

Mechanical Removal of Nonnative Fishes from the Colorado River within Grand Canyon

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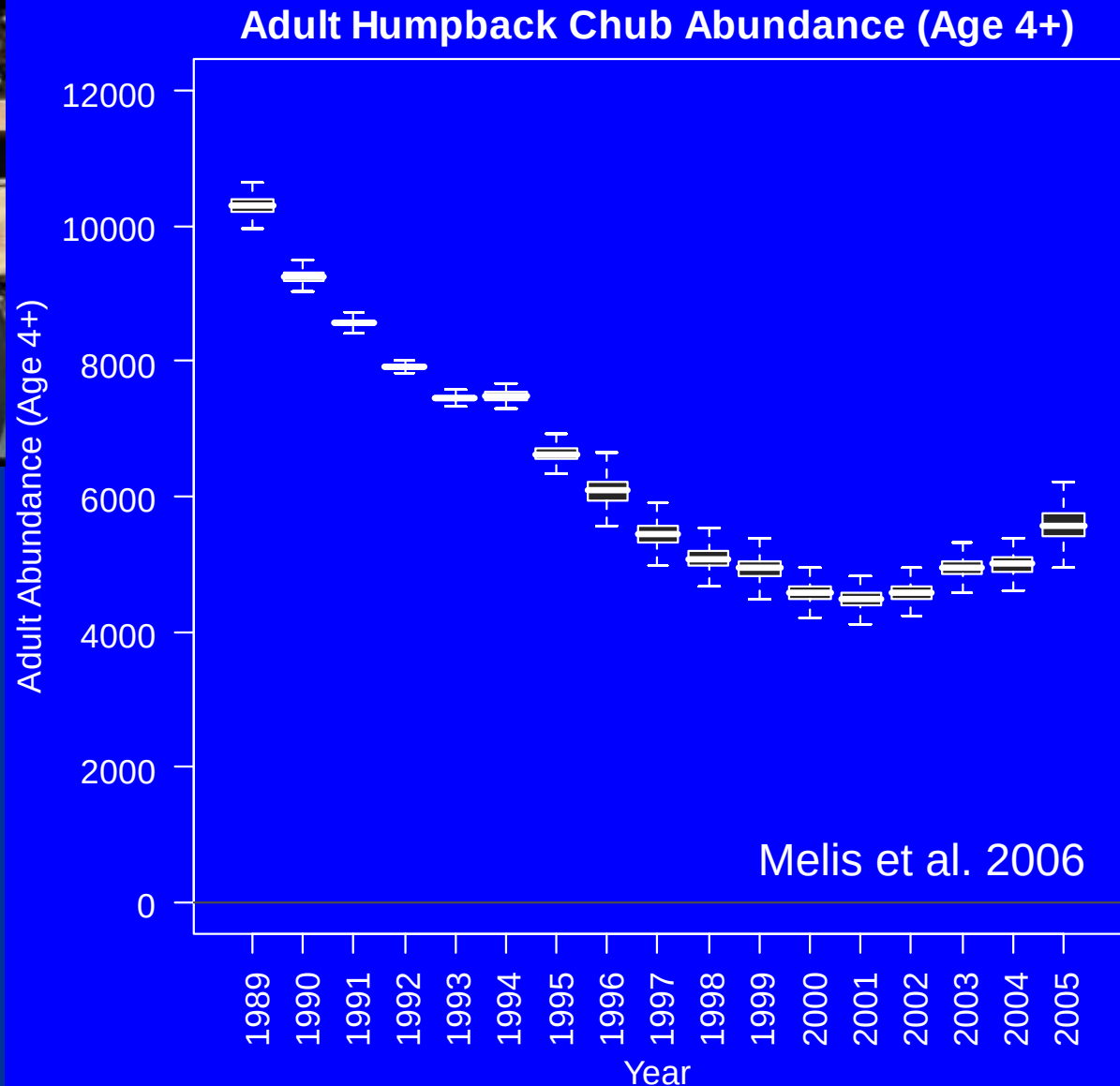
Preliminary Results: Subject to Peer Review and Revision



Background and Motivation



■ In 2002, concern for the downward trend in humpback chub abundance prompted experimental adaptive management actions including removal of non-native fish



Background and Motivation

- Jan 2002, AMWG directed GCMRC to develop a plan of experimental flows:
 - *“In concert with RPA flows for native fish during 2002-2003 request that the GCMRC, in consultation with the TWG, design an experimental flows sequence that tests hypotheses for conservation of sediment. Report to AMWG in April 2002 on the proposed flow sequence.”*
- Chief of GCMRC directs staff to design an experiment to address questions related to providing better management of Sediment **AND** Native Fish.
- What are the factors potentially influencing native fish population dynamics?
 - Dam Operations
 - Water temperature
 - Parasites
 - Non-native Fish (LCR and Mainstem)
 - Backwaters

Background and Motivation

- What are the factors **likely** influencing native fish population dynamics ***that we have the ability to test*** ?
 - Dam Operations
 - Water temperature
 - Non-native Fish (Mainstem)

Background and Motivation

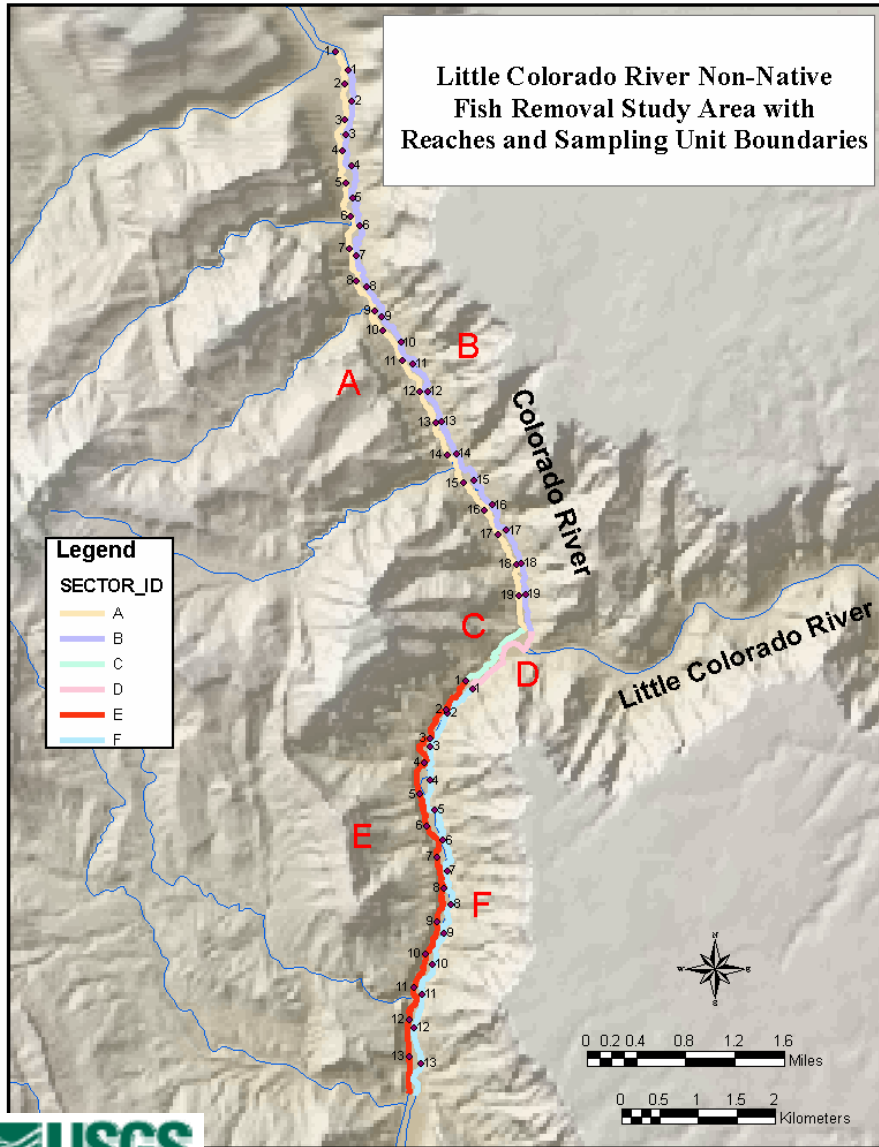
- February 2002, GCMRC proposes a 16 year study to address questions related to providing better management of Sediment **AND** Native Fish.

Year	Mechanical Removal	Fluctuating Flows	Temperature Control Device
1	XXX	XXX	
2	XXX	XXX	
3	XXX		
4	XXX		
5		XXX	
6		XXX	
7			
8			
9	XXX	XXX	XXX???
10	XXX	XXX	XXX???
11	XXX		XXX???
12	XXX		XXX???
13		XXX	XXX???
14		XXX	XXX???
15			XXX???
16			XXX???

Objectives

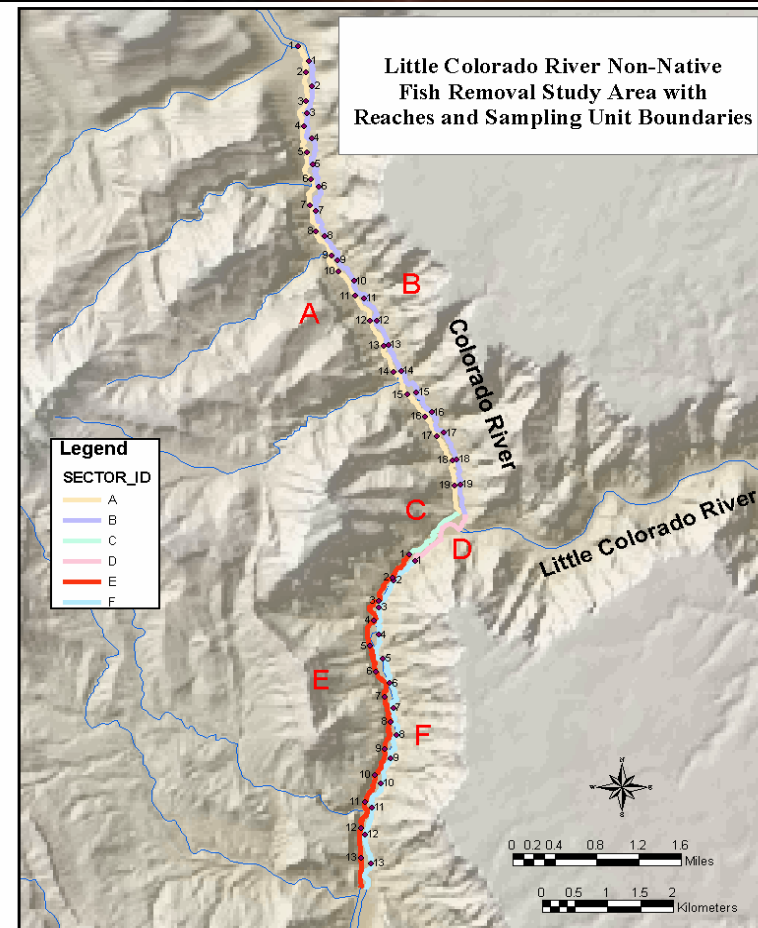
- Evaluate Efficacy of Removing Nonnative Fish
 - To what extent can we remove non-native fishes from a large reach (17 km) of the Colorado River?
- Evaluate Effect of Nonnative Fish Removal on the Population Dynamics of Native Fishes
 - Will humpback chub recruitment increase as a result of non-native removal?

Methods-Study Site



Methods - Removal

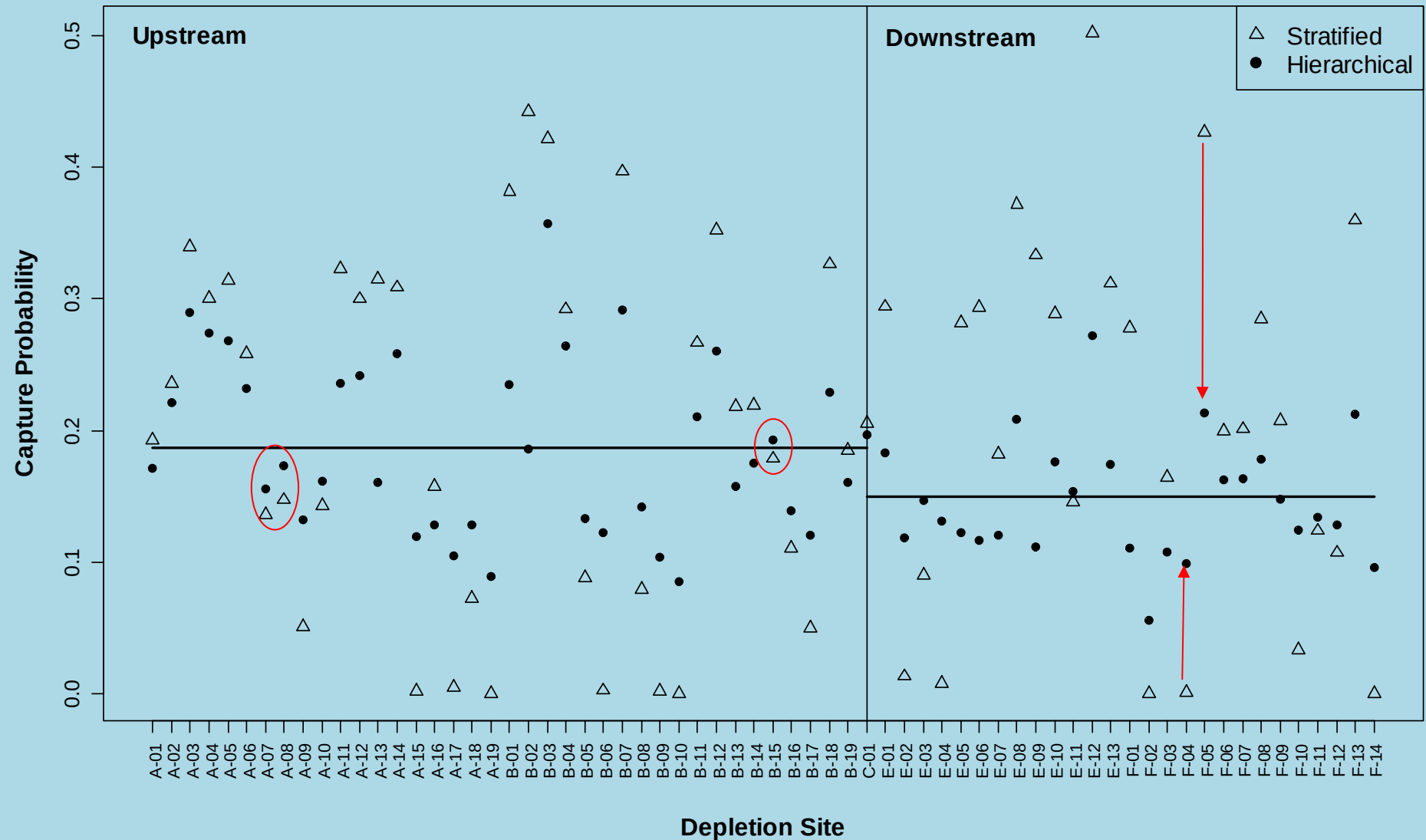
- 2003 to 2006 - 6 trips/year
 - Jan, Feb, Mar (Winter)
 - Jul, Aug, Sep (Summer)
- Electrofishing
 - 4-5 depletion passes within each 500m site
 - Euthanized all non-native fish
 - Live release of all native fish, pit tagged if $TL > 150\text{mm}$



