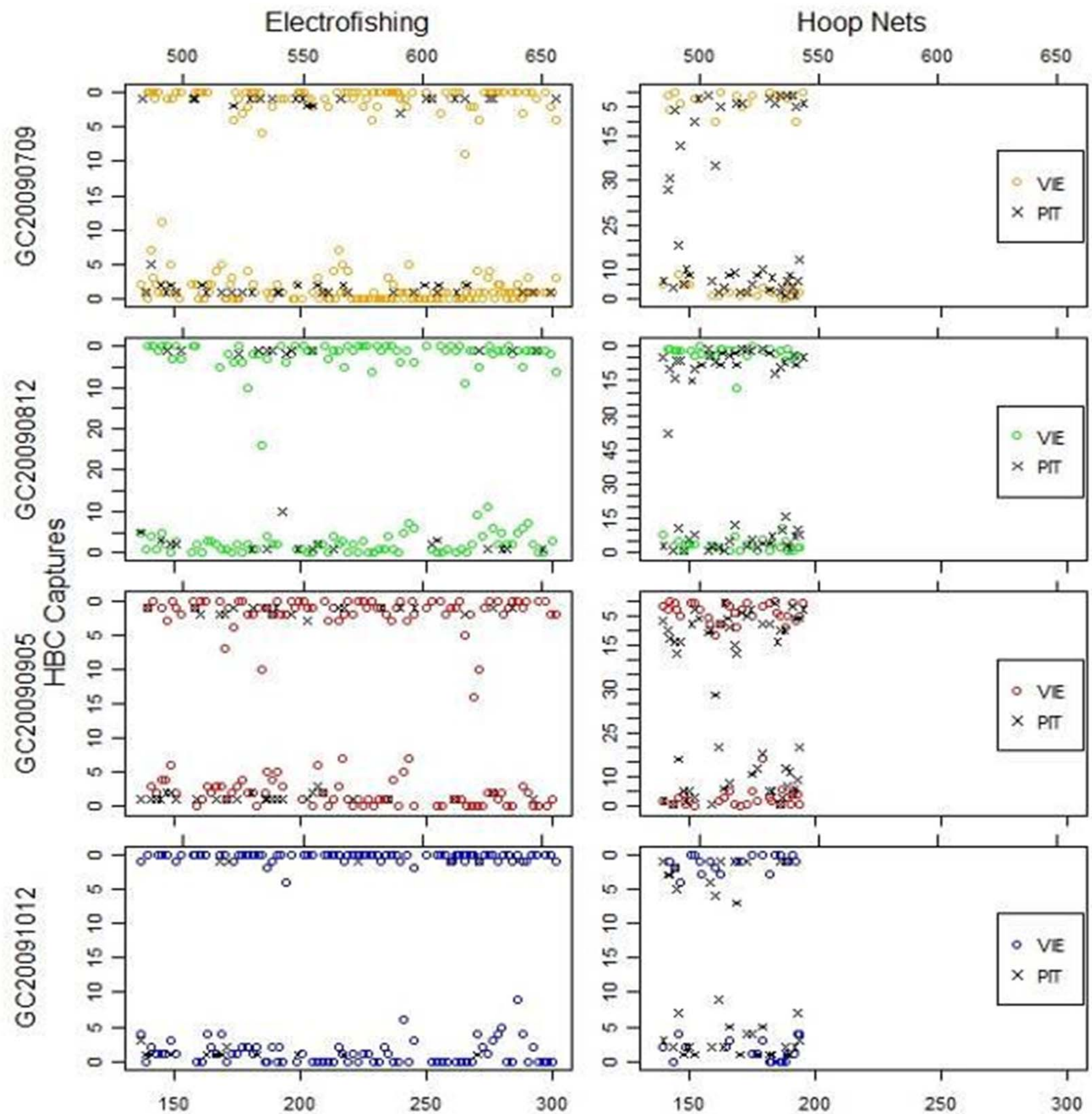
Methods

- Three 3000-m sites sampled (1500-m each side of river)
- Sites delineated into 50-m section of shoreline classified as five discrete habitat types
  - Cliff, Talus, Debris Fan, Sandbar, Backwater
  - Electofishing in every 50-m block
  - 80-hoopnets in Site 1
  - Backwaters (rare in our reach) blocked and sampled with removal seining

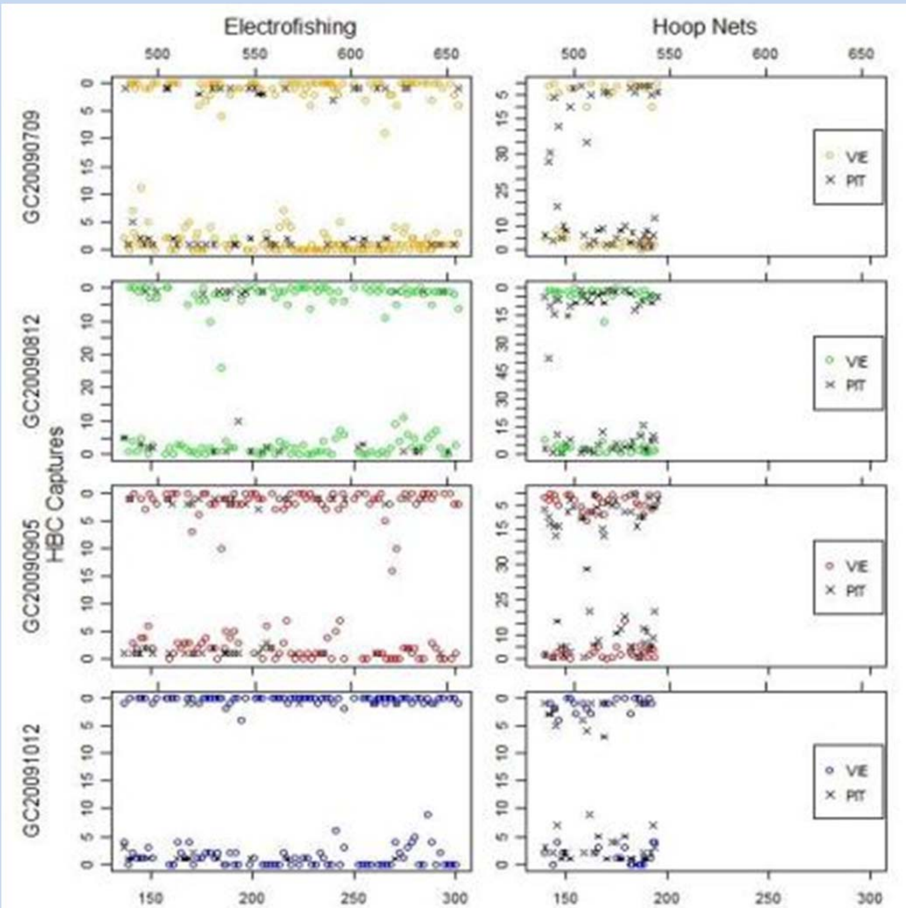


Where do we catch fish?

Distribution of HBC catch

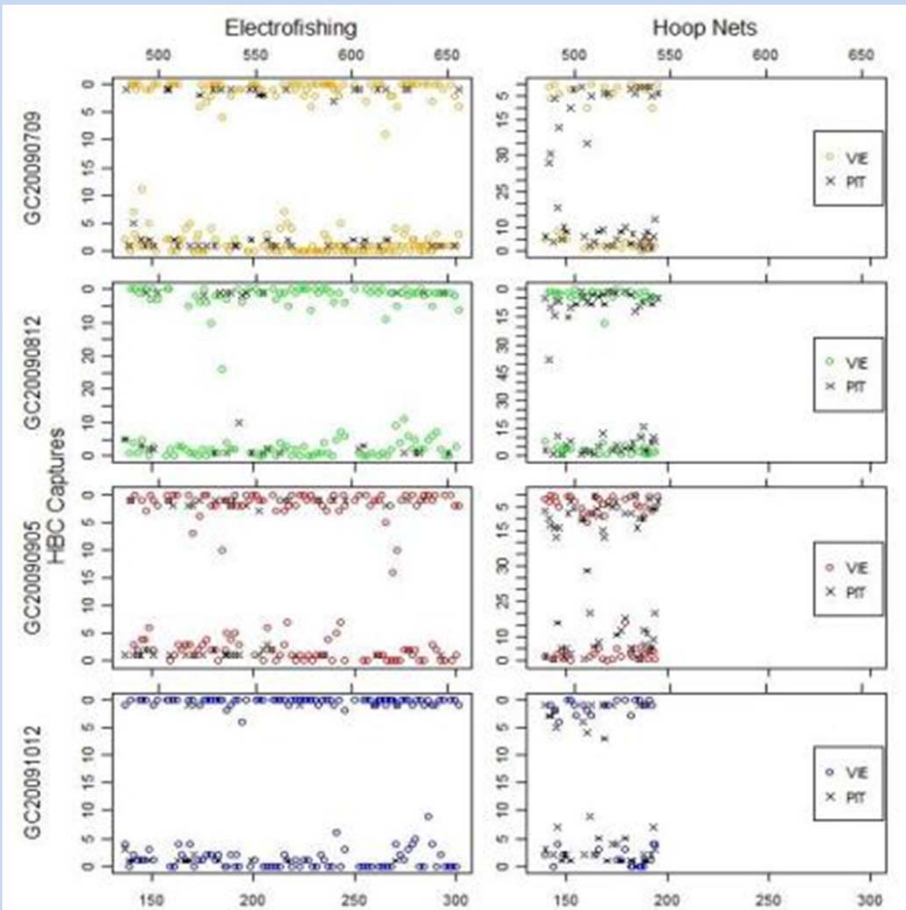


Where do we catch fish?



- Electrofishing samples in all sites, hoopnets sample in reach 1 only
- Humpback chub catches are widely distributed in our sampling reach
- Remember we are just downstream of the LCR

Where do we catch fish?

