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</tr>
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GCMRC Logistics and Permitting Program 2010

Safety
Cost effectiveness
Efficiency

What We Do
Rain (snow) or shine the show must go on......

- Planning
- Permitting
- Scheduling
- 21 River Trips in 2010
- Lees Ferry Trout Research
- Diamond Creek & LF AQFB sampling
- Rim Support
- LCR Helicopter Support
- Food packing
- Shuttle Drives/Vehicles
- Fix broken equipment and fix it again..............

River Trip Cost
How do we spend logistics funding?

2010 Project Support

- Aquatic Foodbase
- Nearshore Ecology
- Monitoring Lees Ferry Fish
- Mainstem Fishes
- Integrated Quality of Water Monitoring
- Little Colorado river Humpback Chub Monitoring and Translocation
- Cultural Research and Development of Core Monitoring
- Survey Control Network
- Kanab Ambersnail Monitoring
- Campsite/Sandbar Area Monitoring
- Nonnative Fish Monitoring-Multigear Sampling Pilot
- Tribal River Trip Support

Our Partners

- USGS/GCMRC Scientists and staff
- Grand Canyon National Park
- AMP Tribal Participants
- Federal and State Cooperators
- University Cooperators
- HSS: Boat Operators
- Volunteers
- VIP’s
- GCY: Youth Volunteers

"Partners in Science"
An innovational partnership linking GCMRC and Grand Canyon Youth Inc.
The objective of the "Partners in Science" program is to provide the opportunity for youth to experience the educational power of participating in handson science, completing service projects in support of the GCMRC science mission and participating on a river trip to travel not as tourists, but as working partners in the mission of providing scientific understanding of the cultural, physical and biological resources of the Grand Canyon.
Since 2004 GCY has been an informal cooperative partner with the Grand Canyon Monitoring and Research Center. Through this partnership, youth have a successful history of working collaboratively with GCMRC scientists to collect field data for multiple projects included in the GCDAMP annual work plan, some examples include:

- Backwater Habitat Measurements
- Weather Station Maintenance
- Kanab Ambersnail monitoring at Vaseys Paradise
- Hoopnet Sampling
- Pit Tagging Service

Thanks and what's next in 2011? HFE? NN Removal Project? ....there’s always more to learn.
NSE Project Update
January 2011
Year 2 of 4
Trips 8 of 12

Colton Finch, Mike Dodrill, and Brandon Gerig
Matt Lauretta and Todd Hayden
(Students and post-doc needing work)

Nearshore ecology project (NSE)

- We designed the NSE project to assess fish population responses to fall steady flow experiment
  - Direct response metrics: fish growth, survival, abundance
  - Indirect responses: habitat use, movement, selection
- Fill key data gaps in native fish ecology
  - Timing of immigration from LCR to mainstem
  - Residency in LCR & mainstem

Nearshore Ecology Study

- Habitat use and selection of fish
- Capture probability by habitat type
- Abundance of all fish species
- Predation rates (habitat and flow)
- Survival
- GROWTH

Mark-Recapture Sampling Framework (four trips annually)

NSE HBC size structure
Key NSE Finding 1

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

NSE HBC preliminary abundance estimates
Key NSE Finding 2

- NSE project can estimate abundance of small fish
  - Across both years we have been able to estimate abundance of small HBC
  - 40-100 mm TL fish from VIE marks
  - 100+mm TL fish from PIT tags
  - Smaller size/younger age than ASMR
- No obvious changes in abundance occurring during flow experiment

NSE HBC preliminary survival estimates

Tagged cohorts persist through time

Annual survival (not M)
NSE HBC preliminary growth estimates

Study Site Water Temperatures

Counterintuitive Result

- Fish growth rate actually **declined** during fall (steady flows) from summer (fluctuating flow)
- Colorado River, $\frac{dL}{dt} = 0.13 \quad \text{to} \quad 0.08 \text{ mm/d}$
- Little Colorado River, 0.21 \quad \text{to} \quad 0.02 \text{ mm/d}
More clues on growth and movement from otoliths....

Dr. Todd Hayden, SUNY-ESF

What’s going on?

Steady flow not so steady...

What NSE does really well...

- Direct estimates of juvenile native fish abundance, growth, and survival
  - At earlier age than ASMR estimates
  - Improved age-at-first-capture estimates via otoliths + ASMR
  - Could become part of core monitoring program to assess juvenile fish population responses to experiments
- Habitat use information
  - Limited to our small study reach
  - Working to link with physical science program
- Surprises from Todd and Karin
  - Growth, movement patterns, timing of outmigration from LCR

Is there a native fish response to current flow experiment?

- Not likely at the current flow contrast level
  - Bigger hammer – increase the magnitude of change
- Switching time periods of flow experiment?
  - Maximized insolation rates would occur in June/July
  - Fewer tributary inputs?
- What next?
  - Steady flows planned in 2011 and 2012
  - NSE project field work planned in 2011 only
  - Is the flow experiment still the primary question of interest?
Thank you

Why can’t I retire like John Hamill?

NSE Research Questions

- “The primary goal of this project is to understand how river flow, through its interaction with physical habitat structure, influences the survival rates of juvenile native and non-native fishes in the Colorado River in Grand Canyon. Nine research questions related to this goal have been identified in the RFP (RFP pages 27-28). (Pine et al. 2008)”

Two fundamental research questions

- (RQ1) Do steadier flows during summer and/or fall increase survival rates of juvenile native and non-native fish?
- (RQ2) To what extent does physical habitat structure (e.g., sand bars and backwaters), in conjunction with flows during these periods, influence survival rate?
Tailing the chub: combining natural tags and growth to assess the impacts of steady flows

Todd A. Hayden¹, Karin E. Limburg¹, William E. Pine, III²
¹State University of New York College of Environmental Science and Forestry
²Department of Wildlife Ecology and Conservation, Program in Fisheries and Aquatic Sciences, University of Florida

Otolith Chemistry
- CaCO₃, protein
- No reabsorption
- Sequential growth - Otolith core = larval lifestage
- Trace elements incorporate into otolith from water-time, location specific marker (Sr:Ca, Se:Ca, δ¹³C)

Photo by K. Limburg

Quantifying Fish growth

Daily increments:
Annual increments:

(ADGF 3 degrees, 24 hrs)

(Project objectives

- Identify natural markers - HBC migration, movements (LCR, COR)-
- Otolith based - age/growth of HBC-
- Link natural markers and growth - impacts of Glen Canyon steady flow on HBC-