Methods – Removal Data Analysis

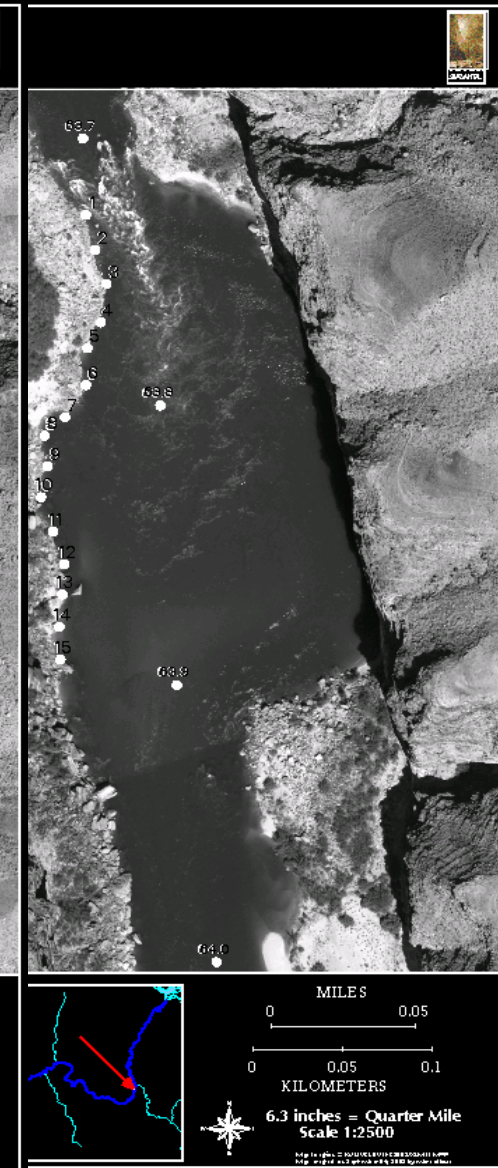
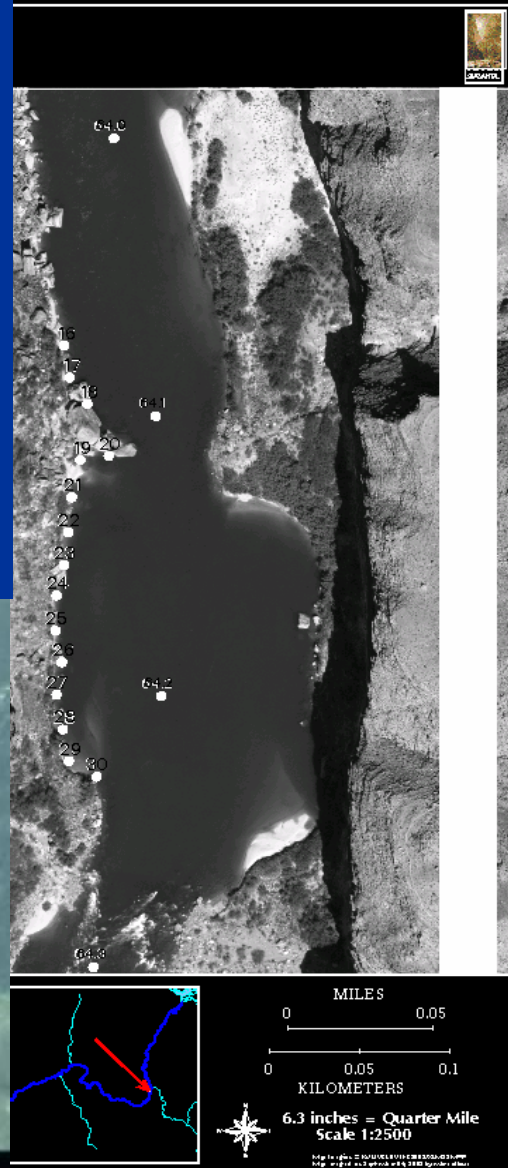
- Constructed abundance estimates for rainbow trout using a Hierarchical Bayes Removal Model (Dorazio et al. 2005).
 - Assumed that **site-specific capture probability** is drawn from a common Beta distribution.
 - Prior on capture probability.
 - Assumed that **site-specific abundance** is drawn from a common Poisson distribution.
 - Prior on abundance.
- Model based aggregation of between site data.
 - Allows sites with high measurement error to be informed or “shrunk” towards the common mean.

Methods – Hierarchical Shrinkage



Methods - Hoopnetting

- Hoopnet sampling
 - 30 sites-3 sets/trip
 - Primarily used as a measure of juvenile humpback chub relative abundance