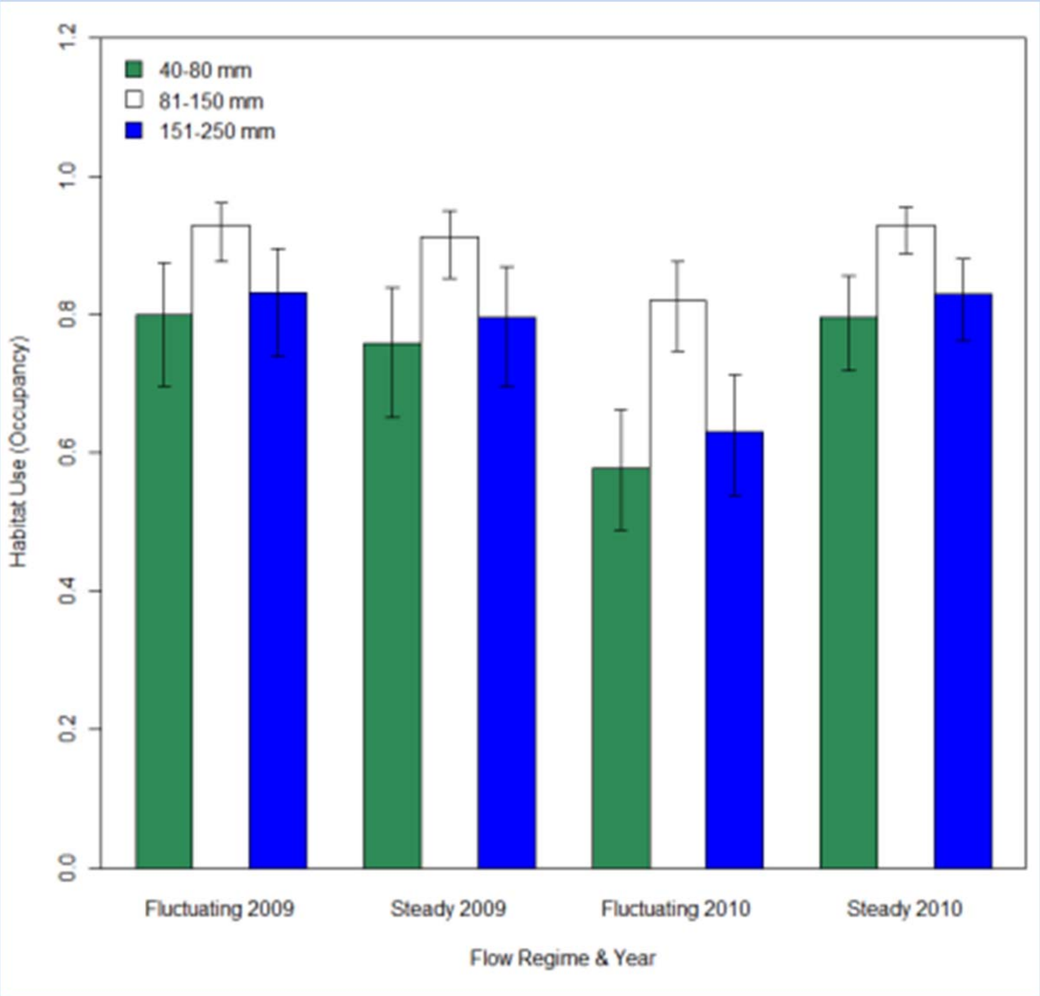


- OK neat….
- Why do we catch fish in some places and not in others?
- Is it because they are there and we just don't catch them?
- Or is it because we didn't catch them?
- And how does flow, turbidity, water clarity, habitat type, depth, flow experiment effect these patterns?

Estimate and assess…

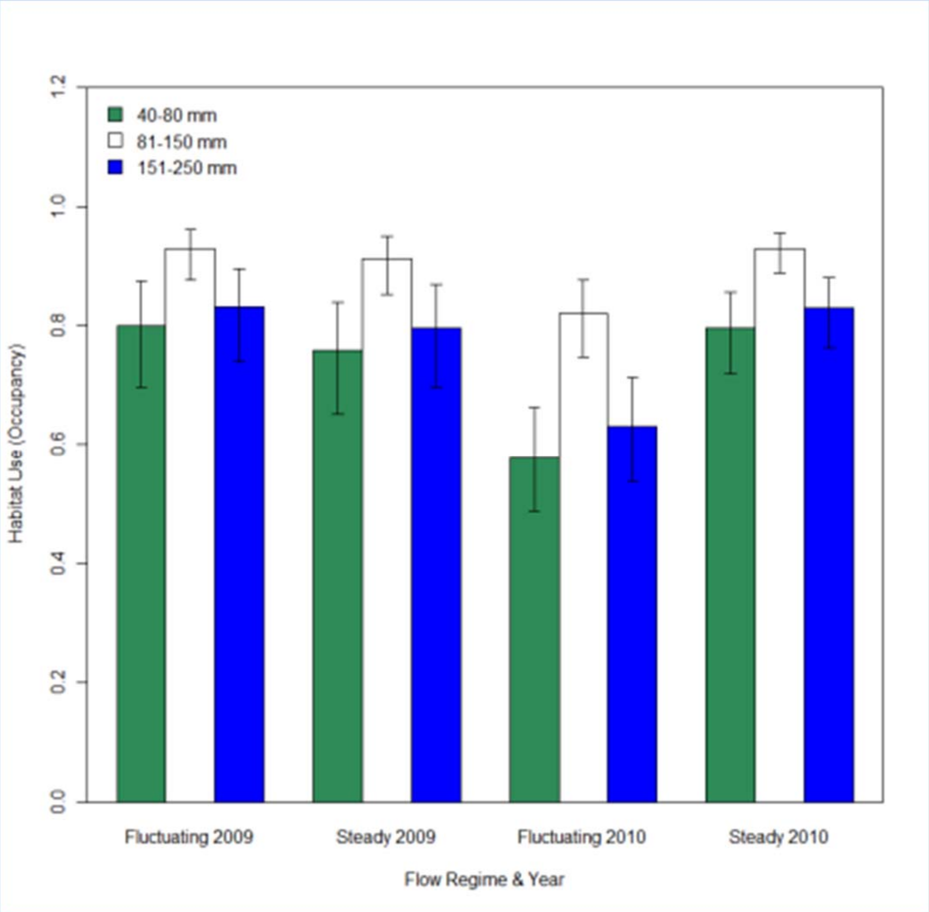
- How is capture probability and occupancy influenced by
  - **Fish Size**: 40-80 mm, 81-150 mm, 150-250 mm
  - **Time**: Year, Trip
  - **Flow Regime**: Fluctuating flow or Steady flow
  - **<u>Habitat Characteristics</u>**
    - Mean depth, Proportion substrate size (GIS)
    - Habitat type (Cliff, Debris Fan, Sandbar Talus)
  - **Pass specific**: Water clarity (turbidity)

Occupancy results…



- Juvenile chub are present in about 75% of our hoopnet sites
- Factors strongly influencing occupancy: <u>fish size</u>
- Factors NOT strongly influencing occupancy: <u>include habitat types</u>

Habitat use….



- So this tells us that a lot of our habitat types are occupied, humpback chub are "present" in these sites
- Let's look at abundance in these different habitats now, shift from presence to abundance

What about backwaters?

Colorado River Backwater Paradigm…

- Thought to be important to juvenile native fish.
  - 2008 Final Biological Opinion for Glen Canyon Dam
  - Warm more than mainstem river
  - Low velocity habitats
- Most previous juvenile fish studies have focused mostly on sampling backwaters, with limited evaluation of other habitats

Colorado River Backwaters

- In our study reach backwaters are:
  - Small spatial area compared to other habitat types
  - Ephemeral, under fluctuating flows or flows above about 15,000 cfs they are underwater

Habitat Selection

Are juvenile humpback chub selecting for backwater habitats?