Water chemistry-2009

~4 campaigns (July-Oct)
-all major tribs and U/S, D/S of confluence

Project objectives

- Identify natural markers - HBC migration, movements (LCR, COR)-
- Otolith based - age/growth of HBC-
- Link natural markers and growth - impacts of Glen Canyon steady flow on HBC-

Date: 1/19   DRAFT DO NOT CITE.
Water chemistry-2009
~4 campaigns (July-Oct)
- all major tribs and U/S, D/S of confluence

δ\(^{13}\)C water

δ\(^{13}\)C\(_{\text{otolith}}\) (±1 SE)

"Resident" Little Colorado River fish

Solute:Ca

Sr:Ca

Se:Ca

HBC scale Sr:Ca- scale

255nm TL- collected ~ 9 km (October 2009, age ~5-6) upstream- LCR

HBC, 33mm TL, collected August 17, 2009 in LCR @ Boulder Camp

HBC, 33mm TL, collected August 17, 2009 in Mainstem

14mm TL, collected August 26, 2009 in Mainstem

109

109.5

110

126.7

135

136

135.5

155.9

156

156.1

226

9.0*

8.8*

6.5*

5.6*

1.0*

δ\(^{13}\)C(otolith) (±1 SE)

Edge Core BHS

HBC scale Sr:Ca- scale

255nm TL- collected ~ 9 km (October 2009, age ~5-6) upstream- LCR

Se:Ca

Sr:Ca

HBC, 33mm TL, collected August 17, 2009 in Colorado River

Sr:Ca

Se:Ca

Resident" Little Colorado River fish

27 mm TL

28 mm TL

25 mm TL

HBC scale Sr:Ca- scale

255mm TL- collected ~ 9 km (October 2009, age ~5-6) upstream- LCR

HBC, 33mm TL, collected August 17, 2009 in Mainstem

HBC, 33mm TL, collected August 17, 2009 in LCR @ Boulder Camp

HBC, 33mm TL, collected August 17, 2009 in Mainstem

HBC, 33mm TL, collected August 17, 2009 in Colorado River

δ\(^{13}\)C\(_{\text{otolith}}\) (±1 SE)
Project objectives

- Identify natural markers- HBC migration, movements (LCR, COR)- Sr:Ca, Se:Ca high in MS, δ¹³C low in MS, scales- not helpful
- Otolith based- age/growth of HBC
- Link natural markers and growth- impacts of Glen Canyon steady flow on HBC.
Project objectives

- Identify natural markers- HBC migration, movements (LCR, COR)- Sr:Ca, Se:Ca high in MS, δ13C low in MS
- Otolith based- age/growth of HBC- difficult to find daily “COR” growth increments, LCR clear increments (at least to ~100mmTL)
- Link natural markers and growth- impacts of Glen Canyon steady flow on HBC.

HBC 104, 63mm, collected 10-24-2009 in COR (steady flow)
Project objectives

- Identify natural markers: HBC migration, movements (LCR, COR) - Sr:Ca, Se:Ca high in MS, $\delta^{13}C$ low in MS
- Otolith based: age/growth of HBC - difficult to find daily “COR” growth increments, LCR clear increments (at least to ~100mmTL)
- Link natural markers and growth: impacts of Glen Canyon steady flow on HBC - No drastic change in growth during steady flow. (NEED TO LOOK AT MORE FISH TO CONFIRM!)

Acknowledgements:

Individuals:
- Colton Finch
- Brandon Gerig
- Michael Dodrill
- Mike Yard
- Darren Dale

Agencies:
- USGS- GCMRC
- USFWS
- NPS
- BOR
- AZGF

Analytical:
- CHESS
- WHOI-NENIMF

SIMS (secondary ion mass spectroscopy)

Sample

Secondary ions

Cs$^+$

Synchroton X-ray fluorescence

Otolith

SBC

Filter

XFlash

CESR
An Overview of Humpback Chub Translocations and Chute Falls Monitoring During 2010

By
Arizona Fish and Wildlife Conservation Office
Flagstaff, AZ

Objectives

- Collect humpback chub for translocation to Chute Falls, Dexter, Shinumo, and Havasu creeks.
- BIO 2.M3.11-12 Monitor and obtain closed mark-recapture population estimates of humpback chub in the upper Little Colorado River (13.6 to ~18 km).
- Estimate what percentage of wild humpback chub are being cropped for translocation purposes.

Humpback Chub Collections and Dispersal

<table>
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<tr>
<th>Year</th>
<th>Chute Falls</th>
<th>DNFHTC</th>
<th>Shinumo</th>
<th>Havasu</th>
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<td></td>
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<td>2004</td>
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<td>2006</td>
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<td>109</td>
<td>185</td>
<td>300</td>
<td>300</td>
<td>894</td>
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<td></td>
<td>Totals</td>
<td>1,752</td>
<td>685</td>
<td>800</td>
<td>300</td>
</tr>
</tbody>
</table>

Dexter since 2008 ~685 age-0 fish

Shinumo Creek since 2008 ~800 age-0 fish

Havasu Creek – 2011 (300 fish)
Chute Falls since 2003
~1,752 mixed age-0 / age-1 fish

Humpback Chub Cropped in 2010 for Translocations

Monitoring the Chute Falls
Reaches

Abundances of Humpback Chub
≥ 200 mm above and below
Chute Falls

Spring 2010 Hydrograph for
Little Colorado River
Displacement of Humpback Chub Downriver between Monitoring in 2009 and 2010

Chute Falls Findings

- Growth of HBC translocated to above Chute has been very high.
- 1-year survivorship of HBC from the 2008 Chute Falls translocation was very high (~89%).
- 1-year survivorship of the 2009 cohort was likely considerably lower (possibly ~29% based on 11 recaps of 194 fish and p of 0.195).
- Chute Falls has much potential as a wild grow out facility.