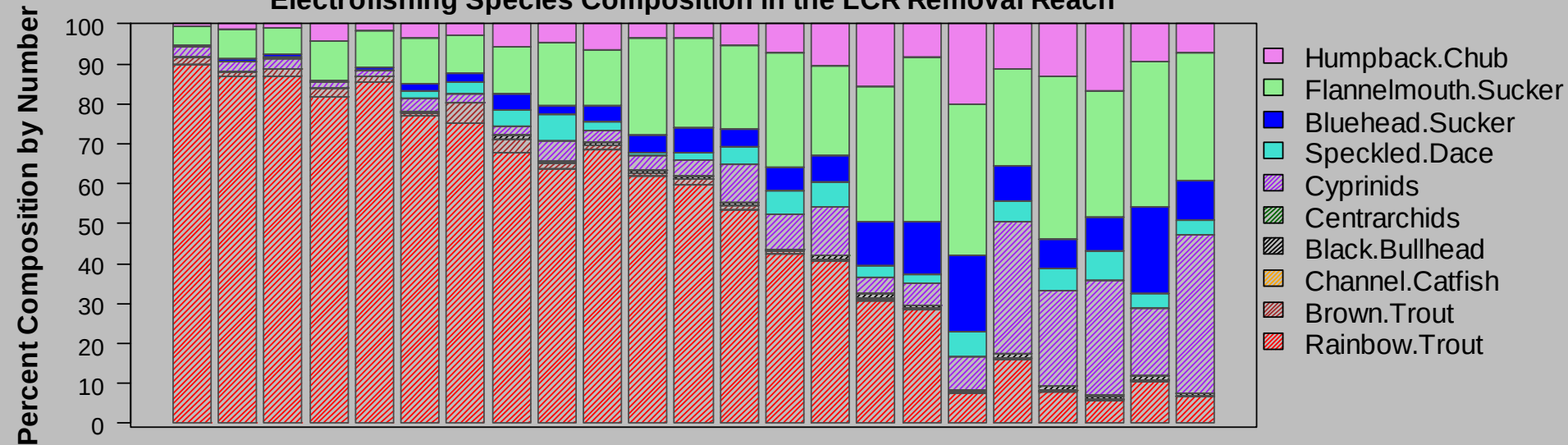


Results: Efficacy of Removal Efforts for Non-native Fish

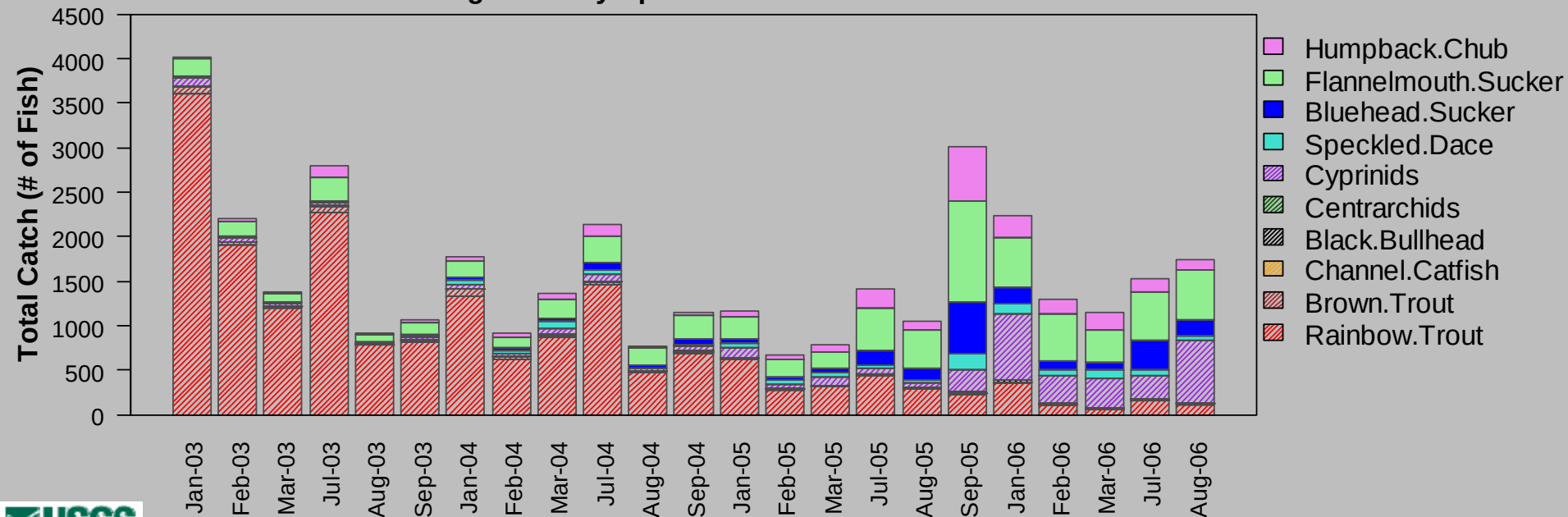


Results - Catch by Number

Electrofishing Species Composition in the LCR Removal Reach

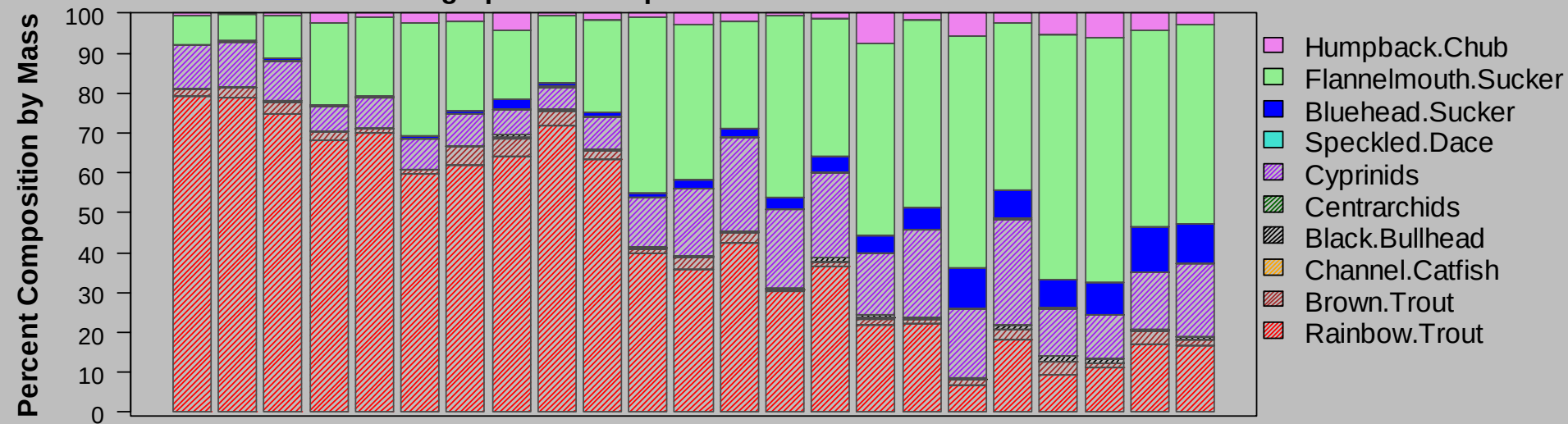


Electrofishing Catch by Species in the LCR Removal Reach

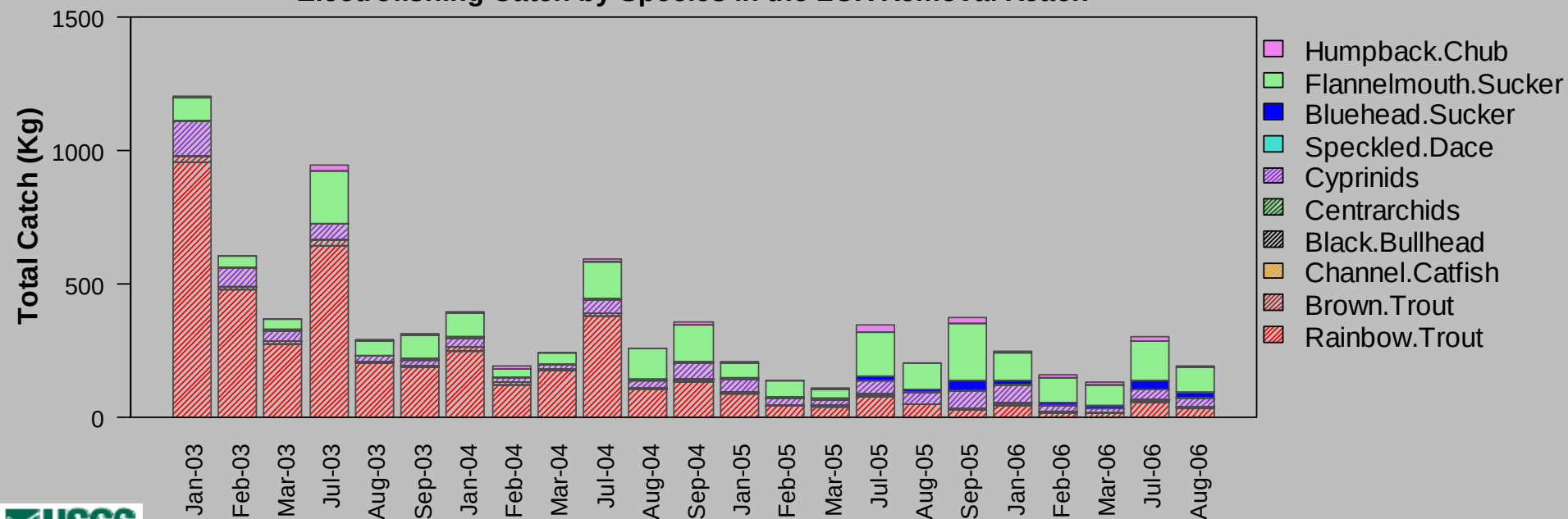


Results - Catch by Mass

Electrofishing Species Composition in the LCR Removal Reach

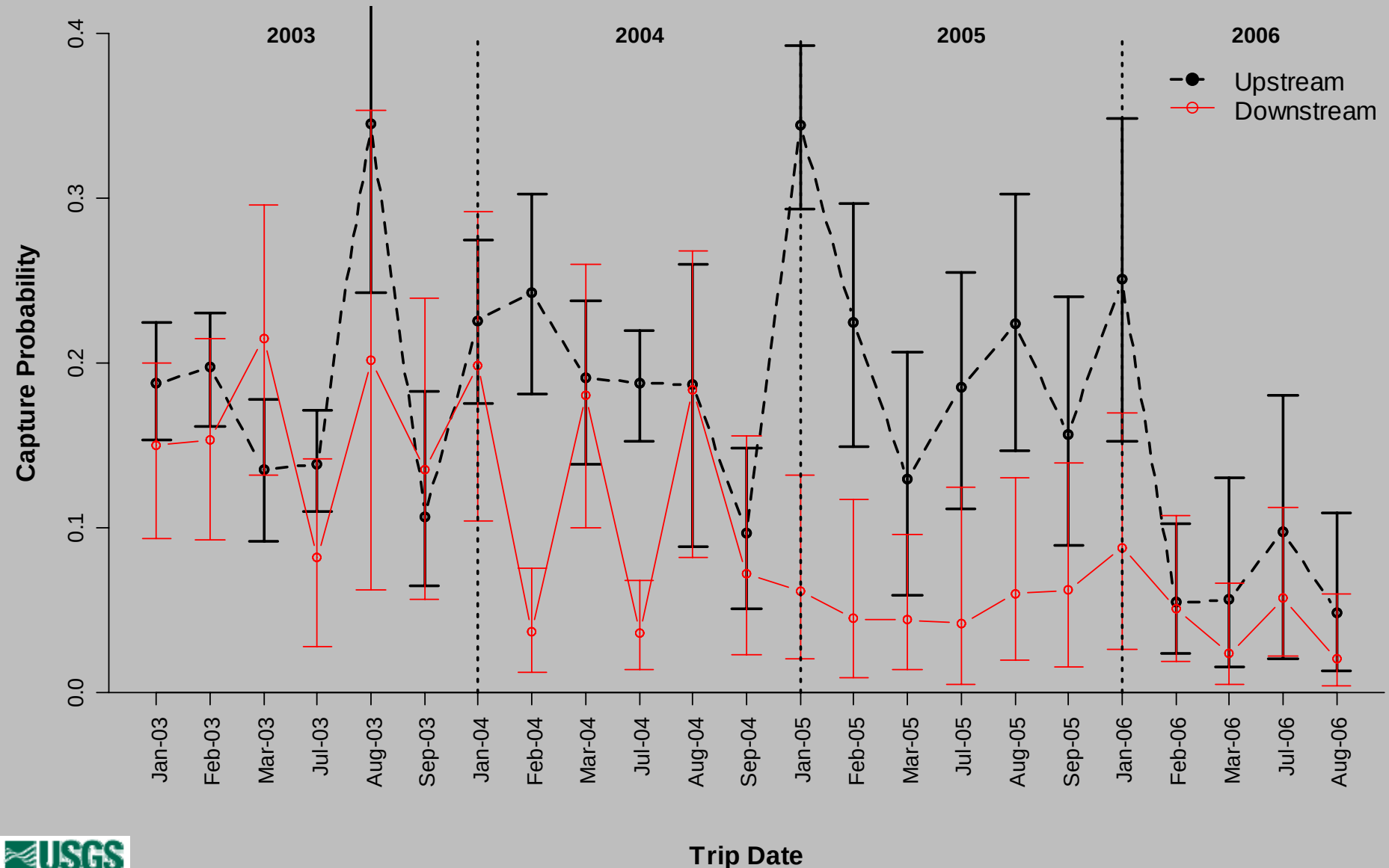


Electrofishing Catch by Species in the LCR Removal Reach



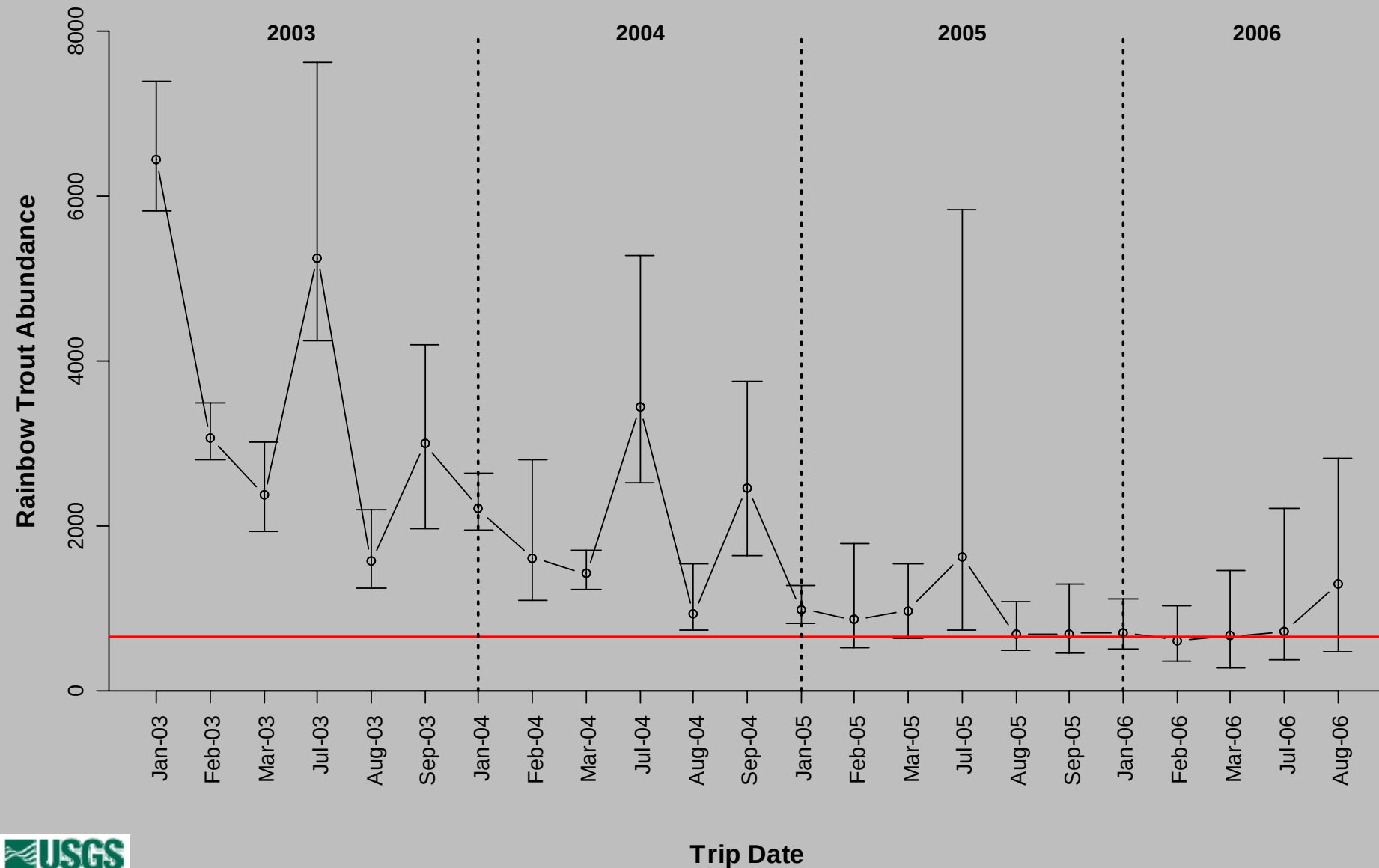
Results - Rainbow Trout Capture Probability

Rainbow Trout Capture Probability in the Little Colorado River Removal Reach (95% Credible Intervals)



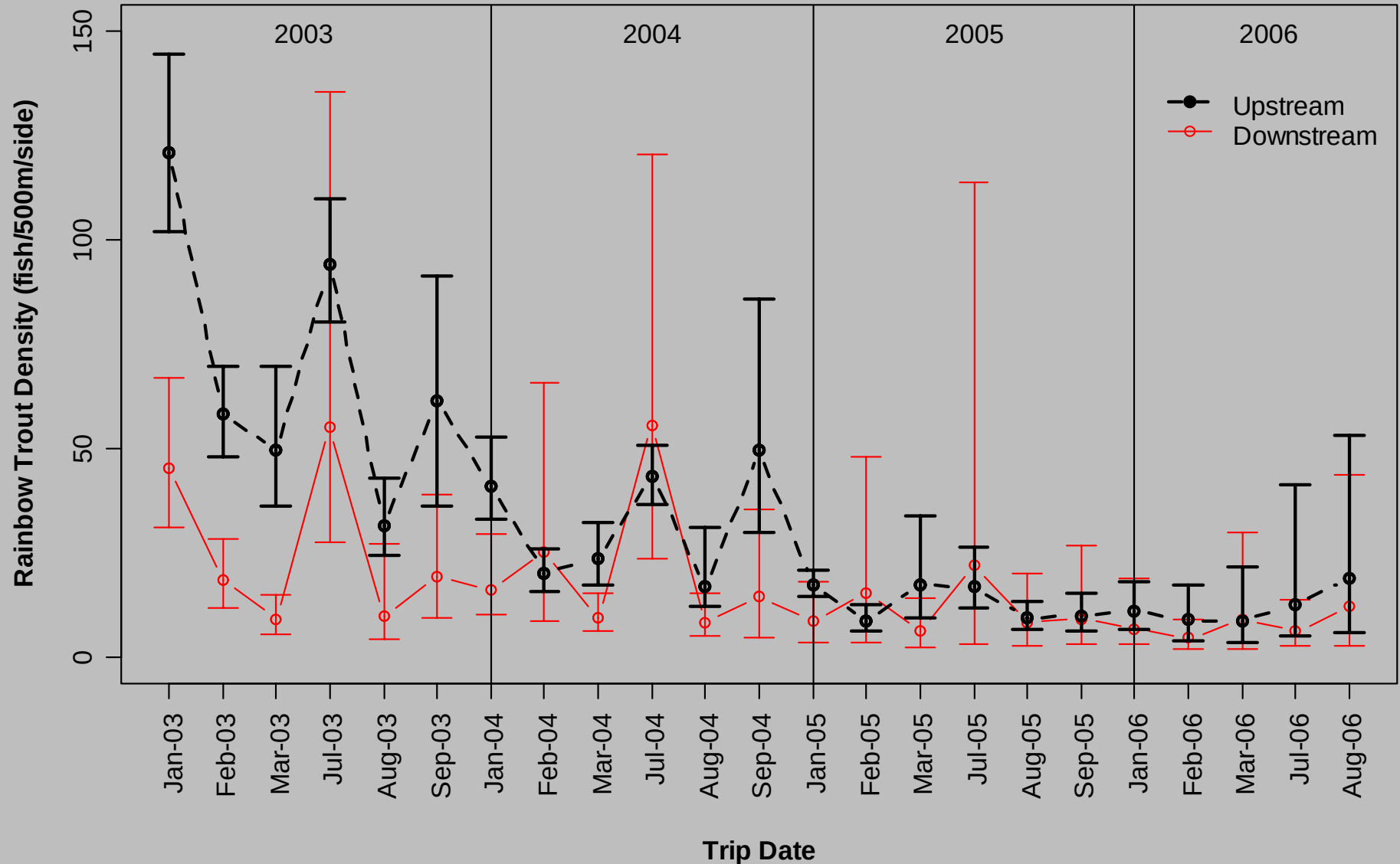
Results - Rainbow Trout Abundance

Rainbow Trout Abundance in the Little Colorado River Removal Reach (95% Credible Intervals)