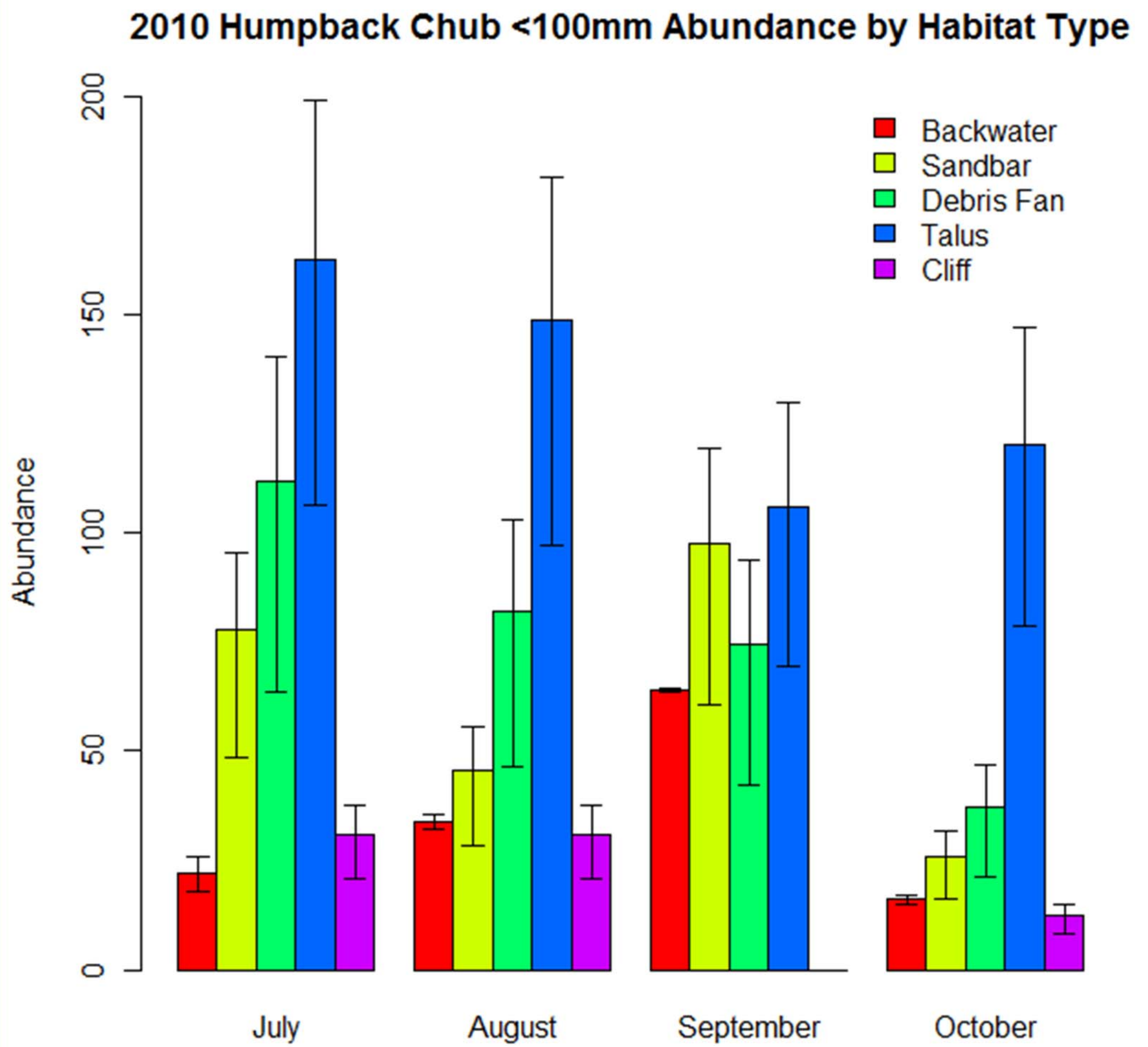
Abundance

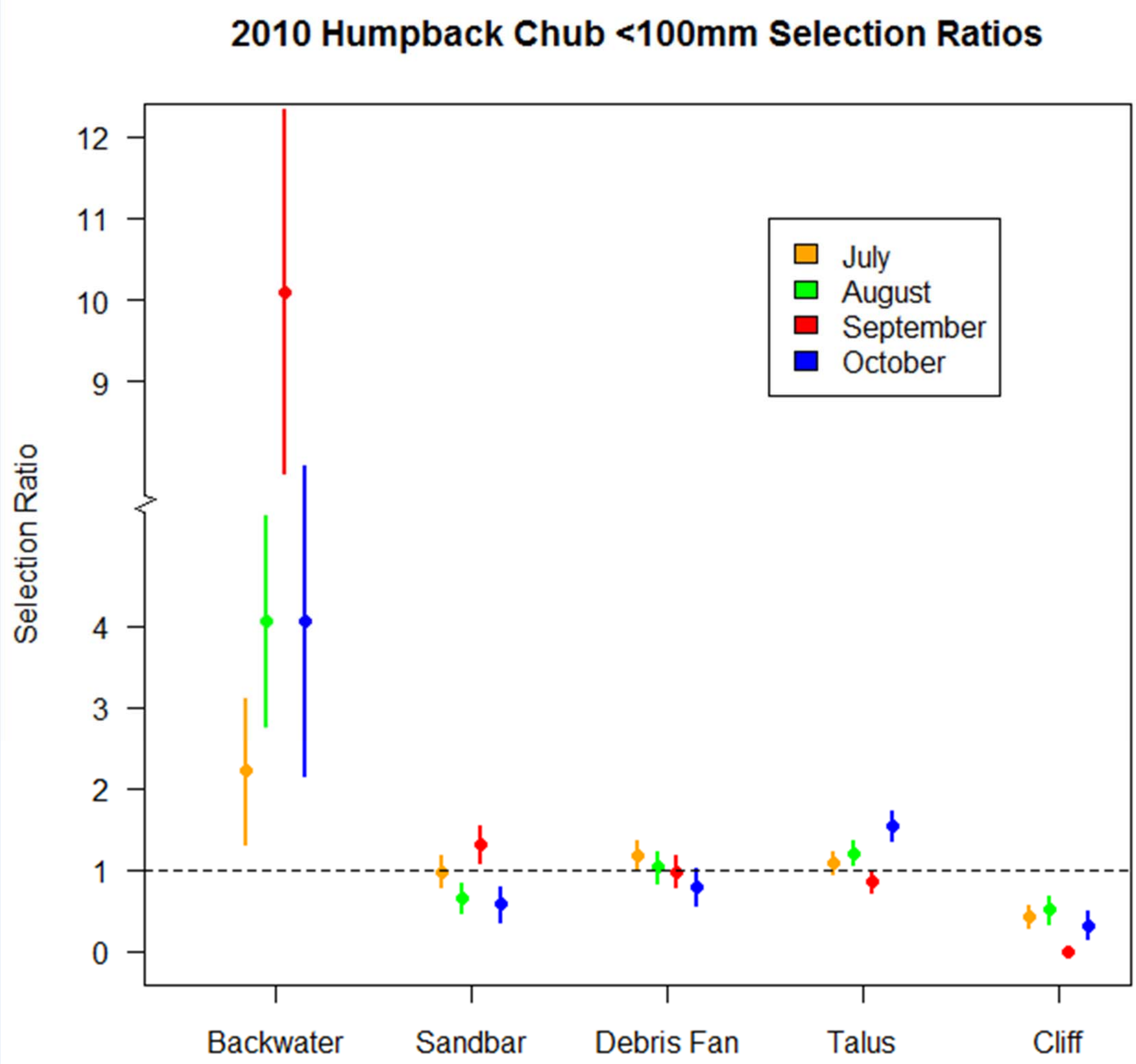
- VIE marks to estimate capture probability and abundance from hoopnets and electrofishing
  - Cliff, Talus, Debris Fan, Sandbar
- Multinomial likelihood to estimate abundance from removal sampling
  - Backwaters
- This let's us compare apples to apples, abundance to abundance in each habitat type

Selection

- Manly's selection ratios

$$Wi = \frac{Abundance\ in\ habitat\ i}{Proportion\ of\ habitat\ i\ avaliable}$$


2010 Humpback Chub <100mm Abundance by Habitat Type
Abundance
0
50
100
150
200
July
August
September
October
Backwater
Sandbar
Debris Fan
Talus
Cliff


2010 Humpback Chub <100mm Selection Ratios
Selection Ratio
12
11
10
9
4
3
2
1
0
July
August
September
October
Backwater
Sandbar
Debris Fan
Talus
Cliff

Conclusions

- The highest abundance of humpback chub was found in talus habitat across all four sampling periods.
- Backwater and cliff habitat had the lowest abundance

Conclusions

- Humpback chub show positive selection for backwater habitats across all four months.
- Suggests that chub are preferentially occupying backwater *when theses habitats are present*.
- Backwater habitats were not always available in our reach *but humpback chub were available and they did not go extinct when backwaters were not present*

Challenging the backwater paradigm?

- NSE results may not be the same elsewhere in GC because
  - We are working in what is likely the highest juvenile HBC abundance in the mainstem, so habitats may be "swamped" with juveniles using required, preferred, and all available habitat
  - No low elevation habitats, no "permanent" backwaters

Challenging the backwater paradigm?

- *So while we might not have some habitat features in the NSE study site, we do have juvenile humpback chub….*
- Going forward…
  - We work 1-3m off the shoreline, are we measuring the right habitat variables in existing GIS?
  - Are juvenile fish just a bit further downstream?
    - Use information from NSE project to identify locations downstream of Lava Chuar rapid that may support juvenile humpback chub aggregations
    - NSE style sampling in those locations

Challenging the backwater paradigm?

- *So while we might not have some habitat features we do have juvenile humpback chub*
- Going forward…
  - Is the proximity to the LCR the only reason juvenile HBC are found in the NSE study site?
    - As Carl says, fish worry first about not getting eaten, then about eating
    - Compare habitat selection and diet in LCR and mainstem

Thank you

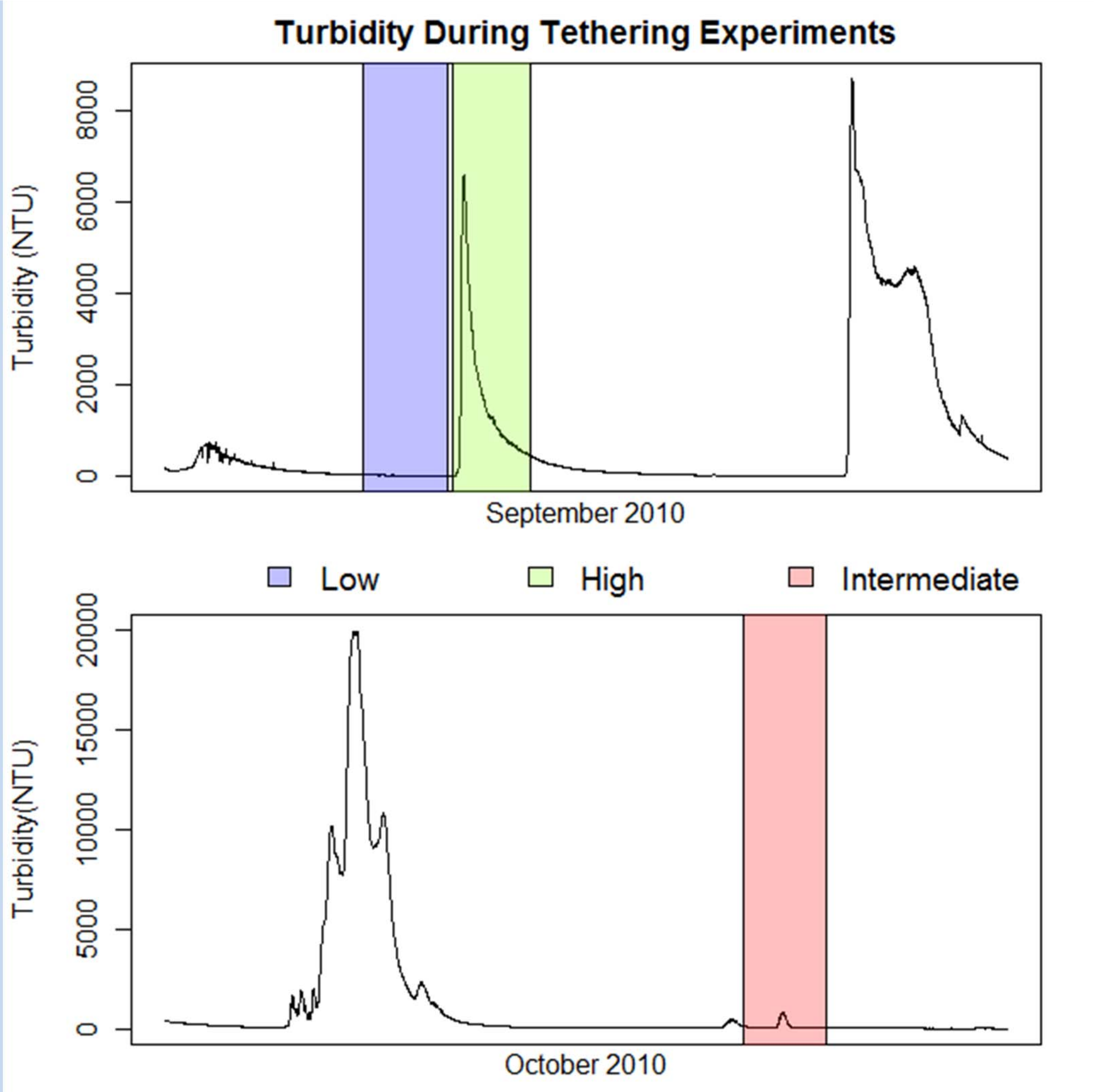
- Questions? Send email to billpine@ufl.edu