Big Habitat

Successful Humpback Chub Survival, Growth and Recruitment
Humpback Chub Translocation Efforts in GRCA: 2010 Update

Brian D. Healy, Emily C. Omana, Melissa Trammell
National Park Service
Jonathan Spurgeon, Craig Paukert, Joanna Whittier
University of Missouri, USGS Cooperative
David Speas
Bureau of Reclamation
Pamela J. Sponholtz
U.S. Fish and Wildlife Service

Cooperators
• Funded by Reclamation and NPS
• Volunteers

Translocation Goals
Ultimate Goals:
Restore Native Fish Populations, including humpback chub, to the Extent Feasible

Tributary Translocation may contribute towards:
- Establish 2nd Spawning Population in Grand Canyon
- Provide Population Redundancy
- Rearing/Grow-out habitat Juvenile Humpback Chub
- Increased Growth (escape predation)
- Augment Colorado River Aggregations

Success of Tributary Translocations?
- Evaluation in progress: Factors influencing survival

Today:
Will Humpback Chub remain in Shinumo Creek?
- Assess/Investigate Factors influencing emigration
- Population Estimates
- Growth of translocated HBC compared to the Little Colorado River
Hatchery Treatments

- Parasite/disease Treatment
- Flow Training
- Pit Tagging
- Weight/length

Non-native fish control

- Improve Survival of Translocated Humpback Chub
- Electrofishing and Angling

PIT Tag Antenna System

Shinumo Translocation

302 in June 2009
300 in June 2010

Melissa Trammell/NPS

Draft data subject to revision. DAY 2 OF 2. TWG review document, DO NOT CITE, reproduce, or distribute.
Results – Will HBC Remain in Shinumo?

Humpback Chub Outmigration and Pop. Estimates
June 15, 2009 - June 23, 2010

- 151 left after 1 year
- 2009 Translocation: June 15
- 2010 Translocation: June 23

PIT Tag Antenna Results - Emigration

- Remained (Mean = 120mm n= 355)
- Left (Mean = 130mm n= 252)

PIT Tag Antenna Results - Summary

- About 250 of 602 (42%) have left (Nov. 2010)
- Largest pulses of outmigration occurred:
  - 1st 10 days after release
  - Prior to spring runoff (prior to 2010 translocation)
  - Movements occurred primarily at night
  - Emigration was not correlated with:
    - Temperature (p=0.56)
    - Stream flow (stage) (p=0.57)
  - Larger Fish = more likely

Mark-recapture Population Estimates

- June and September, 2010
- 2-pass Mark-recapture (all natives)

<table>
<thead>
<tr>
<th>Stream Reach</th>
<th>Day 1 (PASS 1)</th>
<th>Day 2 (PASS 1)</th>
<th>Day 3 (PASS 1)</th>
<th>Day 4 (PASS 2)</th>
<th>Day 5 (PASS 2)</th>
<th>Day 6 (PASS 2)</th>
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<td>Set Nets</td>
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<td>Mark/ recapt</td>
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<td>Mark/ recapt</td>
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<td>Day 4</td>
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<td>Mark/ recapt</td>
<td>Mark/ recapt</td>
<td>Mark/ recapt</td>
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</table>
Results: 2010 Post-Translocation Monitoring

- June and September
- Unique Re-captures
  - 49 of 2009 class
  - 68 of 2010 class

Shinumo - 2010 Population Estimates - Humpback chub

Growth

Translocated HBC (Age-1+) vs. Little Colorado

Water Temperature – 1 year

LCR Growth Curve: Robinson and Childs 2001

Date: 1/19  DRAFT DO NOT CITE.
Will Translocations Augment Colorado River Humpback Chub Aggregations?

GCMRC: September 2010 Aggregation Trip:
- 70% of HBC captures in the Shinumo Inflow Aggregation (RM 108)
- 29 unique fish
- 1 at Randy’s Rock (RM 128)

Recaptured fish grew up to 101 mm since release in 2009

Data Provided by USGS/GCMRC/USFWS—Thanks to Bill P. and Randy V.

Next Steps – Shinumo Creek
- Collected 600 HBC-LCR Nov. 2010
- Bubbling Ponds Native Fish Facility – Rearing HBC
- Shinumo Creek Translocation III
  - June 2011 (300 fish)
  - Continue NNF Fish Control

Next Steps – Havasu Creek
- Most likely to support a 2nd population
- Possibly fewer nonnative predators

Havasu Creek 2011
- Develop Translocation Plan
  - Late winter/Spring
- Baseline Sampling II – May 2011
  - Below Beaver Falls
  - Baseline Fish Survey
  - Water quality
  - Non-native fish
  - Food base
- Translocation 2011 at end of Baseline Trip

Havasu Creek Baseline Survey – February 2010

Rainbow Trout 4%
Bluehead Sucker 49%
Spotted Dace 47%
Bright Angel Creek Trout Reduction Project

Grand Canyon National Park

National Park Service
U.S. Department of the Interior
Grand Canyon National Park

Project Background

- Bright Angel Creek: Major source of Brown Trout to Grand Canyon
- Rainbow trout introduced 1920’s and 1930’s
- NPS Exotic Species Management: “remove, when possible, or otherwise contain individuals or populations of these species that have already become established in parks.” NPS Management Policies 2006

Cooperators

- Funded by Reclamation and NPS
- Volunteers

Purposes:
1. Benefit endangered humpback chub and other native fishes in the Colorado River.
2. Restore and enhance, to the extent feasible, native fishes that once flourished in Bright Angel Creek.

Actions:
1. Install and operate a weir (fish trap)
2. Electro-fishing for monitoring and removal

Winter 2010-2011 Activities

- Electro-fishing/Mechanical Removal – October (3 days)
- Weir installation – October 26 (Planned removal February 4)
- Electro-fishing planned January 24 – February 4

Outreach:
- Recording all visitor interactions
- Outreach materials
Weir Design

Methods
- Checked Morning and Evening
- Water temperatures
- Fish:
  - Length
  - Weight
  - Spawning Condition
  - # eggs
  - Tags
  - Stomach Contents

Beneficial Use
- Weir: 194 Trout Consumed
- Electro-fishing: 103 Trout consumed

Weir Results – through January 10
- Captured/removed:
  - 104 Brown Trout (70% ripe, 62% female)
  - 90 Rainbow Trout (72% ripe, 37% female)

Brown Trout 2010
- N = 104
- Average size = 382
- Length = 685 mm

Eggs: Brown trout = 66,300, Rainbow trout = 38,800
Rainbow Trout 2010

Rainbow Trout Length Frequency

N = 90
Average size = 362

Rainbow Trout Length Frequency

No. Fish

200 240 280 320 360 400 440 480
Total Length (mm)

Results – Weir Captures (BNT)

BAC Brown Trout Capture 10/27-1/10

Results – Weir Captures (RBT)

BAC Rainbow Trout Capture 10/27-1/7

Trout Re-captures

<table>
<thead>
<tr>
<th>Species</th>
<th>Length (mm)</th>
<th>Tag Number</th>
<th>Date Captured</th>
<th>Days at Large Location</th>
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</tbody>
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Date: 1/19   DRAFT DO NOT CITE.
Electro-fishing - October