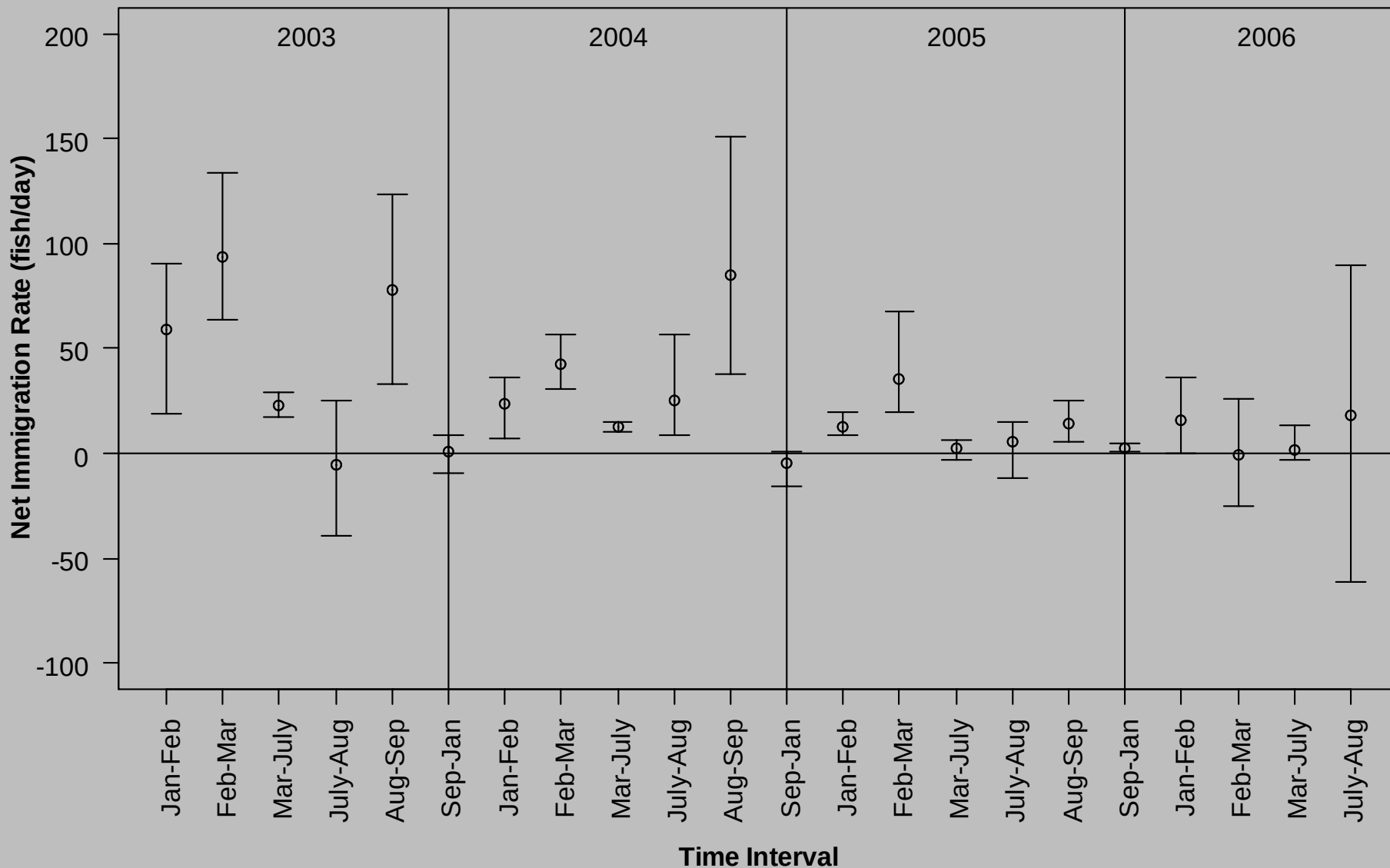
Results- RBT Density

Rainbow Trout Density in the Little Colorado River Removal Reach



Results- Immigration Rate

Net Immigration Rate to the Upstream Portion of the LCR Reach

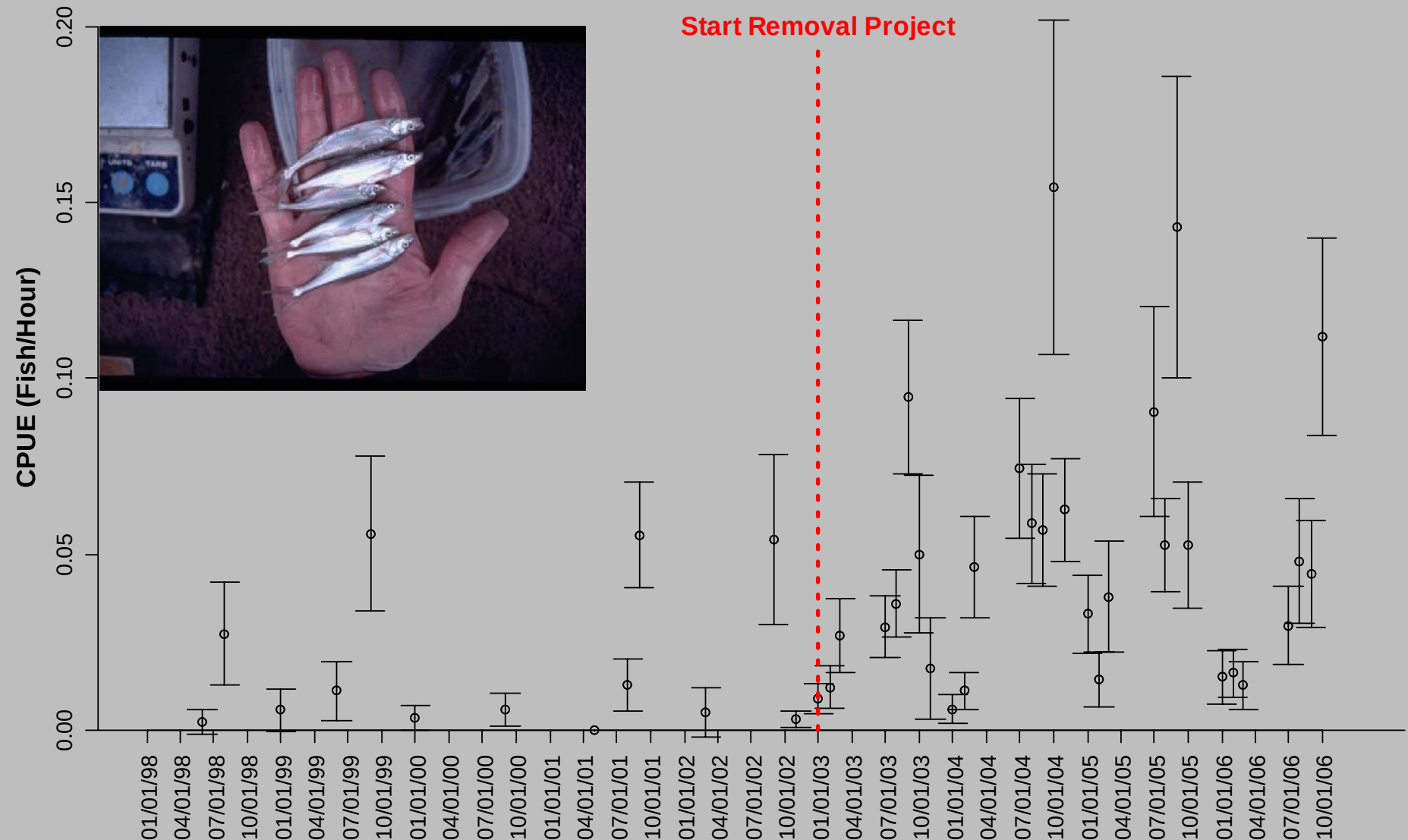


Results: Indicators of Possible Native Fish Population Response



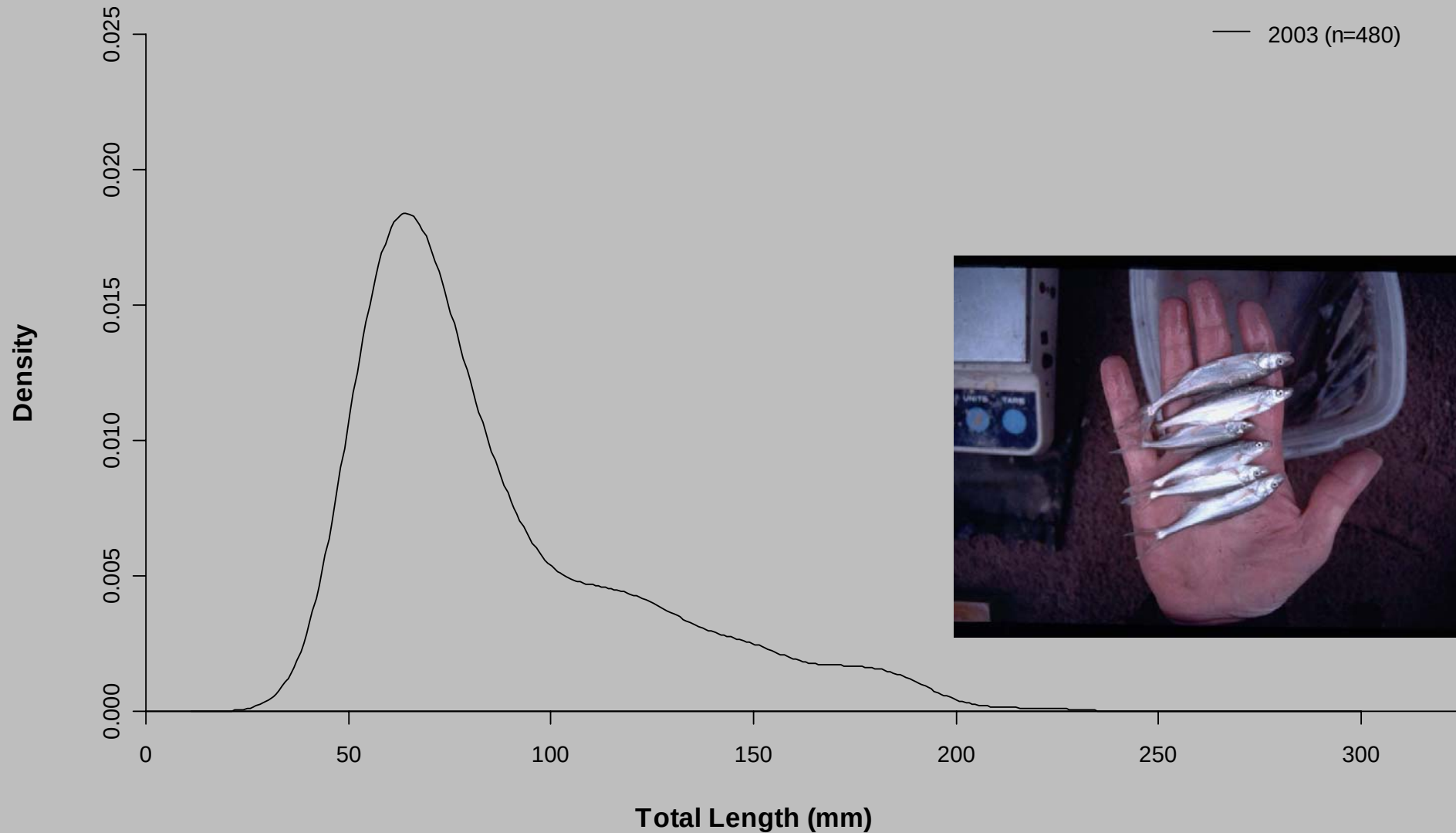
Results - Humpback Chub Relative Abundance

Hoop Net Catch Rate of Humpback Chub Below the LCR Confluence (95% Confidence Intervals)



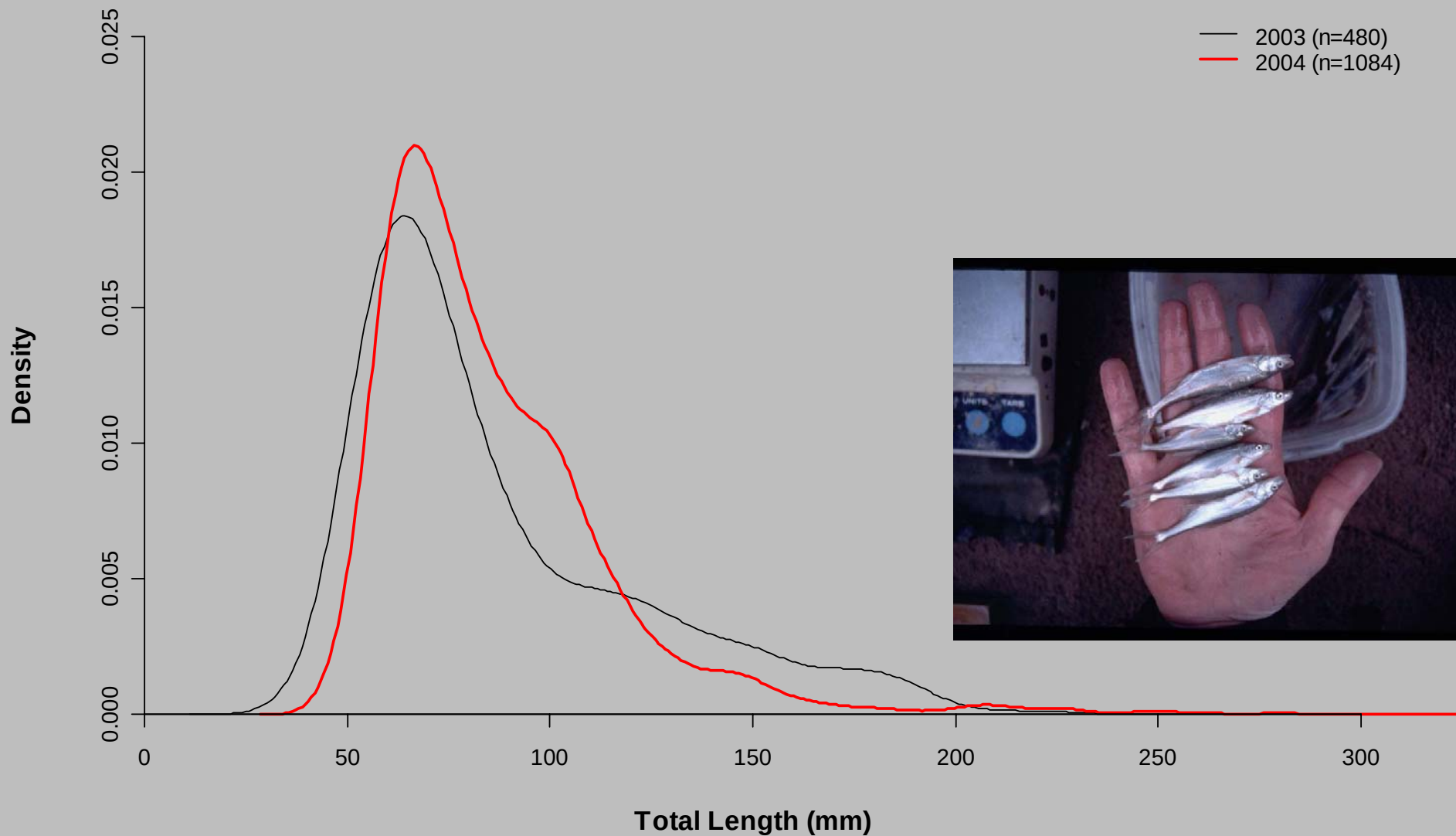
Results - Humpback Chub Length Distribution