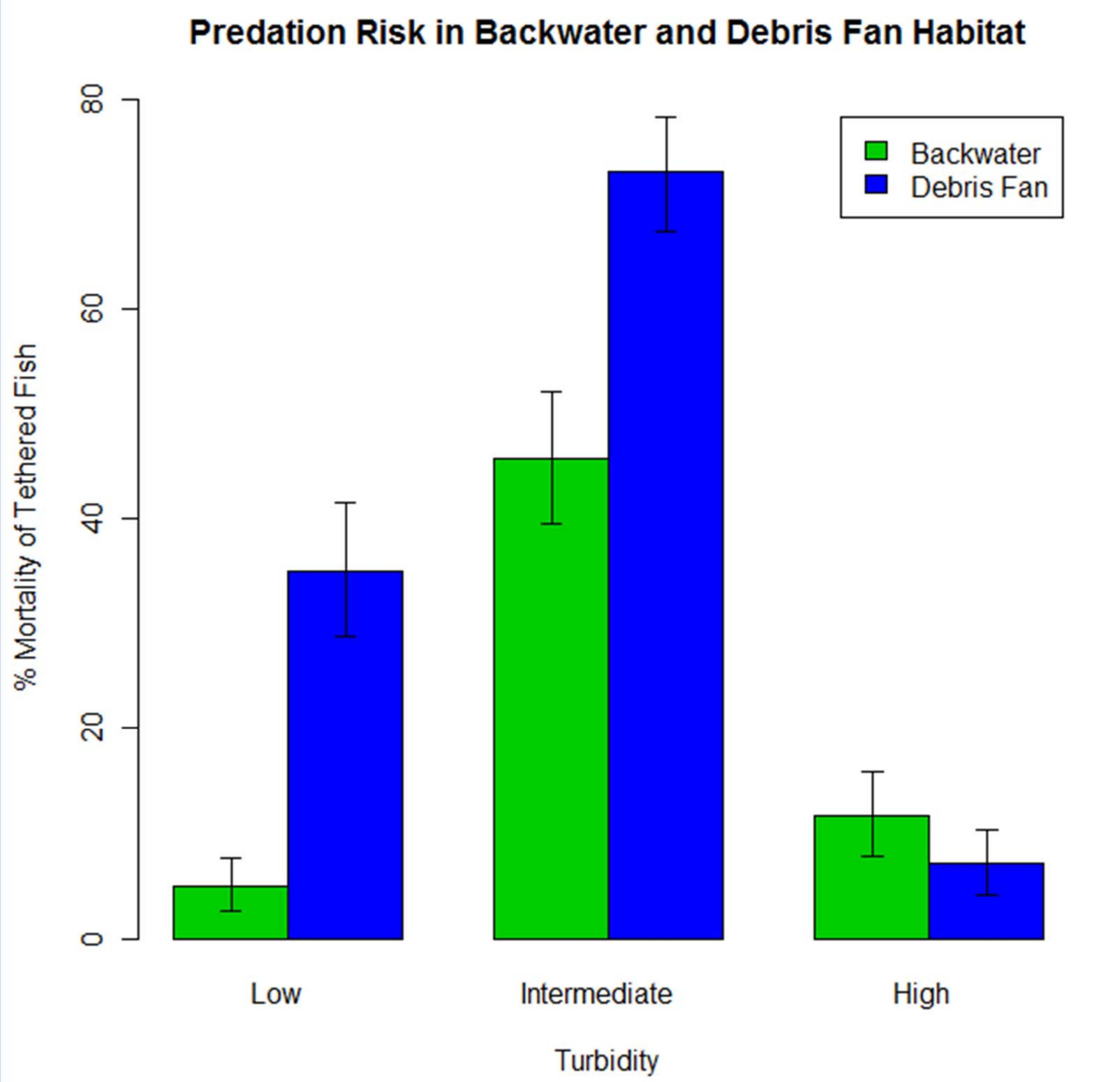
Flow Experiment

- No appreciable differences in habitat use between fluctuating flow regime and steady flow regime
- Why ???
  - Not sufficient contrast in discharge between flow treatments
  - Too short of time-frame to be able to detect differences
  - Time period of high juvenile humpback chub abundance, fish are using all available habitat types *in our reach*
  - Little habitat contrast in our site (no low angle habitats, few backwaters)
  - Dynamics that structure fish populations are governed by multiple factors and flow may play a relatively small role
    - Habitat use patterns of HBC robust to changes in flow

Backwater

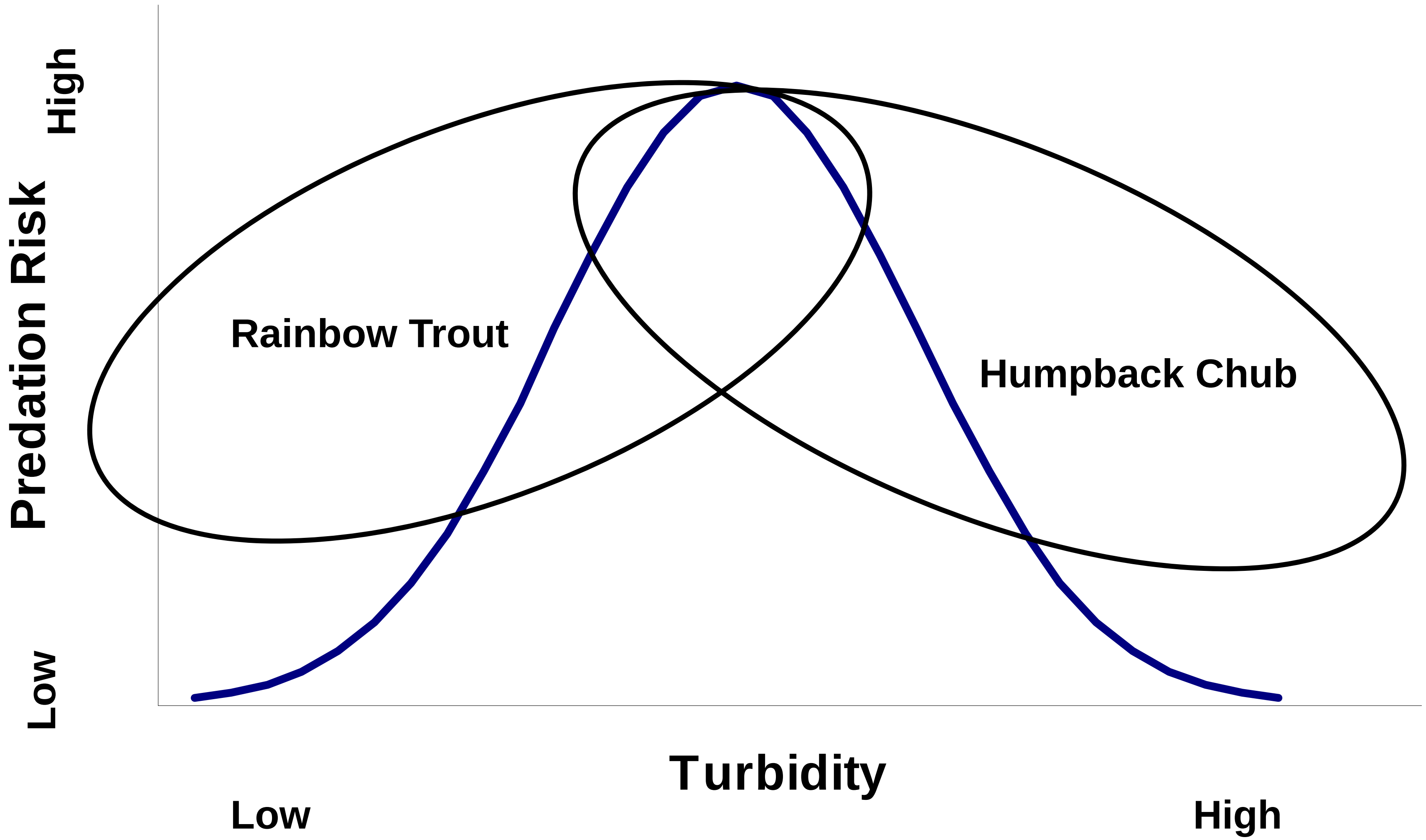
Debris Fan


Turbidity During Tethering Experiments
Turbidity (NTU)
0
2000
4000
6000
8000
September 2010
Low
High
Intermediate
Turbidity(NTU)
0
5000
10000
15000
20000
October 2010


Predation Risk in Backwater and Debris Fan Habitat
80
60
40
20
0
% Mortality of Tethered Fish
Backwater
Debris Fan
Low
Intermediate
High
Turbidity

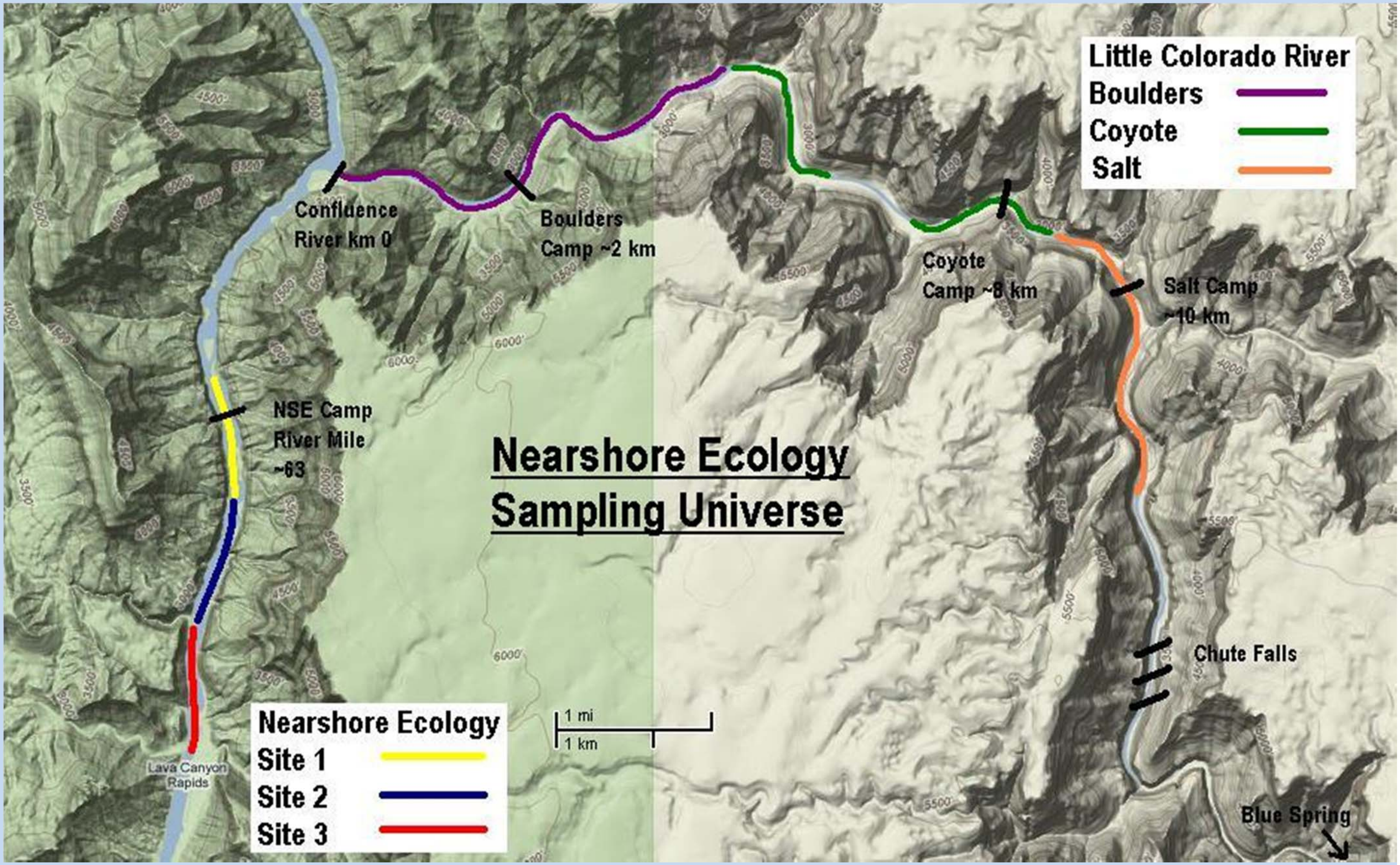
Conclusions

- Predation risk highest at intermediate levels of turbidity.
  - Overlap in effective feeding scope of RBT and HBC