- Sampled = 600 meters over 3 days
- Removed (nonnative fish):
  - 104 Rainbow trout (93% removal efficiency)
  - 125 Brown trout (96% removal efficiency)
- Sampled (native fish):
  - 4 bluehead suckers (<1% of catch)
  - 1046 speckled dace

- Electro-fishing sampling/removal January 24 – February 4
- Remove weir February 4th
Objectives

- BIO 2.R1.10 and BIO 2.M1.11,12: Obtain spring and fall closed mark-recapture population estimates of humpback chub ≥100 mm in the LCR (0 to 13.6 km).
- Obtain fall population estimate of HBC <100 mm through use of VIE tagging.
- SSQ 1-1 and 1-2

Methods: Closed Mark-Recapture Using Hoopnets

<table>
<thead>
<tr>
<th></th>
<th>Spring HBC ≥ 100 mm</th>
<th></th>
<th>Spring HBC 100 – 149 mm</th>
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<th>Spring Abundance of Humpback Chub ≥ 150 mm and ≥ 200 mm</th>
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<tbody>
<tr>
<td></td>
<td>N</td>
<td>SE</td>
<td>95% CIs</td>
<td>N</td>
<td>SE</td>
</tr>
<tr>
<td>2009</td>
<td>12,007</td>
<td>947</td>
<td>10,151</td>
<td>4,328</td>
<td>729</td>
</tr>
<tr>
<td>2010</td>
<td>8,908</td>
<td>534</td>
<td>7,862</td>
<td>762</td>
<td>127</td>
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</table>
Spring Abundance of Humpback Chub from 150 to 199 mm from 2001 to 2010

<table>
<thead>
<tr>
<th>Year</th>
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</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>5,470</td>
<td>581</td>
<td>4,332 - 6,608</td>
</tr>
<tr>
<td>2010</td>
<td>3,887</td>
<td>258</td>
<td>3,371 - 4,383</td>
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</table>

Fall HBC ≥ 100 mm

<table>
<thead>
<tr>
<th>Year</th>
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<th>95% CIs</th>
</tr>
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<tr>
<td>2009</td>
<td>5,470</td>
<td>581</td>
<td>4,332 - 6,608</td>
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<tr>
<td>2010</td>
<td>3,887</td>
<td>258</td>
<td>3,371 - 4,383</td>
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Fall HBC 100 – 149 mm

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<tr>
<td>2009</td>
<td>1,511</td>
<td>167</td>
<td>1,185 - 1,838</td>
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<tr>
<td>2010</td>
<td>384</td>
<td>76</td>
<td>230 - 528</td>
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</table>

Fall Abundance of Humpback Chub ≥ 150 mm and ≥ 200 mm

Comparison of spring and fall adult HBC ≥ 200 mm

Fall Visible Implant Mark-Recapture Efforts
Fall HBC 42-99 mm (VIE Studies)

<table>
<thead>
<tr>
<th>Year</th>
<th>N</th>
<th>SE</th>
<th>95% CIs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>6,882</td>
<td>926</td>
<td>5,067 8,698</td>
</tr>
</tbody>
</table>

- Marked: 380
- Examined: 812
- Recaps: 44

HBC Conclusions
Spring and Fall Mark-Recapture

- Spring LCR abundances of HBC ≥150 mm and ≥200 have continued to steadily increase since 2006.
- Fall LCR abundances of HBC ≥150 mm beginning to decline since 2008, but HBC ≥200 mm appear to be holding steady.
- A relatively small cohort of age-0 HBC in fall 2009 resulted in low abundances of age-1 HBC (100-149 mm) in spring and fall 2010.
- By comparing spring to fall adult abundances, there appears to be a significant increase in the migratory portion of the adult population since 2008.
- First successful river-wide abundance estimate of age-0 humpback chub was obtained. Useful for translocations and HFE.

Thank-You
Little Colorado River Lower 1200 m Monitoring 1987-2010

Brian C. Clark
Arizona Game and Fish Department
Research Branch

Introduction/Background

- Annual standardized AGFD Little Colorado River (LCR) Lower 1200m spring (April/May) hoop net monitoring began in 1987.
- The LCR is the primary spawning site for the endangered humpback chub (HBC). Other native species spawn in the LCR such as flannelmouth sucker (FMS), bluehead sucker (BHS) and speckled dace. Nonnative species such as black bullhead (BBH), channel catfish (CCF), common carp and fathead minnow also spawn in the LCR.
- Catch Per Unit Effort (CPUE) indices are useful as independent validation for Age Structured Mark-Recapture (ASMR) population models of HBC.
- This project is one of the most consistent, standardized long-term monitoring projects in Grand Canyon, with the exception of 2000-2001.

BIO 2 R2 Little Colorado River Humpback Chub Monitoring in the Lower 1,200m:

SA 1. What are the most limiting factors to successful HBC adult recruitment in the mainstem: spawning success, predation on YoY and juveniles, habitat (water, temperature), pathogens, adult maturation, food availability, competition?

OBJECTIVES

- Assess population status and trends (CMIN 2.1.2.)
- Determine catch-per-unit-effort [fish/hour] (CMIN 2.1.2.)
- Determine species composition of catch
- Determine size and length frequency distributions (CMIN 2.1.2.)

Species Composition

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Native</th>
<th>Total Non-native</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>83</td>
<td>0</td>
</tr>
<tr>
<td>1988</td>
<td>571</td>
<td>12</td>
</tr>
<tr>
<td>1989</td>
<td>997</td>
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<tr>
<td>1990</td>
<td>315</td>
<td>1</td>
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<tr>
<td>1991</td>
<td>315</td>
<td>1</td>
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<tr>
<td>1992</td>
<td>997</td>
<td>1</td>
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<tr>
<td>1993</td>
<td>315</td>
<td>1</td>
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<tr>
<td>1994</td>
<td>997</td>
<td>1</td>
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<tr>
<td>1995</td>
<td>315</td>
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<td>1996</td>
<td>997</td>
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<td>1997</td>
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<tr>
<td>1998</td>
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<tr>
<td>1999</td>
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<tr>
<td>2000</td>
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<td>2003</td>
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<td>2004</td>
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<td>2005</td>
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<td>2006</td>
<td>997</td>
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<td>2007</td>
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<tr>
<td>2008</td>
<td>997</td>
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<tr>
<td>2009</td>
<td>315</td>
<td>1</td>
</tr>
<tr>
<td>2010</td>
<td>997</td>
<td>1</td>
</tr>
</tbody>
</table>

Total 2098 100.0
Conclusions

- Catch/Hour of HBC ≥ 200 mm was similar to early 1990’s catch rates [CMIN2.1.2].
- Relative abundance of Flannelmouth sucker continues to remain above historic observations.
- Total catch of nonnative species remains low (< 5%).
- Relative abundance of commonly captured nonnative species tends to vary annually.
- Trends in LCR lower 1200 m adult HBC (≥ 200 mm) are similar to trends in Age Structured Mark Recapture abundance estimates for adult HBC.