Length Distribution of Hoopnet Caught Humpback Chub



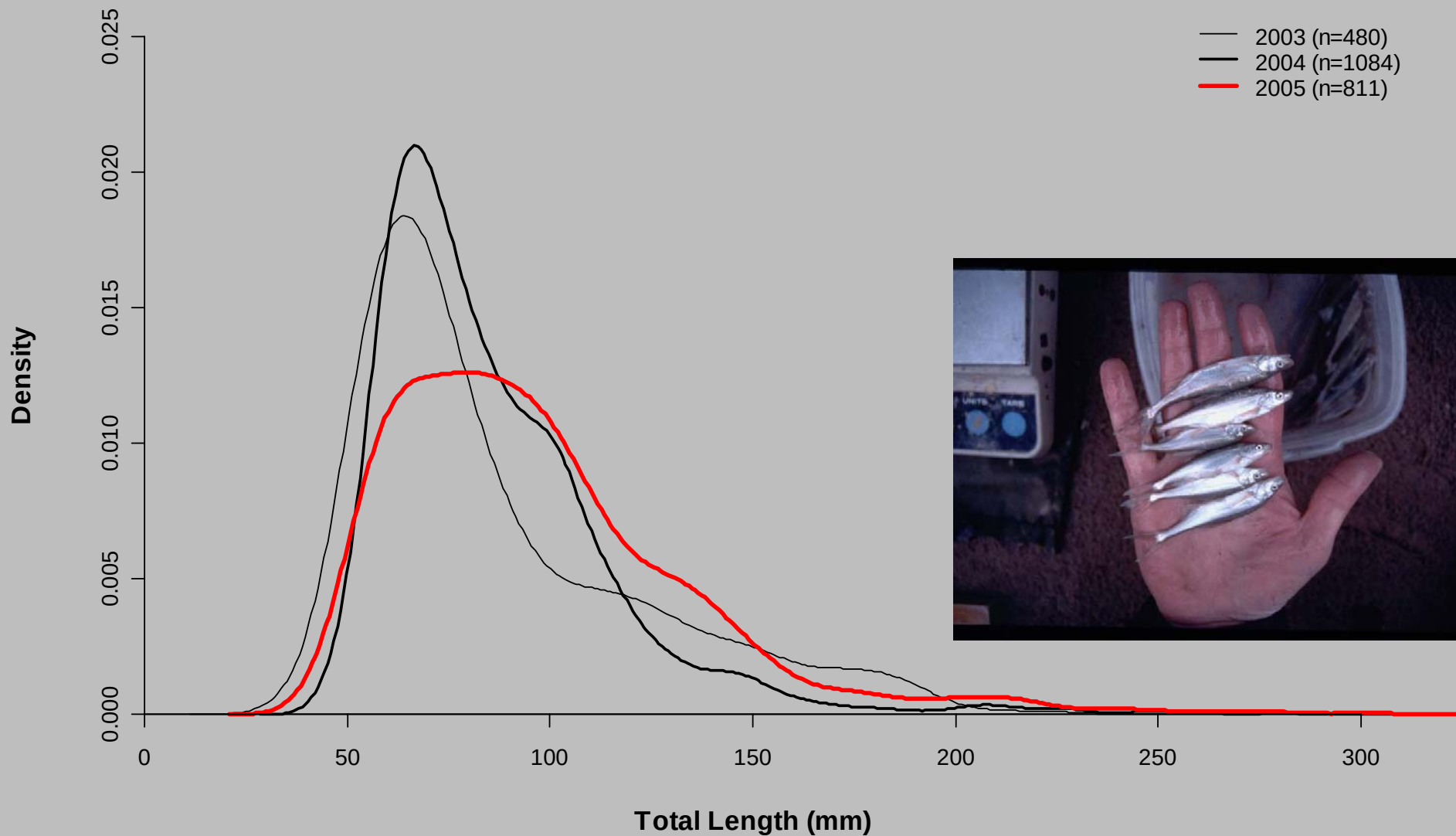
Results - Humpback Chub Length Distribution

Length Distribution of Hoopnet Caught Humpback Chub



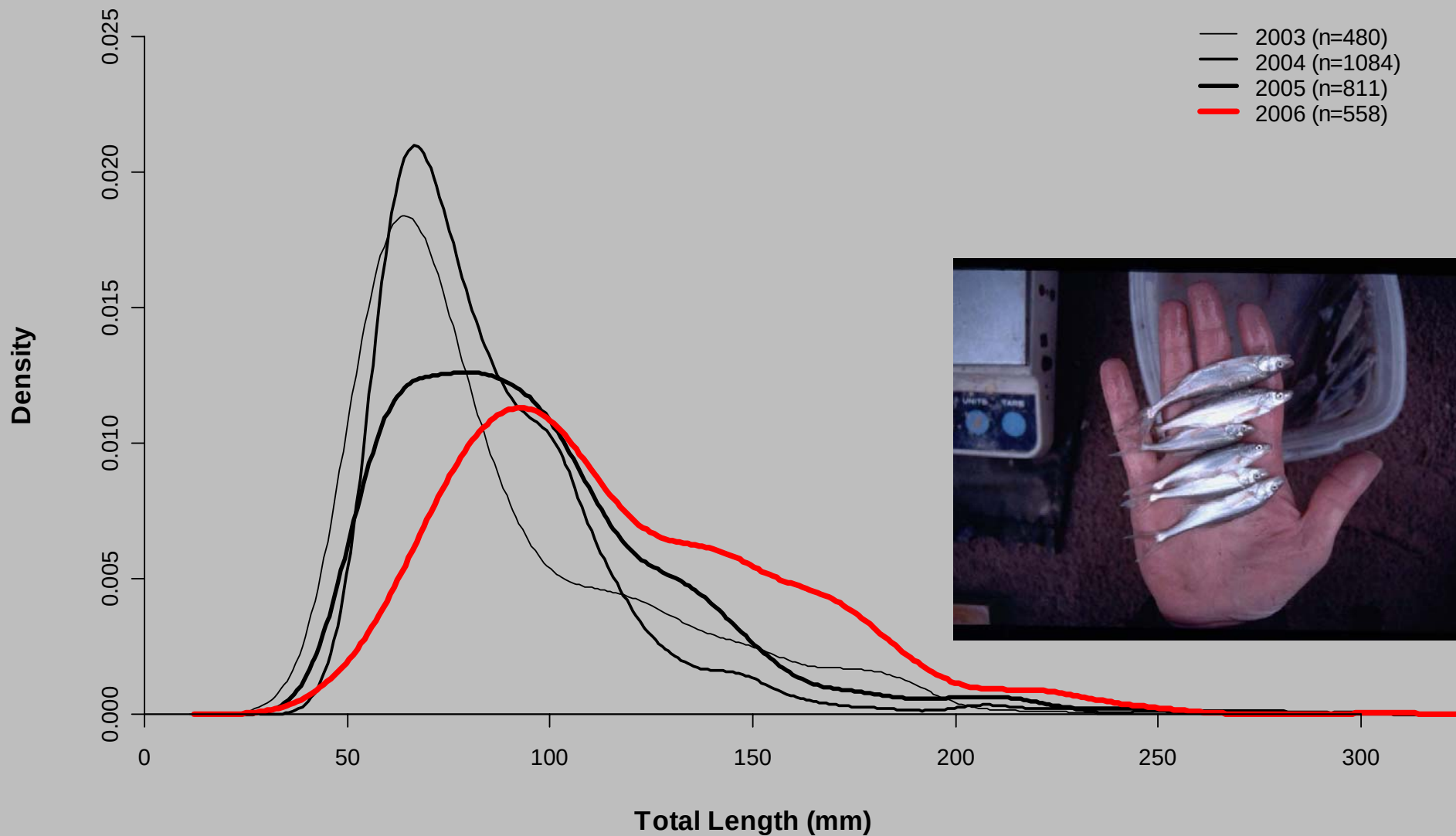
Results - Humpback Chub Length Distribution

Length Distribution of Hoopnet Caught Humpback Chub



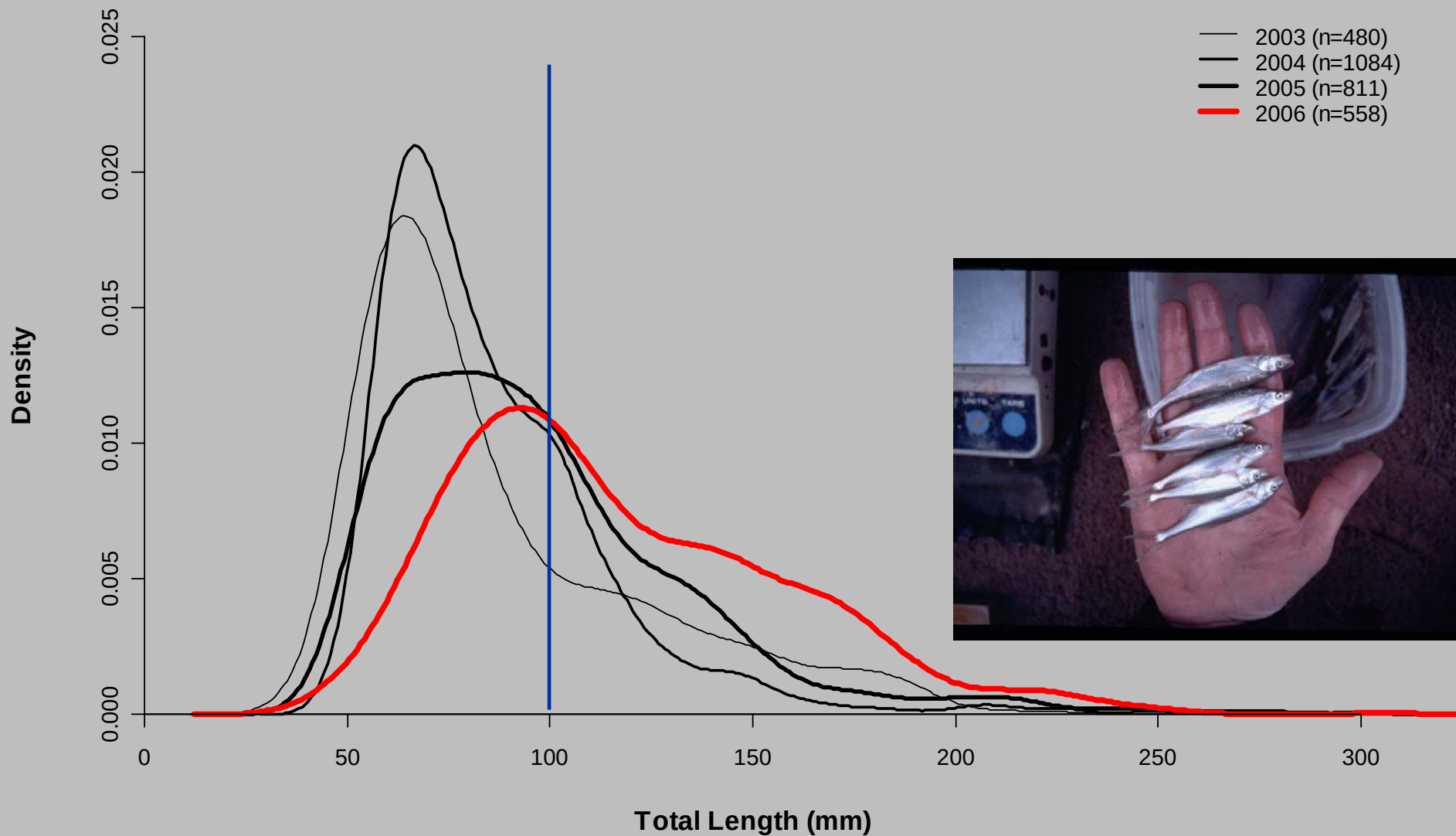
Results - Humpback Chub Length Distribution

Length Distribution of Hoopnet Caught Humpback Chub



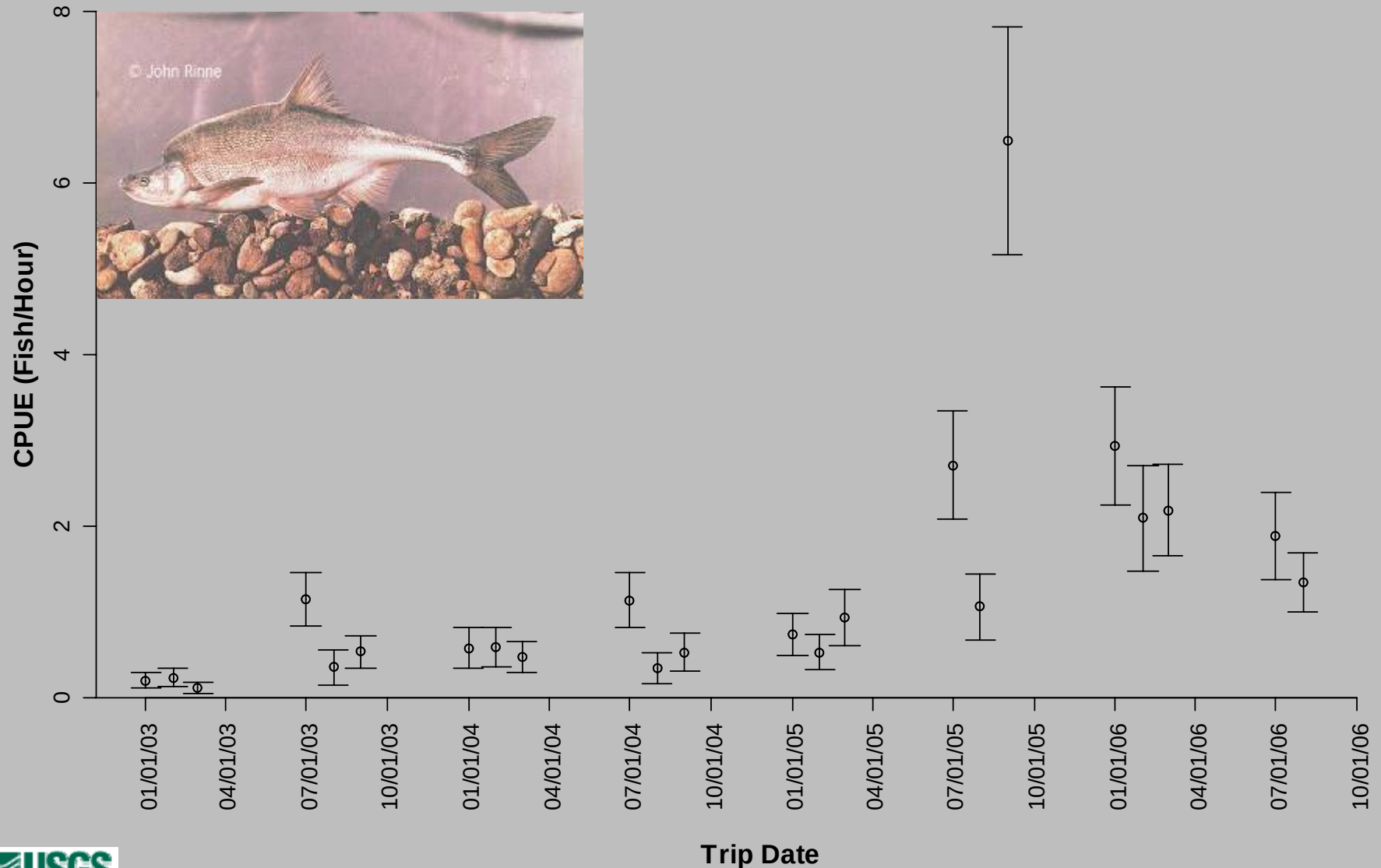
Results - Humpback Chub Length Distribution