High
Predation Risk
Low
Rainbow Trout
Humpback Chub
Turbidity
Low
High

Flow Experiment

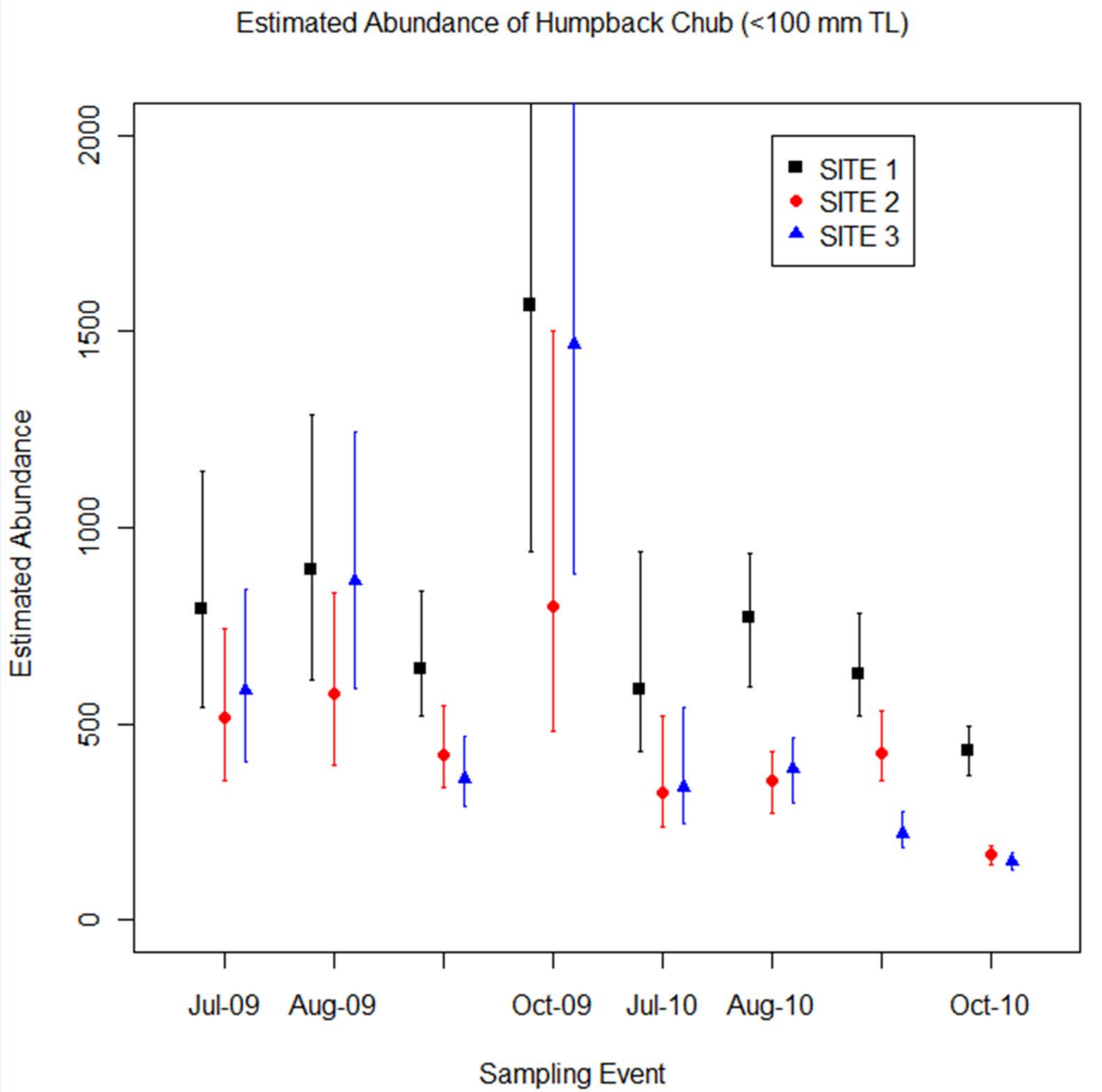
- This study adds support that the response of fish populations to hydrologic change may not be very predictable and may produce counterintuitive results

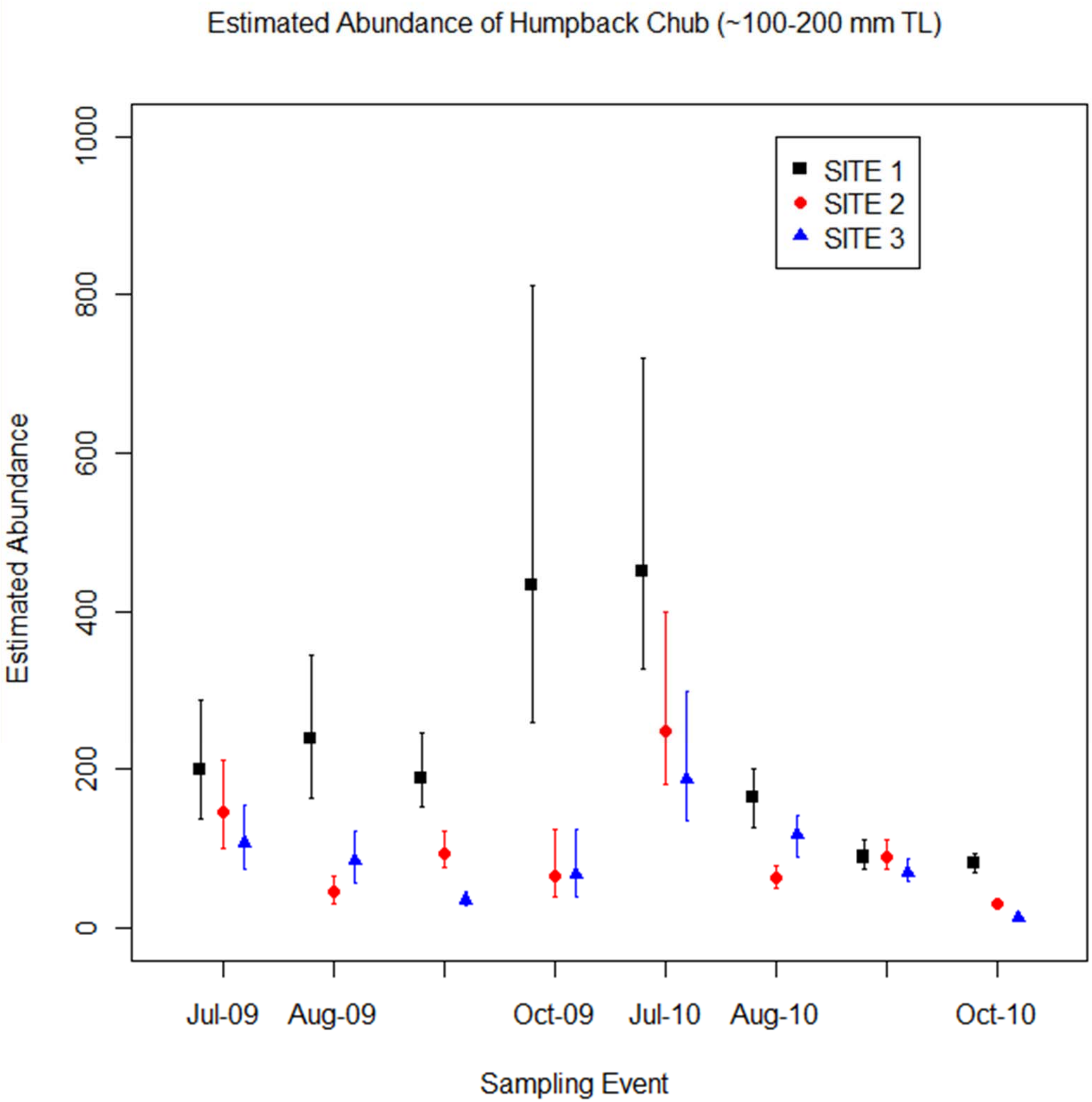


Each site is ~3000-m (1500-m each side of river)

Key NSE Finding 1

- NSE project catches small native fish
  - Smaller fish generally collected via EF than hoopnets (key size difference fish < 50-mm TL when water is clear)
  - NSE electrofishing is <u>much</u> slower (8 sec/m) than other electrofishing efforts (1.2 sec/m)
  - Targets shoreline habitats
  - Larger fish may avoid NSE electrofishing

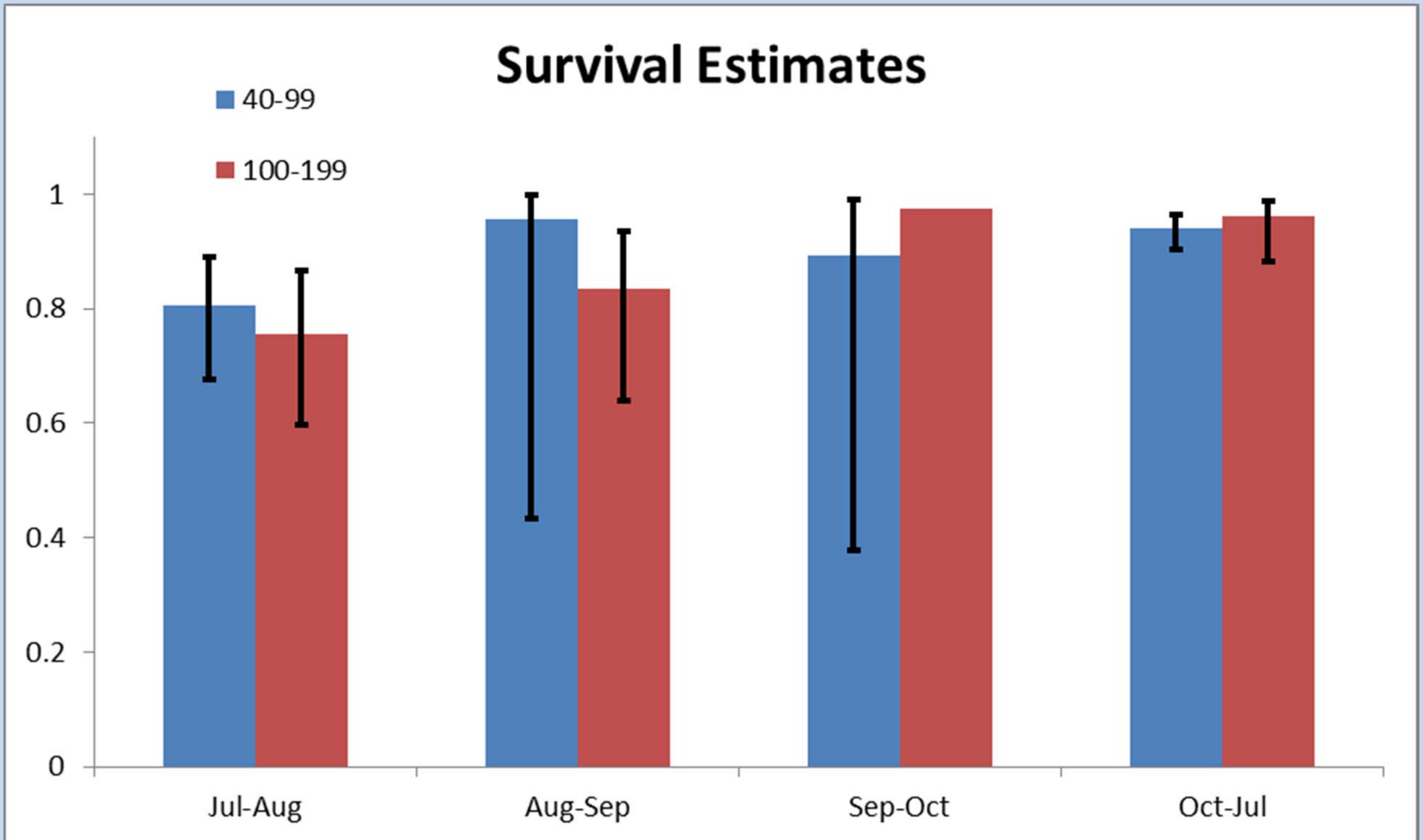

Estimated Abundance of Humpback Chub (<100 mm TL)
Estimated Abundance
0
500
1000
1500
2000
SITE 1
SITE 2
SITE 3
Jul-09
Aug-09
Oct-09
Jul-10
Aug-10
Oct-10
Sampling Event