Acknowledgements

Luke Avery, Aaron Bunch, Triska Hoover, Andy Makinster, William Persons

GCBMC logistical support

USFWS personnel

Mark Santee (BOR pilot)
SSQ 3-6

- What GCD operations (ramping rates, daily flow range, etc.) maximize trout fishing opportunities and catchability?
- Lees Ferry angler based model
- Since 1991
  - High mean low fluctuating flows (MLFF)
- Recent flow events
  - March 2008 high flow event (HFE)
  - Fall steady flows

CMINs

- 4.1.1
  - Determine annual population estimates for rainbow trout in the Lees Ferry reach.
- 4.1.2
  - Determine annual proportional stock density of rainbow trout in the Lees Ferry reach.
- 4.1.4
  - Determine annual growth rate, relative condition (Kn), and relative weight of rainbow trout in the Lees Ferry reach.

Sampling

- Since June 2002, 27 random and 9 fixed sites sampled 3 times/year (spring, summer, fall)
  - PIT tagging in fixed sites
  - Floy tagging in random sites (2007)
- 2010, Fully random design, 36 sites, only 2 trips
  - PIT tagging in 9 sites that were near old fixed sites
  - Floy tagging elsewhere
  - Summer trip replaced by warm-water non-native trip

CMINs

- 4.1.1
  - Determine annual population estimates for rainbow trout in the Lees Ferry reach.
- 4.1.2
  - Determine annual proportional stock density of rainbow trout in the Lees Ferry reach.
- 4.1.4
  - Determine annual growth rate, relative condition (Kn), and relative weight of rainbow trout in the Lees Ferry reach.

Relative abundance

- [Graph showing relative abundance over years]
Relative abundance/Size structure

Angler creel survey

CMINs

• 4.1.1
  – Determine annual population estimates for rainbow trout in the Lees Ferry reach.

• 4.1.2
  – Determine annual proportional stock density of rainbow trout in the Lees Ferry reach.

• 4.1.4
  – Determine annual growth rate, relative condition (Kn), and relative weight of rainbow trout in the Lees Ferry reach.

Proportional Stock Density (PSD)

\[ PSD = \frac{RBT \geq 406}{RBT \geq 305} \times 100 \]

305 mm (12 inches) = Mean stocking size
406 mm (16 inches) = Preferred catch size

Size structure
Size structure

• Is PSD still relevant?

\[ PSD = \left( \frac{RBT \geq 406}{RBT \geq 305} \right) \times 100 \]

- If RBT \( \geq 406 \) increase in abundance, PSD goes up
- OR, if RBT 305 - 405 decrease in abundance, PSD goes up, but it doesn’t mean the fish are getting any larger
  • Currently an irrelevant metric?

PSD Alternatives

• Change standard length cutoffs

\[ PSD = \left( \frac{RBT \geq 356}{RBT \geq 254} \right) \times 100 \]

- New regulation: \( \geq 356 \text{ mm (14 inches)} \) must be released (quality)
- 254 mm (10 inches) catchable (stock)
CMINs

4.1.1
- Determine annual population estimates for rainbow trout in the Lees Ferry reach.

4.1.2
- Determine annual proportional stock density of rainbow trout in the Lees Ferry reach.

4.1.4
- Determine annual growth rate, relative condition ($K_n$), and relative weight of rainbow trout in the Lees Ferry reach.

Relative condition

$$K_n = \left( \frac{W}{W'} \right) \times 100$$

$W$ = weight

$$W' = e^{(-4.6 + 2.856) \times \ln TL}$$

Growth rate

von-Bertalanffy estimated length at age

$$L(t) = L_{\infty} \left(1 - e^{-Kt}ight)$$

Relative condition

Year


Mean RBT relative abundance


Mean RBT condition


Relative condition

Year


Mean RBT relative abundance


Mean RBT condition


RBT 152-304 mm TL

RBT < 152 mm TL

RBT > 405 mm TL

RBT 305-405 mm TL
Relative condition

Conclusions

- Lees Ferry fishery monitoring
  - Last year it was concluded that fall steady flows aided in YOY and juvenile survival. It now looks as though the spring HFE and its impact on the foodbase had more to do with that and the effects are diminishing.
  - Recruitment of 2008 cohort into young adult population. Not so much with the 2009 cohort.
  - Numbers of small fish remain high while numbers of large fish continue to decline.
- Whirling disease
  - First detected in June 2007
  - No detections since

2009 PEP recommendations

1. Reduce effort to sample adult RBT population in Lees Ferry to 1-2 trips/year and get rid of fixed sites
2. Redirect efforts for more non-native sampling
3. Incorporate Rainbow Trout Early Larval Life-history Study (RTELLS) work

Recommendation 1

- Sampling trips to occur in spring and fall
  - Spring serves as decent indicator of adult population
  - Fall is best opportunity to detect WD and cohort strength
Relative abundance

Relative abundance/Size structure

Do we need the summer trip?

Recommendation 2

• Summer sampling trip geared towards non-native fish

• Areas of interest
  – Carp pond/Slough
  – Springs
  – Base of the GCD
July 21–23, 2010
Colorado River mile -12.10 → -12.33

Objectives

- Detect non-native species in slough area
- Determine best technique to capture non-native species
- PIT tag common carp (CRP) to track future growth and movement
- Obtain population estimate of CRP in slough area

Methods

- Back-pack electrofishing
- Boat electrofishing
- Trammel nets
- 20 hoop nets
  - Stink cheese (10 catfish nets)
  - Aquamax (10 standard hoops)
- 20 minnow traps
  - Canned cat food bait
- Block net set at mouth of slough

Results

Table 1. Number of each species captured per sampling method near RM -12.0 during July 2010 sampling. Species are coded as followed: common carp (Cyprinus carpio; CRP); flannelmouth sucker (Catostomus latipinnis; FMS); rainbow trout (Oncorhynchus mykiss; RBT); and green sunfish (Lepomis cyanellus; GSF).