Length Distribution of Hoopnet Caught Humpback Chub



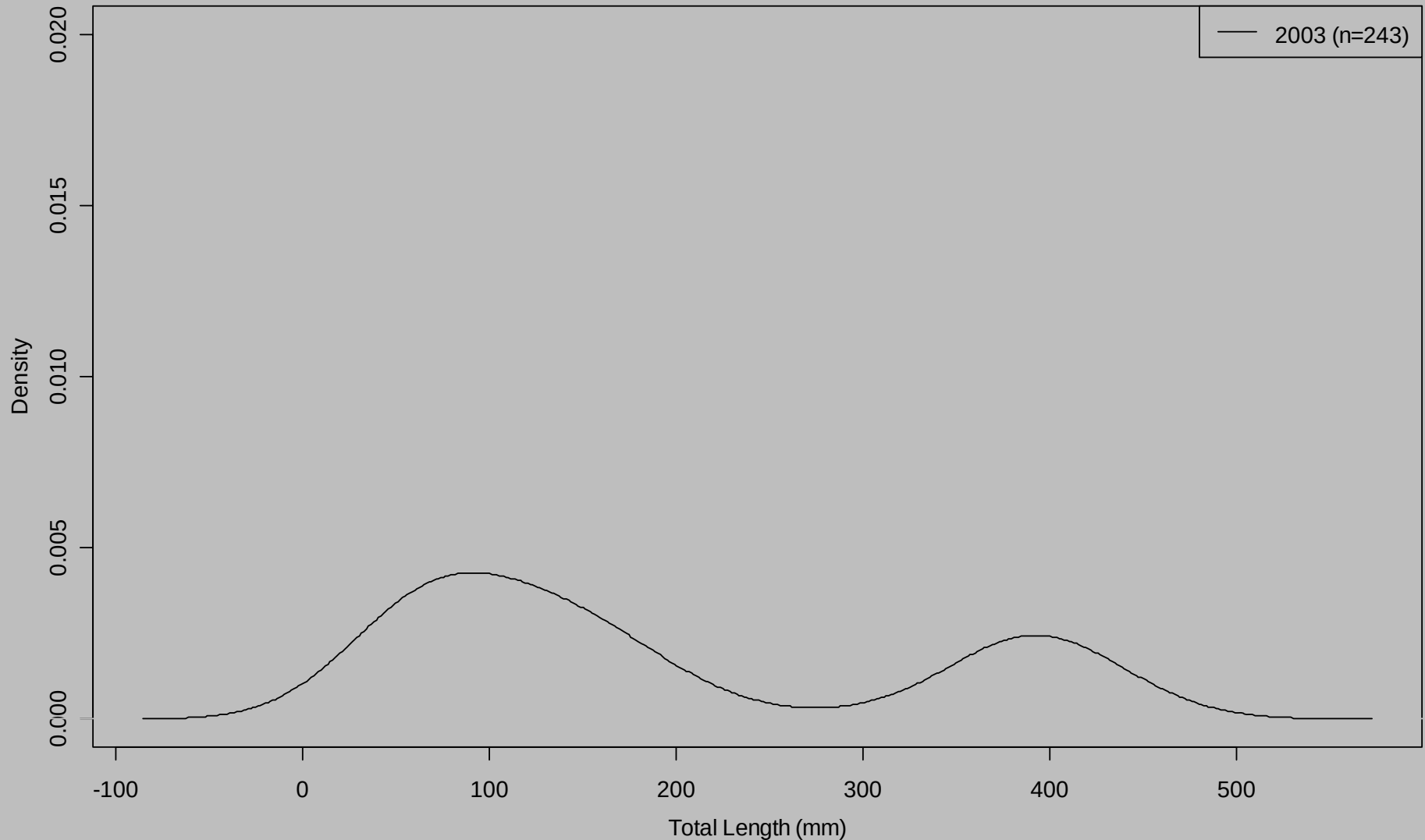
Results - Humpback Chub Relative Abundance

Electrofishing Catch Rate of Humpback Chub in the LCR Removal Reach (95% Confidence Intervals)