Estimated Abundance of Humpback Chub (~100-200 mm TL)
SITE 1
SITE 2
SITE 3
Estimated Abundance
0
200
400
600
800
1000
Jul-09
Aug-09
Oct-09
Jul-10
Aug-10
Oct-10
Sampling Event

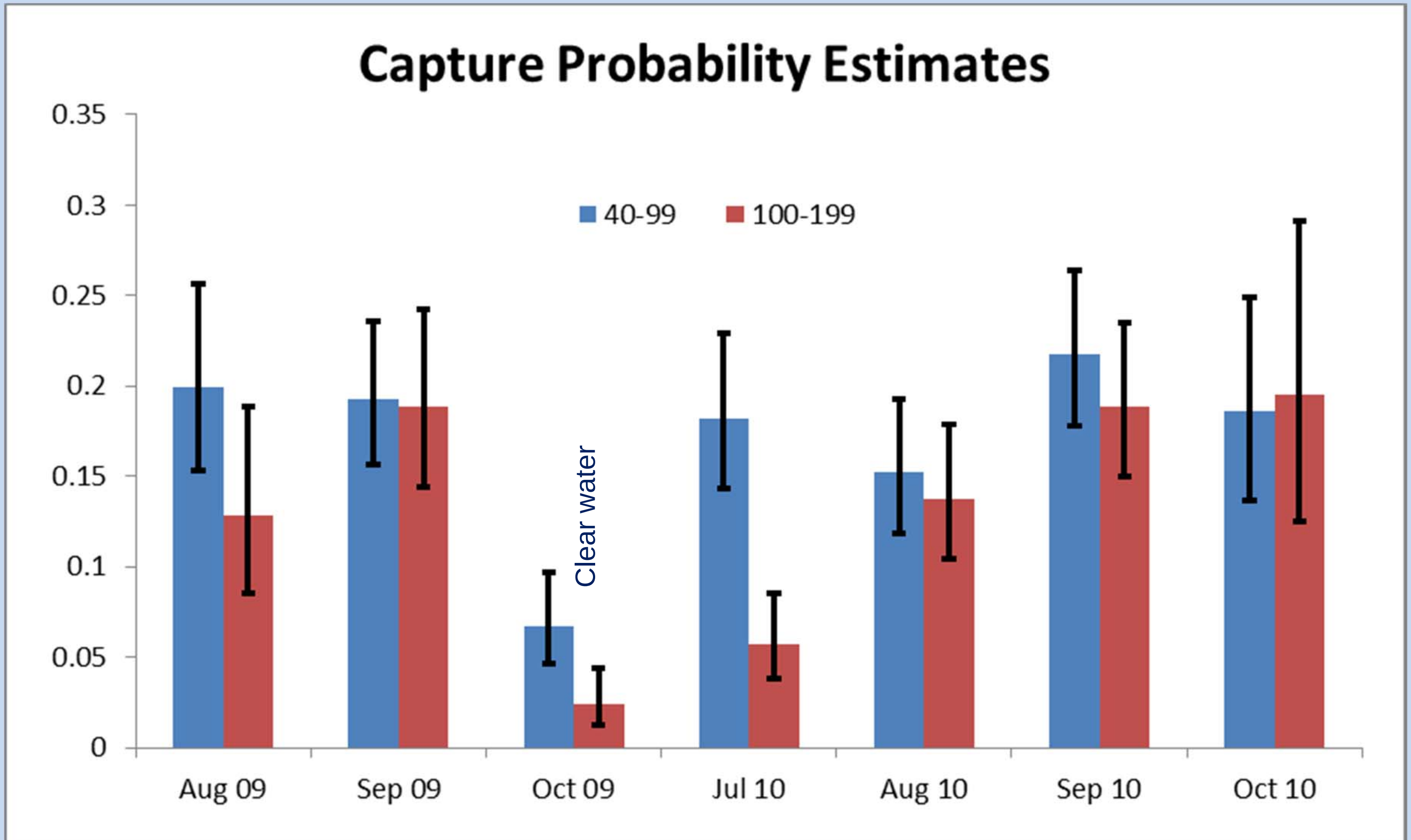
Key NSE Finding 2

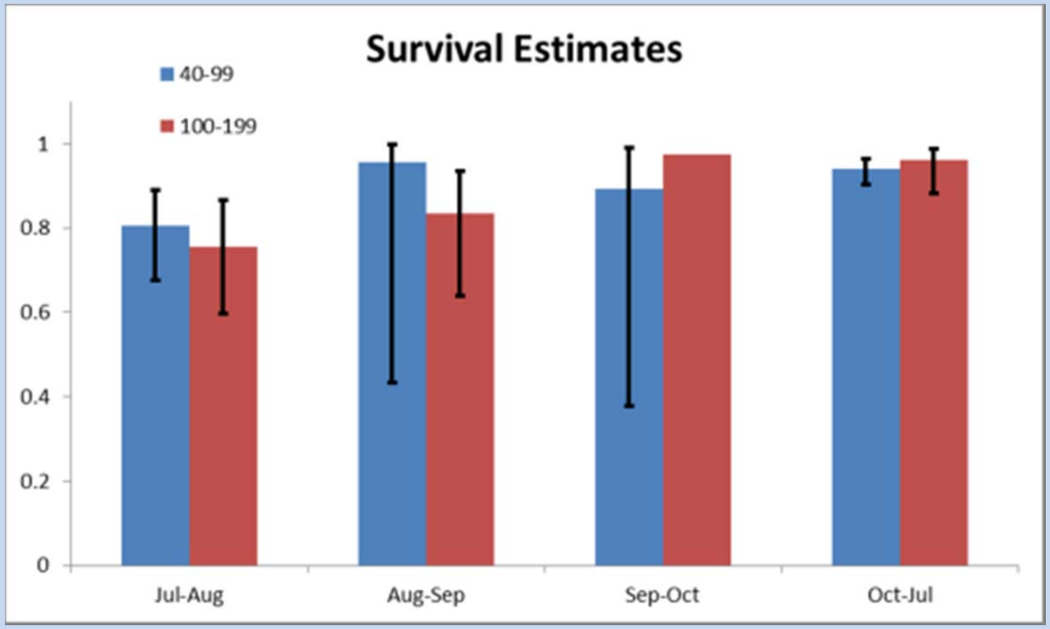
- NSE project can estimate abundance of small fish
  - Direct estimates of abundance vs. reconstructions from ASMR
- No obvious changes in abundance occurring during flow experiment
- High uncertainty in abundance estimates driven by low capture probabilities (typical w/ fish) making it possible to only detect relatively large changes in abundance

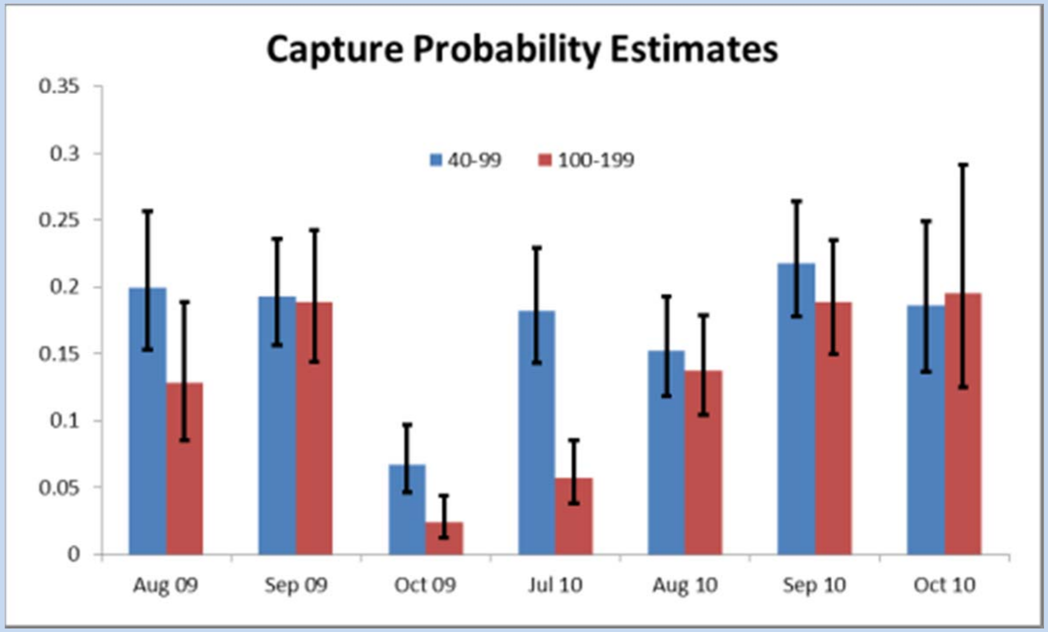
Juvenile HBC monthly mainstem survival - years pooled



Juvenile HBC mainstem capture probabilities by trip - gears pooled







- Uncertainty in survival and abundance greatly influenced by capture probability
- Capture probability strongly influenced by turbidity

Tagged cohorts persist through time

	July_09	Aug_09	Sept_09	Oct_09	July_10	Aug_10	Sept_10	Oct_10
	T1	T2	T3	T4	T5	T6	T7	T8
M	R	R	R	R	R	R	R	R
278	27	48	49	21	35	26	33	42
307		36	55	24	30	27	29	55
329			47	19	25	43	42	59
132				7	13	10	13	18
203					25	32	34	45
279						47	84	53
517							90	95
434								100