<table>
<thead>
<tr>
<th>Date</th>
<th>Method</th>
<th>CRP</th>
<th>FMS</th>
<th>RBT</th>
<th>GSF</th>
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<tbody>
<tr>
<td>7/21/10</td>
<td>Back-pack electrofishing</td>
<td>7</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7/22/10</td>
<td>Boat electrofishing</td>
<td>13</td>
<td>3</td>
<td>19</td>
<td>2</td>
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<tr>
<td>7/22/10</td>
<td>Boat electrofishing</td>
<td>114</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7/22/10</td>
<td>Trammel netting</td>
<td>3</td>
<td>7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7/23/10</td>
<td>Boat electrofishing</td>
<td>70</td>
<td>2</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>7/23/10</td>
<td>Trammel netting</td>
<td>2</td>
<td>4</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>209</td>
<td>16</td>
<td>28</td>
<td>3</td>
</tr>
</tbody>
</table>

% Composition: 81.6%, 6.3%, 10.9%, 1.2%

Table 2. Growth and movement information resulting from recaptures of PIT-tagged common carp (Cyprinus carpio; CRP) and flannelmouth sucker (Catostomus latipinnis; FMS) captured during July 2010 sampling near RM -12.0. Mark location LCR indicates species was tagged in the Little Colorado River and is calculated into distance moved by adding the value to Mark location, where RM 0 indicates the Brownfield confluence. Negative values for distance moved indicates movement upstream.

<table>
<thead>
<tr>
<th>Method</th>
<th>Species</th>
<th>Tag number</th>
<th>Date</th>
<th>Mark location</th>
<th>Recap location</th>
<th>Distance moved (miles)</th>
<th>Growth (mm/day)</th>
</tr>
</thead>
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<tr>
<td>Electrofishing</td>
<td>CRP</td>
<td>3D9 1BF198D35C</td>
<td>11/3/2003</td>
<td>-12.00</td>
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<td>FMS</td>
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<td>61.70</td>
<td>5/17/1999</td>
<td>-74.05</td>
<td>0.0272</td>
</tr>
</tbody>
</table>

Results

CRP Length Frequency
All Gear Types

Draft data subject to revision. DAY 2 OF 2.
TWG review document, DO NOT CITE, reproduce, or distribute.

Date: 1/19  DRAFT DO NOT CITE.
Results

Conclusions

- Slough is dominated by common carp
- Large population of carp in 0.23 mile span may suggest sampling occurred during spawning aggregation; 71 ripe males out of 180 that did not include recaps = 39.4% of population
- 26 total CRP recaptures from boat electrofishing; 165 new PIT tags (boat electrofishing) reflects a low recapture rate/ lots of carp
- No CRP or FMS ≤ 100 mm TL were captured during this sampling; adult population
- No fish species captured in hoop nets or minnow traps throughout sampling
- Slough most likely serves as a thermal refuge for CRP and FMS
- Future monitoring of the slough may be incorporated into Lees Ferry monitoring trips

Recommendation 3

- Coordination with Korman and Foster
- Continue sampling larval fish to determine effects of experimental actions
- Continue fall-winter redd counts

Foodbase

- Results available through Ted Kennedy
  - Started in 2003
  - Very informative and, along with RTELLS, helps explain recent trends
  - Provides better picture of Lees Ferry ecology and rainbow trout population responses to various flow regimes
  - We would like to see this work continue and possibly expand
Relative abundance/Size structure

- New regulation as of October
  - Release fish ≥14" (356 mm TL)
    - Old regulation; release ≥12" (305 mm TL)
  - <152 mm, 152 - 254 mm, 255 – 355 (10" – 14"; stock size), ≥356 mm (quality size)

PSD Alternatives
Grand Canyon Fish Community Monitoring
Annual Reporting Meeting
2010 Update

Aaron J. Bunch
Colorado River Research Office

SSQ

• SSQ 1-1. To what extent are adult populations of native fish controlled by production of young fish from tributaries, spawning and incubation in the mainstem, survival of young-of-year and juvenile stages in the mainstem, or by changes in growth and maturation in the adult population as influenced by mainstem conditions?

Background

Non-native salmonids (i.e., rainbow and brown trout) have increased in abundance since early 1990’s

Salmonids may limit recruitment of native fishes
(Minckley 1991; Marsh and Douglas 1997; U.S. Department of Interior 2002)

GCMRC Protocol Evaluation Program advocated long-term monitoring of non-native fish species

Mainstem fish community monitoring

2010 Objectives

• Describe trends in nonnative salmonid and carp, and native cairns and caiyd catch-per-unit-effort (CPUE; fish/hr) and distribution from 2000 – 2010.

• Measure changes in fish CPUE near the confluence of the Little Colorado River.

• Evaluate the ability to monitor movement and growth of rainbow trout by Floy tagging.

Methods: Electrofishing

• Two trips conducted in Spring (April–May)

• Randomized site selection within study reaches

• Single-pass shoreline electrofishing at night (2 boats)

• ~900 transects (1 transect = ~300 sec. shock time)

• Data attained: Species ID, TL (all species) & FL (natives only; mm), Wt (g), and tag returns (i.e., Floy, PIT, and/or fin-clips)

Goal: Gather information on any fish we can get our hands on!

Non-native monitoring targets:

Also, rare and elusive species (e.g., centrarchids)

Native monitoring targets:
Methods: Tagging

PIT Tags:
- Brown trout > 149 mm TL
- Most native species > 149 mm TL
- Humpback chub > 99 mm TL

Floy Tags:
- Rainbow trout > 199 mm TL
- Common carp > 199 mm TL

Fin-clip:
- Brown trout (adipose fin)
- Rainbow (left pelvic)
- Common carp (dorsal spine)

2010 Objectives

- Describe trends in nonnative salmonid and carp, and native catostomid catch-per-unit-effort (CPUE; fish/hr) and distribution from 2000 – 2010.
- Measure changes in fish CPUE near the confluence of the Little Colorado River.
- Evaluate the ability to monitor movement and growth of rainbow trout by Floy tagging.