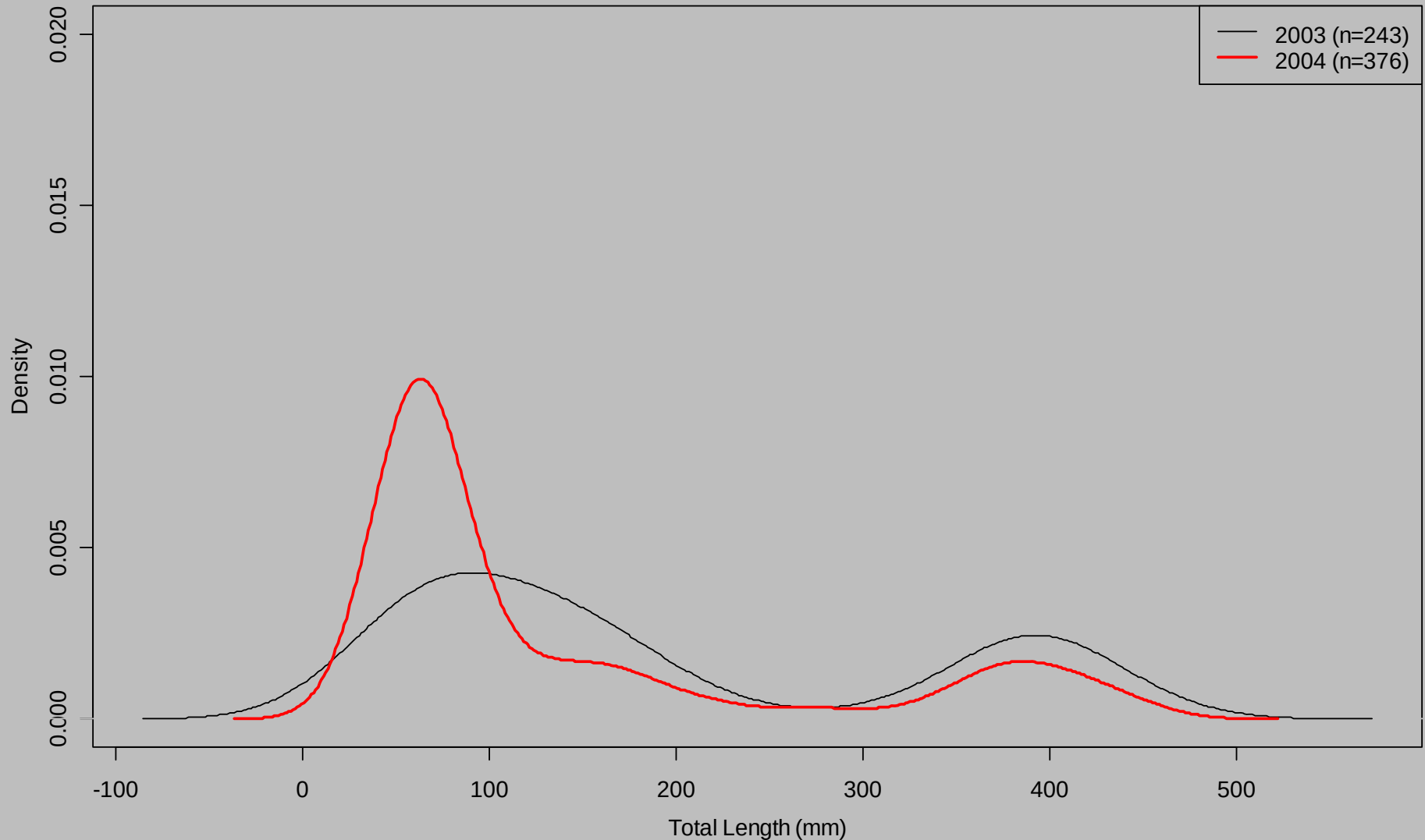
Results – HBC Length Distribution

Length Distribution of LCR Removal Reach Humpback Chub



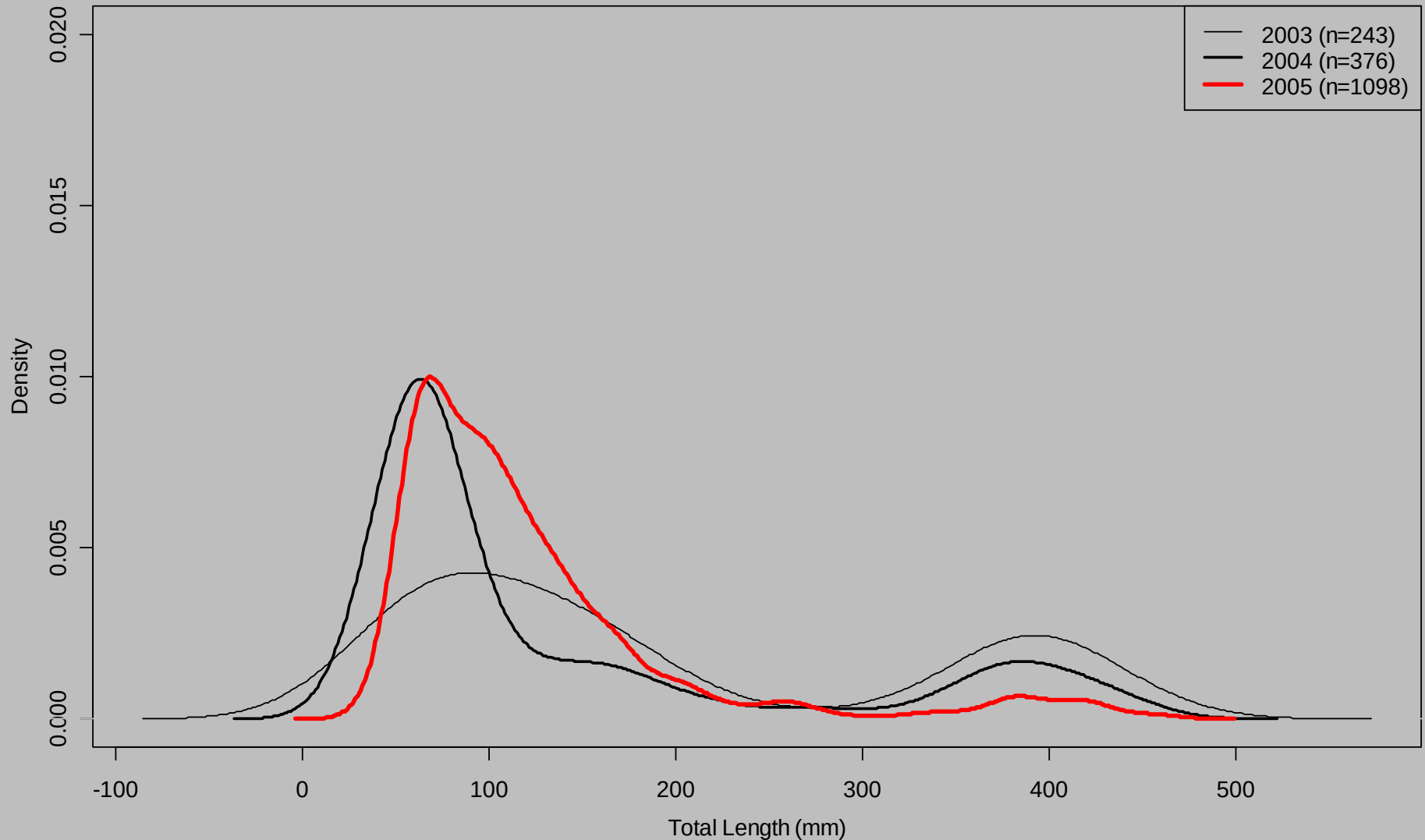
Results – HBC Length Distribution

Length Distribution of LCR Removal Reach Humpback Chub



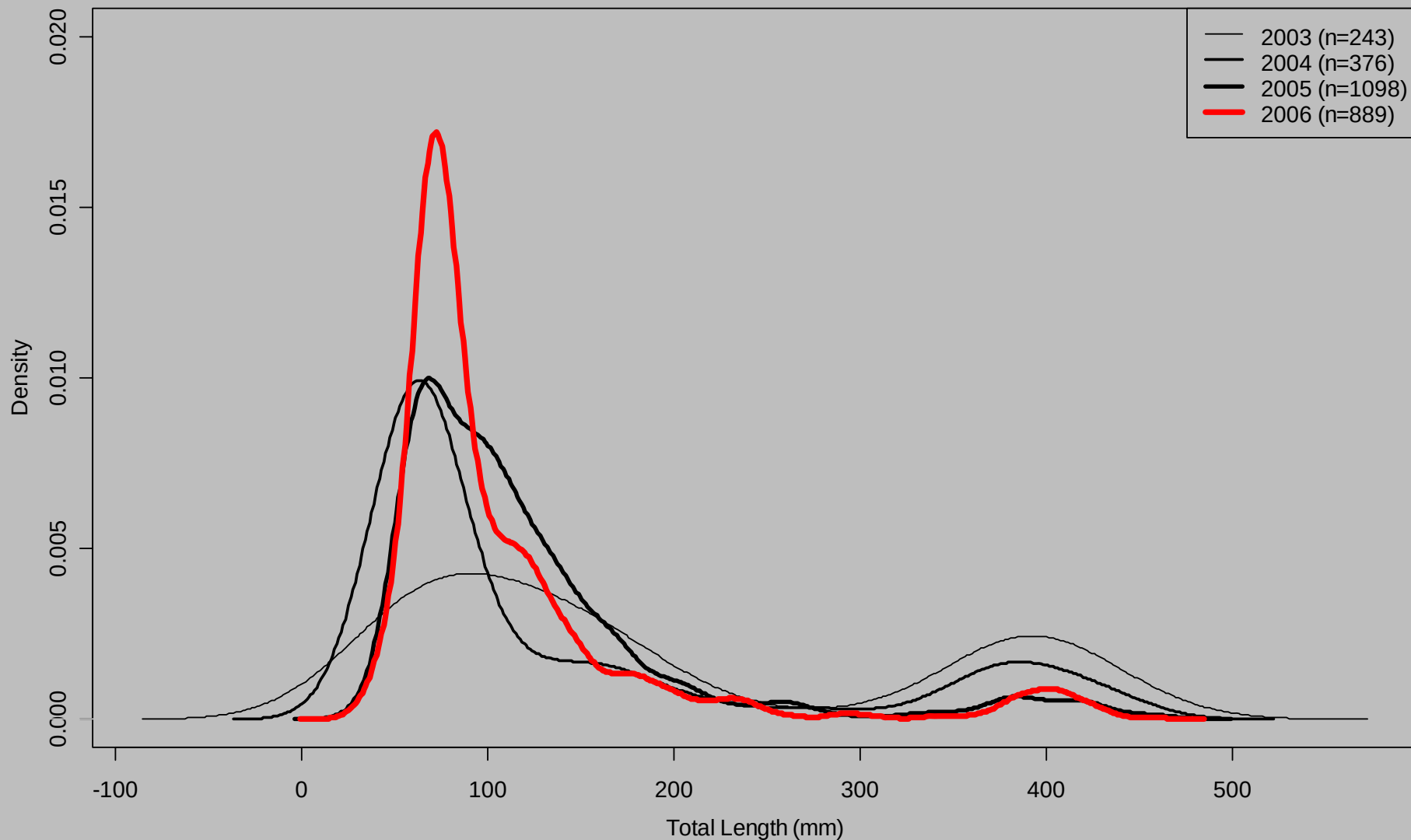
Results – HBC Length Distribution

Length Distribution of LCR Removal Reach Humpback Chub



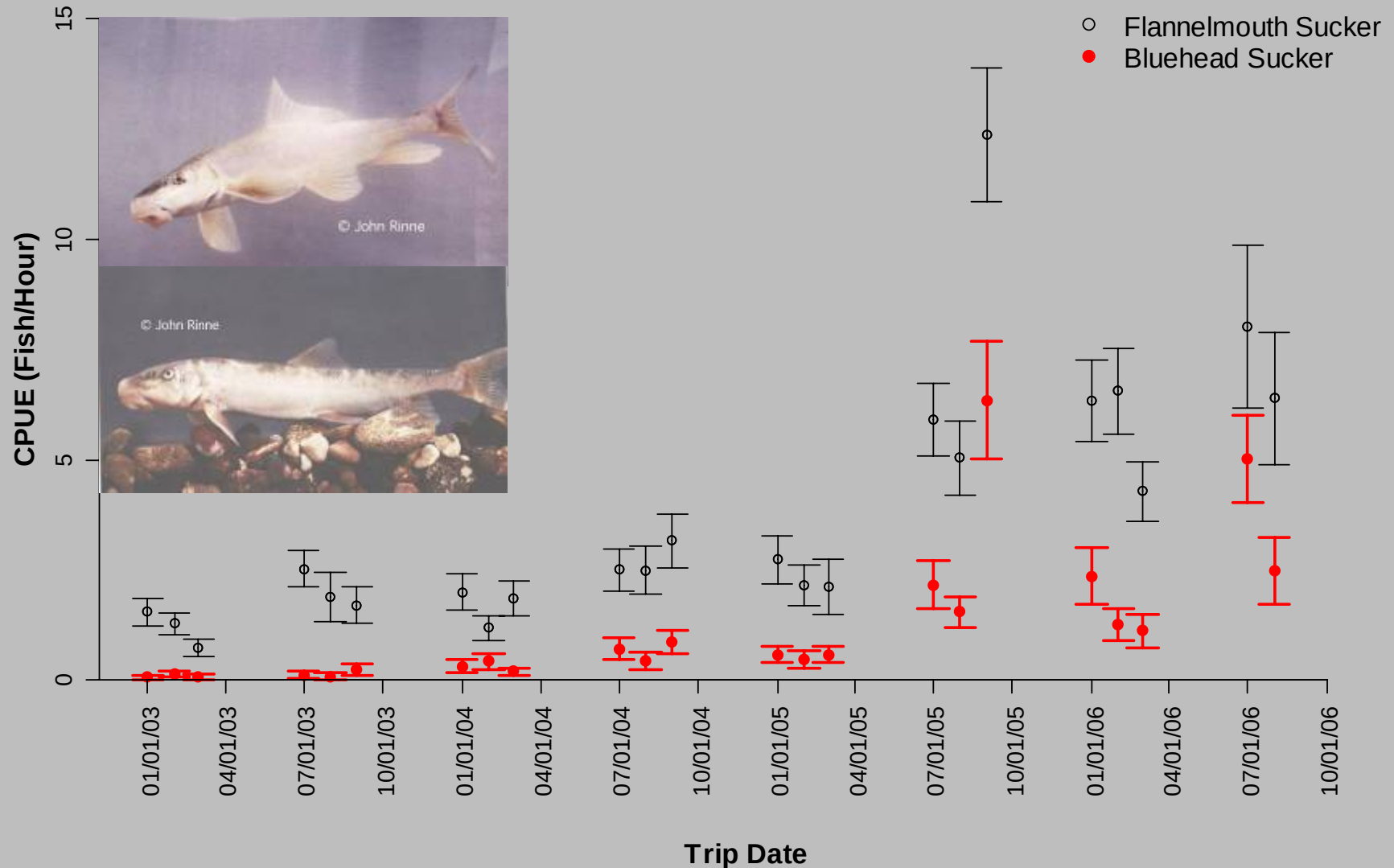
Results – HBC Length Distribution

Length Distribution of LCR Removal Reach Humpback Chub



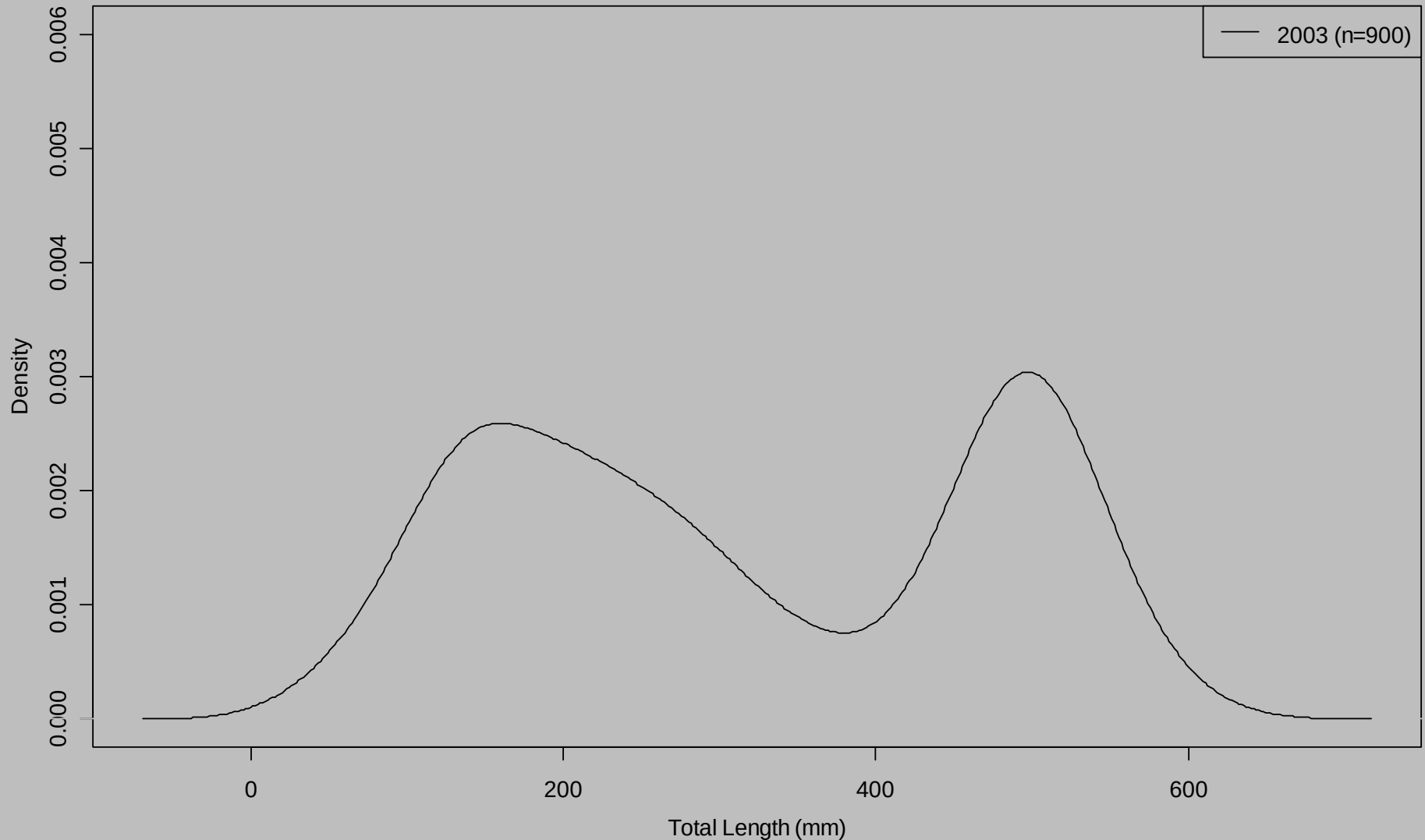
Results - Sucker Relative Abundance

Electrofishing Catch Rate of Flannemouth and Bluehead Sucker (95% Confidence Intervals)