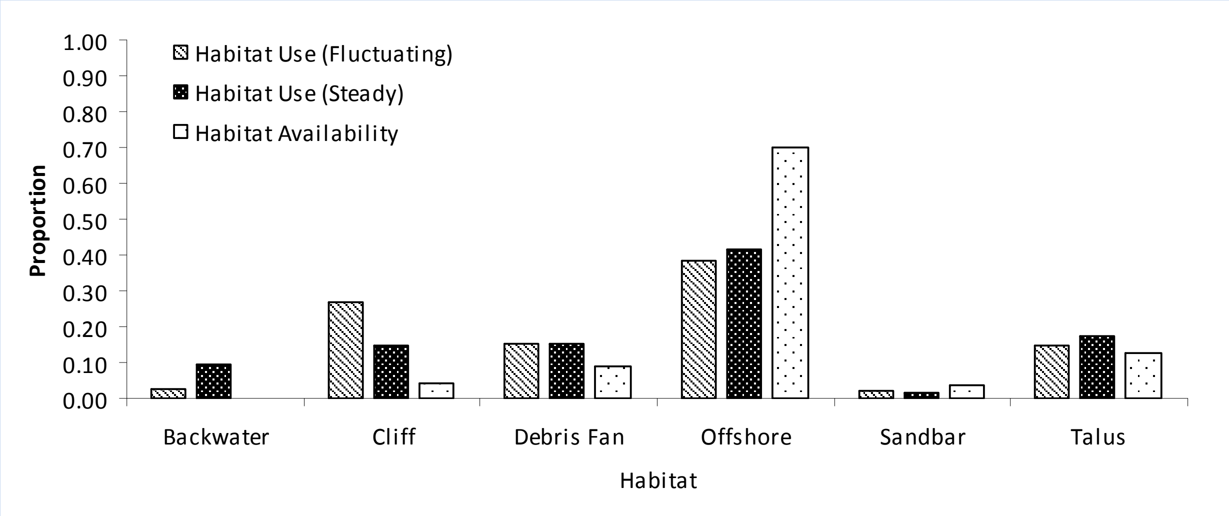
Key NSE Finding 3

- Juvenile HBC survival in the mainstem is very high
  - Annual survival about 40% for fish between 40-100-mm TL and 100-200-mm TL
  - No obvious changes in survival occurring during flow experiment
  - Less uncertainty in survival than abundance estimates because only working with marked fish, may be more likely to detect a change in survival than abundance

Key NSE Finding 3

- How can this be if trout numbers are high, water is cold, and flows are fluctuating (or steady)?
  - Are trout numbers high?
  - Maybe predation impacts HBC < 40-mm TL?
  - Water is cold, but warmer than the 1990's…
  - Steady flows were not so steady, LCR inputs

Habitat use



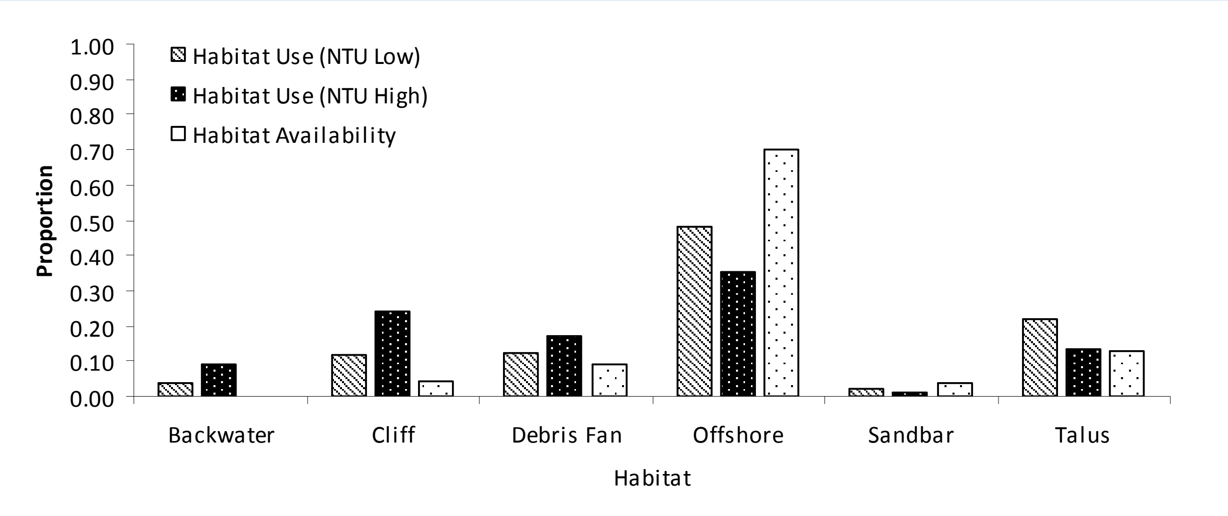
Telemetry relocations
HBC 180-210-mm TL

Offshore is >15-m from shoreline

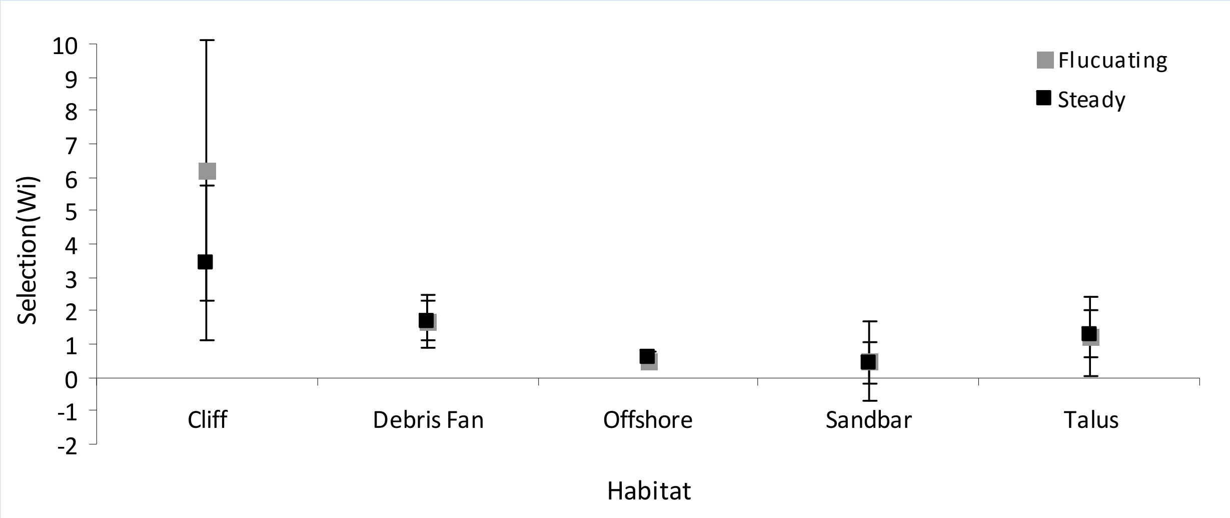
80% of relocations were in eddies and eddies were adjacent to cliffs and debris fan

Flow experiment

Turbidity contrast



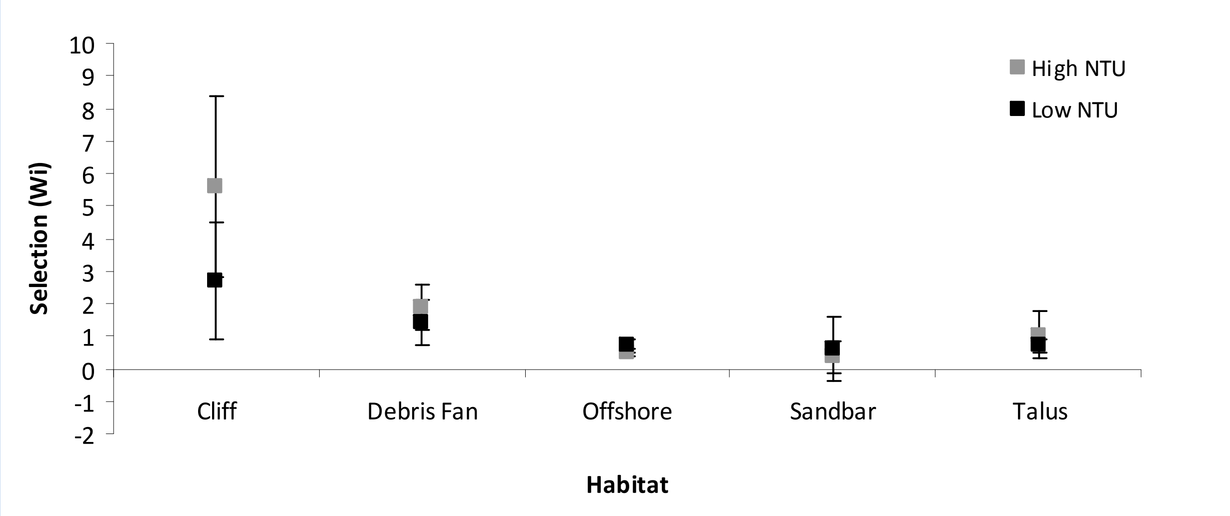
Habitat selection



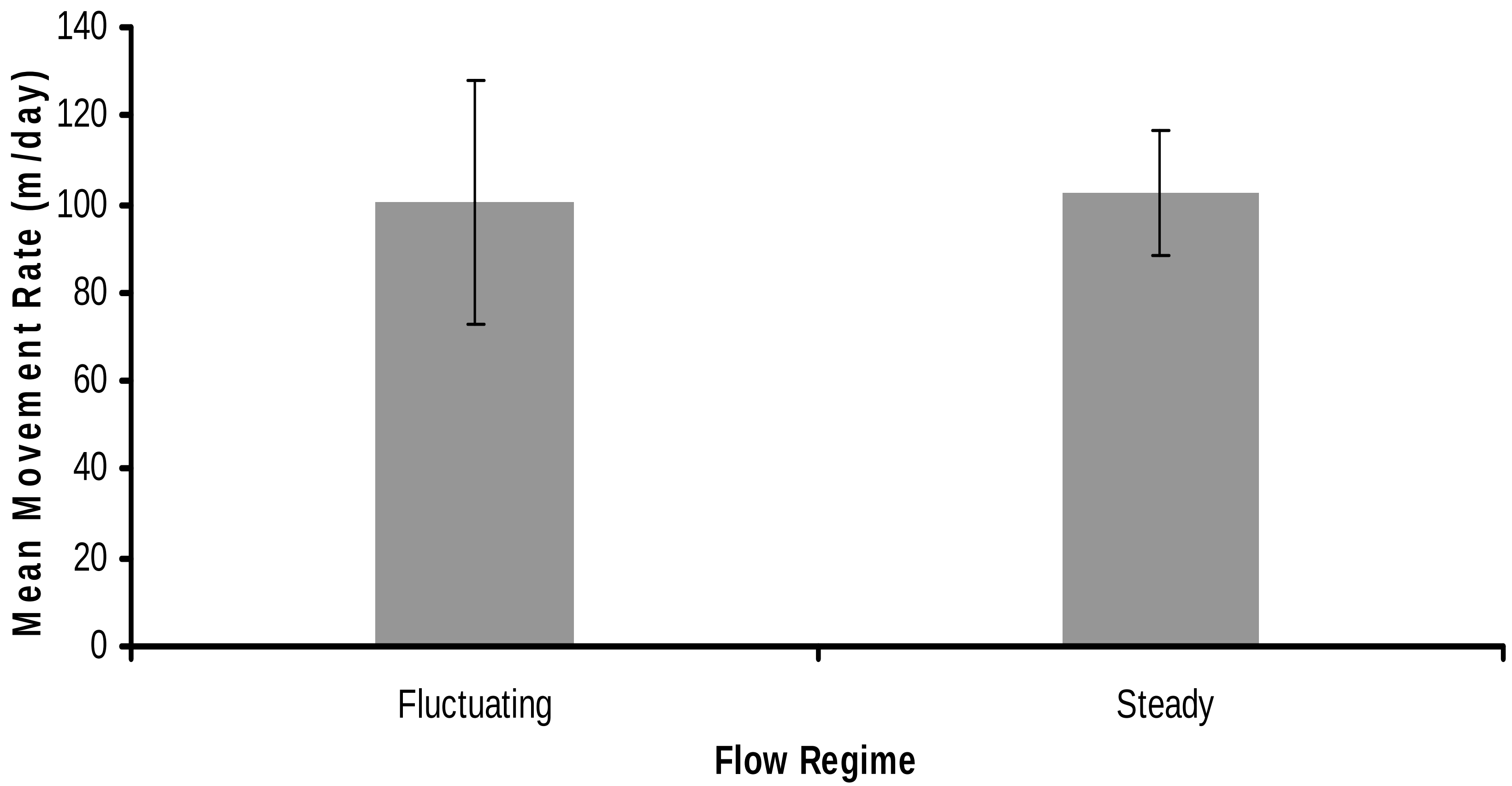
Backwaters make up 1-2% of available habitat in our reach. Telemetered fish do occasionally use backwaters, particularly during turbid conditions. Because backwaters make up only a small proportion of the available habitat, it makes the selection appear very large, so we didn't include backwaters here.