Rainbow trout

Brown trout

Date: 1/19   DRAFT DO NOT CITE.
<table>
<thead>
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</tr>
</thead>
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<td>2</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total length (mm)</td>
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<td>100</td>
<td>200</td>
<td>300</td>
<td>400</td>
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<td>Co</td>
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<td>50</td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>250</td>
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</tbody>
</table>

**Common carp**

<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>Mean CP</td>
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<td>3</td>
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<td></td>
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<tr>
<td>Total length (mm)</td>
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<td>100</td>
<td>200</td>
<td>300</td>
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<td>10</td>
<td>20</td>
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<tr>
<td>River Mile</td>
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<td>50</td>
<td>100</td>
<td>150</td>
<td>200</td>
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<tr>
<td>CPUE</td>
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<td>20</td>
<td>40</td>
<td>60</td>
<td>80</td>
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<td>River Mile</td>
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<td>50</td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>250</td>
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</tbody>
</table>

**Flannelmouth sucker**

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</tr>
</thead>
<tbody>
<tr>
<td>Mean CP</td>
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<td>2</td>
<td>3</td>
<td></td>
<td></td>
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<td>Total length (mm)</td>
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<td>200</td>
<td>300</td>
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<td>30</td>
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<tr>
<td>River Mile</td>
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<tr>
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<td>River Mile</td>
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<td>50</td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>250</td>
</tr>
</tbody>
</table>

**Bluehead sucker**

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Mean CP</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total length (mm)</td>
<td>0</td>
<td>100</td>
<td>200</td>
<td>300</td>
<td>400</td>
<td>500</td>
</tr>
<tr>
<td>Co</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>River Mile</td>
<td>0</td>
<td>50</td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>250</td>
</tr>
<tr>
<td>CPUE</td>
<td>0</td>
<td>20</td>
<td>40</td>
<td>60</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>River Mile</td>
<td>0</td>
<td>50</td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>250</td>
</tr>
</tbody>
</table>
2010 Objectives

- Describe trends in nonnative salmonid and carp, and native catostomid catch-per-unit-effort (CPUE; fish/hr) and distribution from 2000 – 2010.
- Measure changes in fish CPUE near the confluence of the Little Colorado River.
- Evaluate the ability to monitor movement and growth of rainbow trout by Floy tagging.

Conclusions

- Since mid-2000’s - increasing trends in CPUE for all species both native and nonnative
- Fish distribution consistent with previous years
- Few humpback chub collected (N=15)
- Currently, best tool to assess when the 1,200 rainbow trout trigger is met for mechanical removal to occur
- Potential issues with 1 trip vs. 2 trips
  - Reduce the ability to collect rare nonnative fishes
  - Turbidity drastically influences capture probability

Results: Removal Reach

Conclusions

- Higher CV's and larger confidence intervals – adding more uncertainty (e.g., rainbow trout)

Questions?
Progress on Processing

2009 High-Resolution Airborne Imagery

Philip A. Davis and Laura E. Cagney

Primary Objectives

Provide consistent, calibrated, and undistorted multispectral image database for the Colorado River corridor from Lake Powell to Pierce Ferry for late May, 2009 with 20-cm spatial resolution and 30-cm positional accuracy.

Such a database, not previously obtained, should provide more capability, accuracy, and efficiency in image analyses that produce specific monitoring databases.

Conclusion: Our analyses thus far have proven this to be true.

Environmental Issues During the 2009 Overflights

Normally, data collection would occur under clear sky conditions, within a narrow daily time window, which would constrain environmental parameters that affect airborne image data.

The weather during the 2009 collection was the worst ever, producing variations in solar flux, atmospheric transmission and scattering, and solar phase angle throughout the mission, all of which had to be normalized for each flight line of image data.

Environmental Effects on Image Data

The general radiometric equation:

\[ E_o \lambda = E_d \lambda + (E_a \lambda - R \lambda \sin^2 \theta_s) \]

\[ E_d \lambda = E_o \lambda \cos^2 \phi \]

\[ E_a \lambda = E_o \lambda \sin^2 \phi \]

These parameters, solar flux, downwelling scattering, and atmospheric scattering, are a function of clouds, water vapor, and aerosols in the atmosphere.

Vehicle radiance directly back to the sensor.

Surface with reflectance \( R \lambda \) and slope \( \theta_s \).

Surface with reflection \( R \lambda \) and slope \( \theta_s \).

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Date:1/19   DRAFT DO NOT CITE. 46
Overlapping flight lines provide multiple stereo pairs for each image pixel (for a DSM) and provide a higher likelihood for image defect removal. Originally, I thought defect removal would require 2-3 flight lines per image quad, during actual mosaicking I realized this required TWICE that number.

Monsoon storms forming near noon forced data collections to cluster in the morning and, as the storms persisted, forced collections earlier than our prescribed 11 AM in order to cover the Canyon.

Processing Flow for 2009 Image Mosaics

Sequence performed whenever additional images required

- Calibrate image
- Trim images to common extent
- Inter-flight-line Calibration
- Map coarse sediment
- Classify vegetation
- Map standing water
- Map fine sediment
- Map gross vegetation
- Store map data

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Image Mosaic Tile Scheme (USGS Map Quads)

Resulting image mosaics are flawless, except for issues designated on the right.

The most extensive flaw within upper 1/3 of the canyon is a small band of smearing along 2 scarps.
Red arrows point to the small basal smears.

Adjacent Flight Lines South of LCR
River left – western flight line shows smearing along slopes, as well as distortion (smearing) of near-shore vegetation.

Adjacent Flight Lines South of LCR
River left – eastern flight line shows no smearing. Acquired a different day, hence change in water color.

Adjacent Flight Lines South of LCR
River right – eastern flight line shows smearing along slopes.

Adjacent Flight Lines South of LCR
River right – western flight line shows no smearing along slopes.

Objective was to provide consistent, accurate reflectance on land and in the water and to minimize image distortions.
East side of Lake Powell

2009 natural-color images

Glenn Canyon

Comparing image data:
- 2009 natural color
- 2005 natural color
- 2002 natural color
- 2002 4-band natural color

2009 natural color
30-45 Mile

Comparing image data:
- 2009 natural color
- 2005 natural color
- 2002 natural color
- 2002 4-band natural color
FY11 Plans

Complete 2009 4-band image quads for entire corridor.

Complete most, if not all, derivative map products that depict geomorphic-landscape (GLC) elements, similar to derived from the 2002 and 2005 image data. These databases can be produced much faster in the 2009 data than its image mosaicking.

Start vegetation classification.