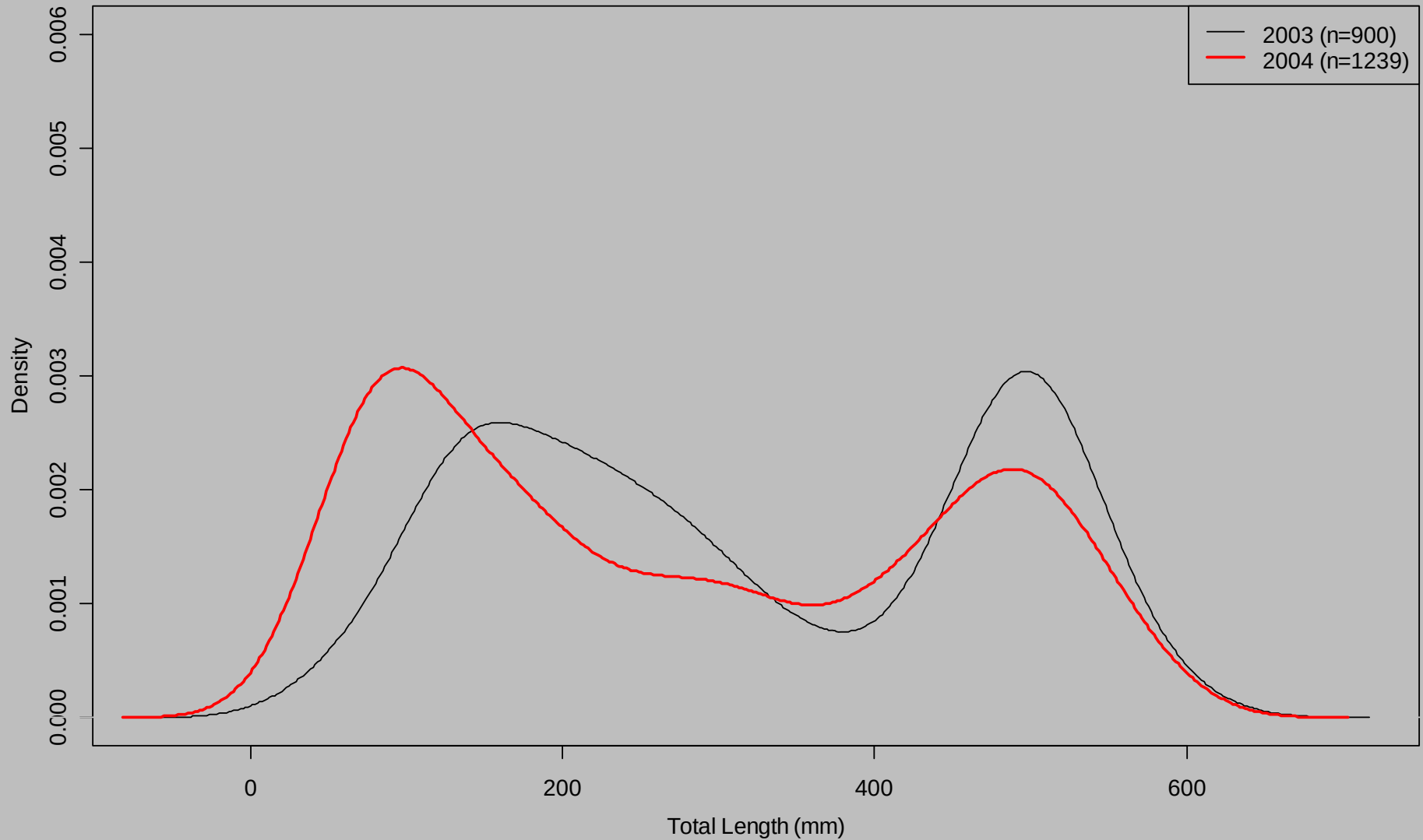
Results – FMS Length Distribution

Length Distribution of LCR Removal Reach Flannelmouth Sucker



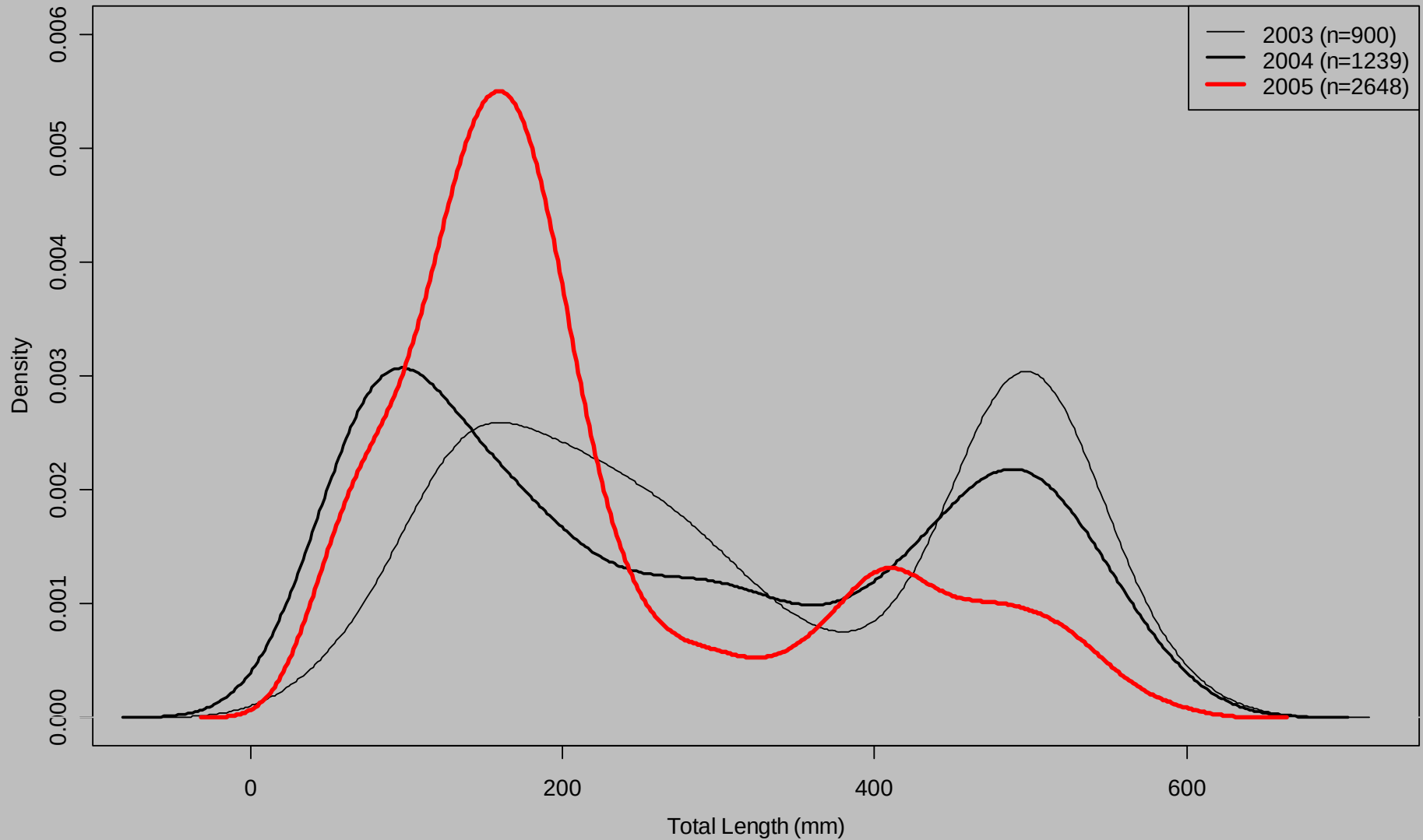
Results – FMS Length Distribution

Length Distribution of LCR Removal Reach Flannelmouth Sucker



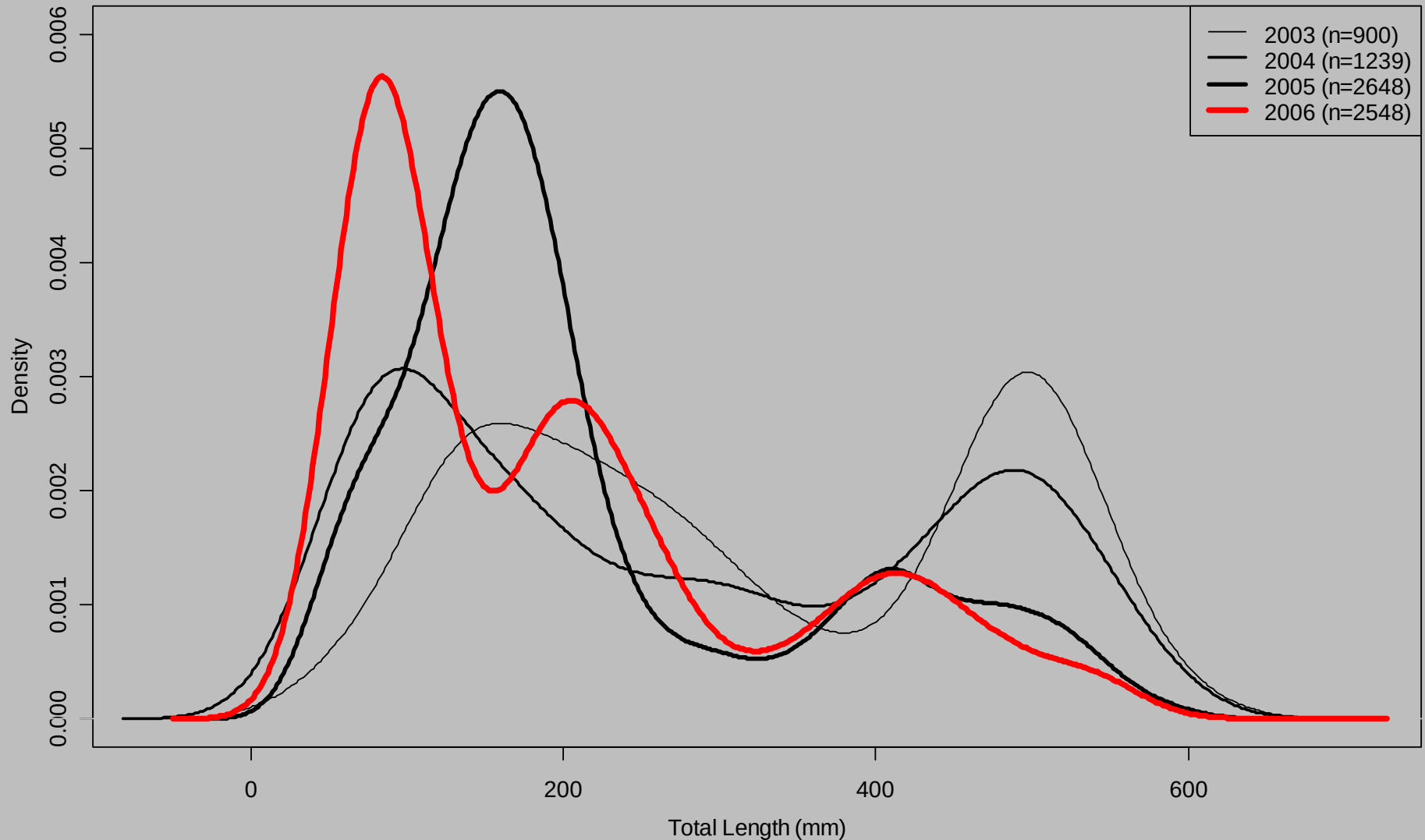
Results – FMS Length Distribution

Length Distribution of LCR Removal Reach Flannelmouth Sucker



Results – FMS Length Distribution

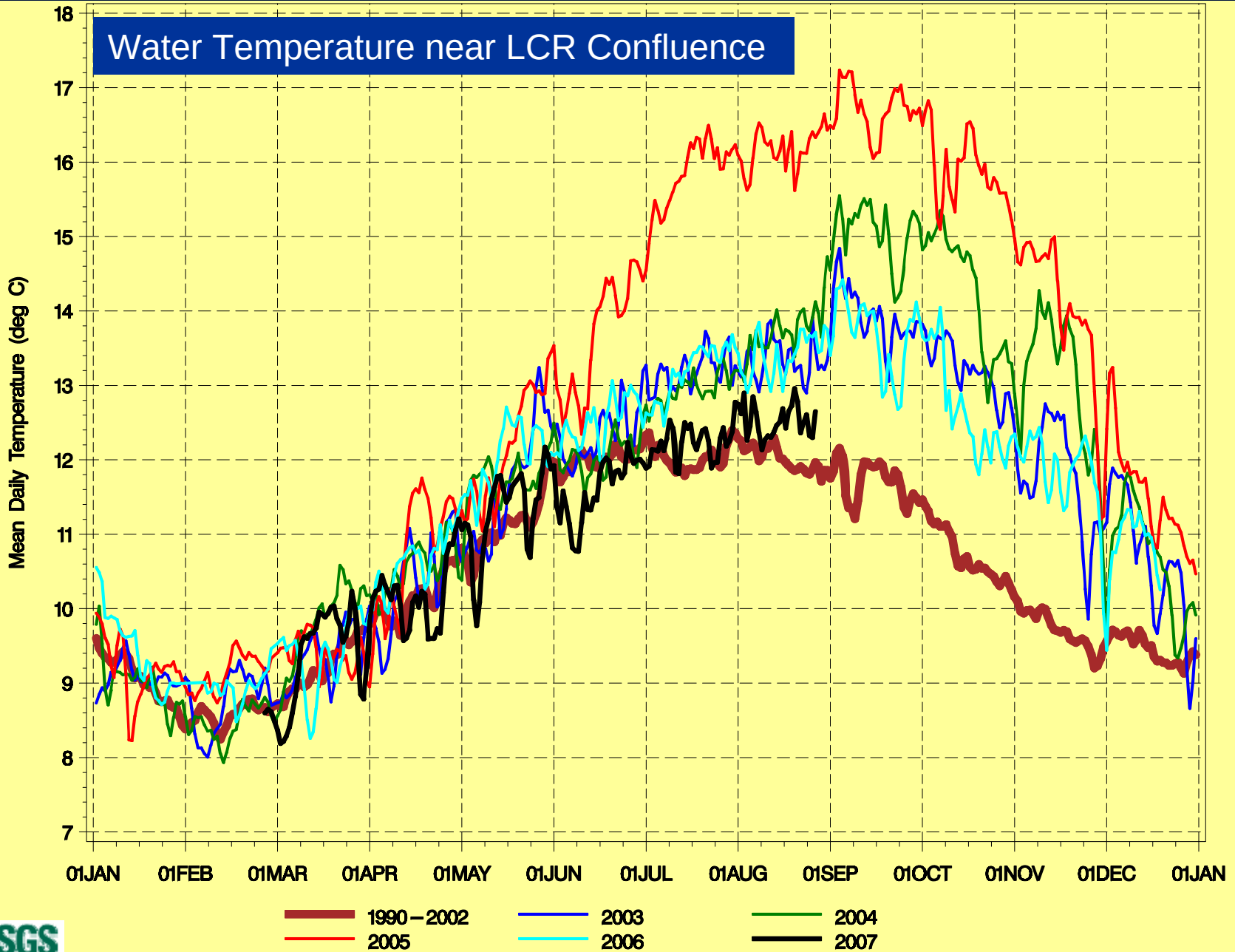
Length Distribution of LCR Removal Reach Flannelmouth Sucker



One Big Confounding Factor!

- Water temperature
 - Cold water temperature following installation of Glen Canyon Dam is known to inhibit vital rates for native fishes.
 - Growth (Clarkson and Childs 2000, Robinson and Childs 2001)
 - Reproduction (Hamman 1982)
 - Swimming ability (Ward et al. 2002)
 - Predation Risk (Ward and Bonar 2003)

One Big Confounding Factor!



What Really Happened

Year	Mechanical Removal	Fluctuating Flows	Temperature Control Device
1 (2003)	XXX	XXX	"Naturally Elevated Temp"
2 (2004)	XXX	XXX	"More Naturally Elevated Temp"
3 (2005)	XXX	XXX	"Even More Naturally Elevated Temp"
4 (2006)	XXX		"Naturally Elevated Temp"
5 (2007)	(Non-natives in low abundance)		"Reduced Temperature??"
6	?????????	?????????	?????????
7	?????????	?????????	?????????
8	?????????	?????????	?????????
9	?????????	?????????	?????????
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11	?????????	?????????	?????????
12	?????????	?????????	?????????
13	?????????	?????????	?????????
14	?????????	?????????	?????????
15	?????????	?????????	?????????
16	?????????	?????????	?????????

Conclusions

■ Non-native Removal Efficacy

- Mechanical Removal appears to be an effective way to control salmonids in the mainstem Colorado River.
 - Rainbow trout abundance reduced to near target level (<10% original abundance) in 2005 and 2006.
 - Catch composition (by mass) of non-native fish reduced from >90% to <40%
 - Capture Probability ~10-20% / pass
 - Low apparent immigration rate in 2005-2006.

■ Native Fish Trends

- Relative abundance assessments (catch-rate) no substitute for mark-recapture based stock assessments to determine recruitment trends.
 - Assessment of 2003 cohort will require 2007 and 2008 monitoring data.
- However, there have been large increases in juvenile humpback chub relative abundance. Additionally, flannelmouth and bluehead sucker displaying overall positive trends in relative abundance.
- Relative influence of non-native fish versus temperature still unknown.

Predictions

- Rainbow Trout trends
 - Very preliminary indications of rainbow trout recovery both in Glen and Marble Canyons.
- Water Temperature?
 - Seager, R., Ting, M., Held, I., Kushnir, Y., Lu, J., Vecchi, G., Huang, H.-P., Harnik, N., Leetmaa, A., Lau, N.-C., Li, C., Velez, J., and Naik, N. 2007.
Model projections of an imminent transition to a more arid climate in southwestern North America.
Science 316: 1181-1184.
- Other nonnative species
 - Smallmouth Bass, Crayfish, Others?