Flow experiment

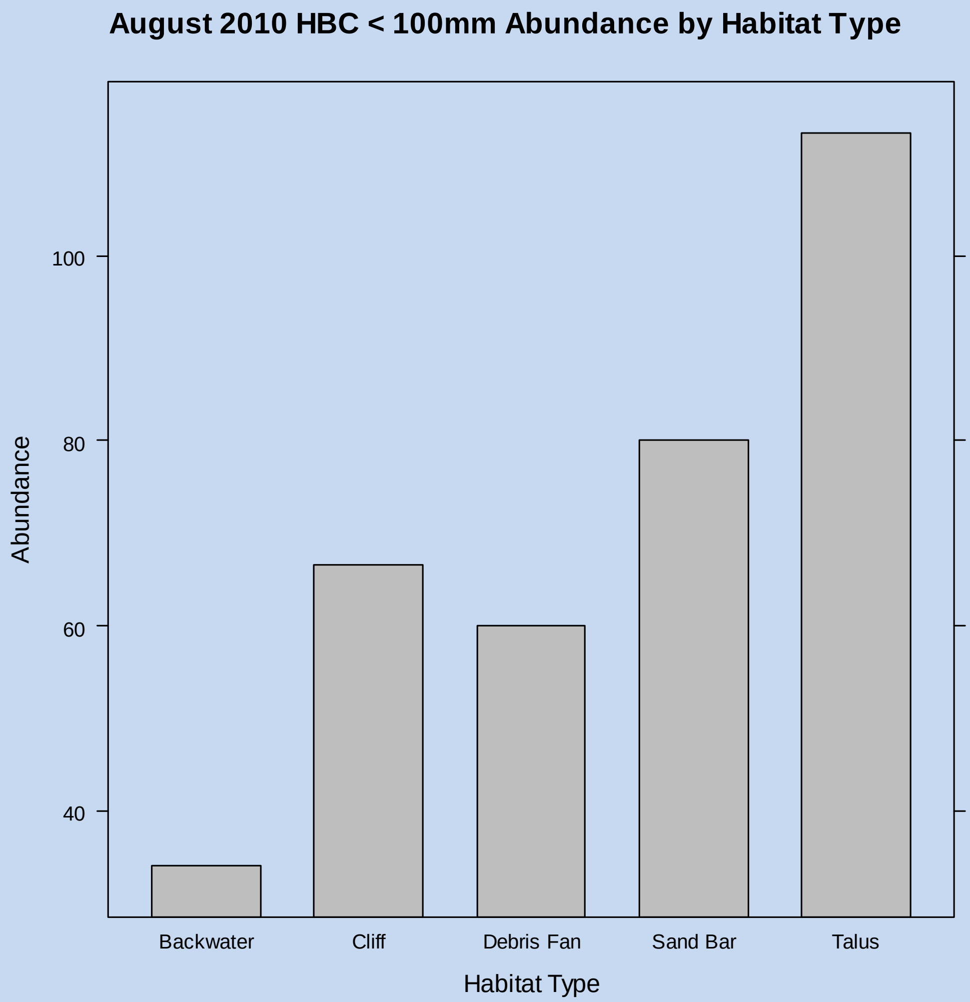
Turbidity contrast



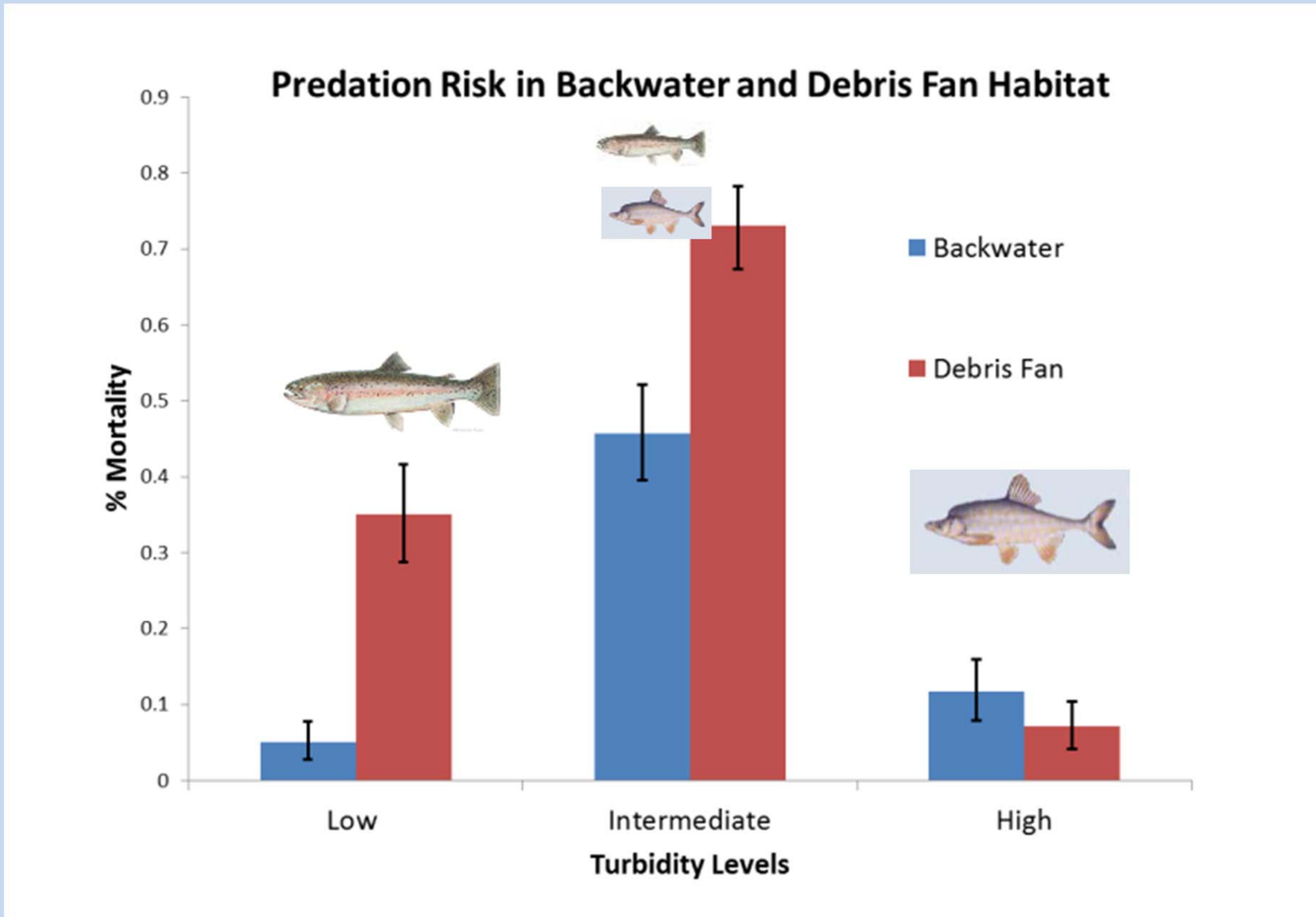
Daily movements



Example abundance by habitat…



Hints from tethering…



Key NSE Result 5

- Limited movement between sites
- Apparent selection for eddy habitats
- Similar daily movements and habitat use between flow events
- Higher relative predation at “moderate” turbidities of ~400- NTU
- Continuing to examine occupancy of habitat types and link to physical science program
- Very informative for informing mark-recapture

Key NSE Result 6

- Movement between LCR and mainstem and then back to LCR by juvenile (<100-mm TL) HBC
- All HBC assessed from downstream of LCR have LCR natal signature (including 60-mm HBC from RM 119)
- Some hints from microchemistry of larger juveniles captured in mainstem spending longer periods of early life in LCR than smaller juveniles.

What's going on?

What NSE does really well…

- Direct estimates of juvenile native fish abundance, growth, and survival
- **Habitat use information**
  - Limited to our small study reach
  - HBC are widely distributed in our reach
  - Really interesting on-shore – off-shore movement patterns of telemetered fish and eddy selection
  - Working to link with physical science program
- Surprises from Todd and Karin
  - Growth, movement patterns, timing of outmigration from LCR

Key Uncertainties & Experiments/Monitoring

1. How do LCR and mainstem juvenile HBC abundances compare? Is the NSE estimated mainstem abundance a significant fraction of HBC annual cohort?
2. Are variations in LCR juvenile HBC production greater than “benefits” from mainstem management actions? (bad mainstem conditions in late 1990’s or low LCR production?)
3. Create contrast between seasonal changes and experimental flows by flipping the timing of flow treatment from the fall steady (similar to NSE) to a summer steady treatment.
4. NSE estimated high survival for HBC > 40-mm, what about < 40-mm? Are there large numbers of HBC <40-mm that are never seen because they rapidly die, drift downstream, or are not selected by gear?
5. Differential residency time in LCR by juvenile HBC. Are there differences in survival due to these differences in residency time? Possible hint from microchemistry that larger HBC captured in the mainstem spent more time in LCR than smaller fish (currently working on this more).
6. Continue NSE sampling to (1) see if survival changes due to increases in RBT and/or temperatures, (2) how NSE tracked cohorts match ASMR reconstructions, (3) evaluate whether the 2009-2011 NSE sampling occurred during a completely anomalous period of low predators and warm temperatures.
7. NSE has demonstrated ability to capture-recapture large numbers of small fish. Need to transition to micro-PIT tags or gene tags to continue to track small fish as VIE color/body locations are limited.