Publish the 2002 and 2005 GLC databases, as soon as we verify and, if necessary, correct the 2005 vegetation data.
**Data Acquisition and Management System (DAMS)**

2010 GCMRC Annual Report Meeting  
January 19, 2011  
Glenn Bennett

**DAMS Design Features**

- Rapid creation of tabular databases
- Associates reports and metadata files with data sets
- Accepts data from users and automated data retrieval systems
- ‘Smart’ data synchronization
- User controlled web publishing
- ‘Fine-grained’ publishing
- ‘Snapshot’ archiving system

**DAMS Shoebox to Web**

The Data Acquisition and Management System (DAMS) is a suite of software applications that automates the process of database and web design for individual datasets.

After initial dataset definition, DAMS facilitates project scientists and data stewards to upload, manage, and publish tabular data.

**DAMS Public Datasets**

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Records</th>
<th>Period of Record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acoustic - Silt Clay &amp; Sand</td>
<td>1,184,288</td>
<td>8/11/2002 - 5/10/2010</td>
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<tr>
<td>Instantaneous Stage Discharge</td>
<td>2,191,042</td>
<td>11/15/1925 - 8/25/2010</td>
</tr>
<tr>
<td>Glen Canyon Dam (hourly)</td>
<td>15,936</td>
<td>10/10/2008 - 1/17/2011</td>
</tr>
<tr>
<td>USGS - Stage Discharge (unit)</td>
<td>6,089,966</td>
<td>10/7/1980 - 1/18/2011</td>
</tr>
<tr>
<td>Lake Powell - Profiles (weekly)</td>
<td>17,264,612</td>
<td></td>
</tr>
</tbody>
</table>

**DAMS Internal Datasets**

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Records</th>
<th>Period of Record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambersnail 20 cm plots</td>
<td>812</td>
<td>4/2/2004 - 9/22/2008</td>
</tr>
<tr>
<td>USGS - Stage Discharge (daily)</td>
<td>197,935</td>
<td>10/1/1921 - 7/16/2010</td>
</tr>
<tr>
<td></td>
<td>4,525,524</td>
<td></td>
</tr>
</tbody>
</table>

**DAMS Online Demo**

www.gcmrc.gov/dasa/tabdata/
DAMS Future Plans

- Improve QA/QC and data validation
- Improve flexibility of web based queries
- Add Graphing Interface – Data Plotting
- Incorporate analysis tools and procedures

DAMS Screenshots

Select Tabular Data

Select Dataset

Select Table

View Metadata & Reports

Select Station(s)
GIS Support for Integrated Analysis and Projects

GCDAMP Annual Reporting Meeting
January 19, 2011
Phoenix AZ

Main components of GIS Support
- Maintain software and spatial data processing capabilities for Center
- Provide Spatial Analysis support to science projects
- Create Mapping / Cartographic products ranging from field support to publications
- Develop internal and external access to Center’s spatial databases

GIS / RS Software
- ESRI ArcGIS suite (v9.3.1)
  - Enterprise environment – available to most researchers
  - Desktop and Server options for data processing
  - Additional add-ons for improved functionality
  - Includes ArcGIS Server used for publishing maps on the Web.
- ENVI Image processing software
  - Added 3 seats to support 2009 data
  - Set up custom training for software
- ERDAS, XTools, etc.

Spatial Analysis Support
- Model builder to Python
  - Workflow allows GIS users to build some processing components in Model builder,
  - Export to Python Script, then edited by GIS programmer,
  - Final scripts can then be run by all GIS users in group.
- Python Script Library
  - Approx. 50 scripting routines developed for GIS

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Date: 1/19  DRAFT DO NOT CITE.
Image Analysis Support

- Improved workflow within Image Analysis project
  - Trained 3 new staff on using GIS/RS for project
  - Share data between ArcMap & ENVI software platforms.
    - Allows for overlay of 2009 image data during image processing steps.
    - Will increase ability to share new data faster.

- Allows for overlay of 2009 image data during image processing steps.
- Will increase ability to share new data faster.

Mapping and Cartographic Support

- Continued field support with customized river maps
  - Utilizes an add-on to ArcGIS (MapBook).
  - Thematic layers added for specific research purposes

- Numerous maps made for publications for GCMRC staff and cooperators

Access to Spatial Data

- Migration from IMS to Arc Server
  - Necessary to phase out Internet Map Server
    - not supported by ESRI very well
    - Built on older technology
    - Unstable web configuration

- Newer technology allows for much greater functionality
  - Greater flexibility in how Map Services are consumed.
  - Can incorporate data sets from other entities in-house.

Date:1/19   DRAFT DO NOT CITE.
Access to Spatial Data

- **Arc Server System Configuration**
  - Spatial data stored in Oracle SDE
  - Arc Server Manager and Web Servers in DMZ
  - Services developed using various data sources
  - Requests go from “client” to Servers and back

- **GCMRC Spatial Database**
  - GIS Server / Map Services
  - Web Server / Applications
  - DMZ

- **Web Map User**

- **Using Arc Server map services in ArcMap...**

- **Access to Spatial Data**
  - **Arc Server Display**
    - Spatial data organized in services
    - Services with large data sources are cached to improve performance
    - Platform allows for creating tools to enhance experience

- **Imagery**
  - 2002
  - 2005
  - 2009

- **Topo**
  - 10m DEM
  - 2002 DSM
  - 2009 DSM

- **Maps**
  - Base Data
  - Thematic layers
Access to Spatial Data

- **Arc Server Benefits**
  - Services created in Arc Server can be consumed in more customizable services (i.e., MS Silverlight, Adobe Flex, Google Maps,...)
  - Can change levels of detail to provide better user experience
  - Allows for cached map services that greatly improve performance

Access to Spatial Data

- **Arc Server Web components can work with other web-based mapping programs**...

Access to Spatial Data

- **Example of Arc Server using MS Silverlight**
  
  [Link](http://www.gcmrc.gov/gis/silvermap1.aspx)
QUALITATIVE APPROACHES
- SIMPLISTIC METHODS AND MODELS
- EASILY UNDERSTOOD AND APPLIED
- LOW USER COST AND TIME INVESTMENT
- LIMITED USE OF COMPLEX ASSESSMENTS
- CONSTRAINED TO MORE COARSE ANALYSIS

QUANTITATIVE APPROACHES
- COMPLEX METHODS AND MODELS
- MORE DIFFICULT TO UNDERSTAND SYSTEM DETAIL
- REQUIRES ANALYSTS TO OPERATE
- HIGH DEVELOPMENT COST
- SUMMARY OUTPUTS USEFUL IN MORE SIMPLISTIC MODELS
- USEFUL FOR COMPLEX ASSESSMENTS AND MICRO-ANALYSIS

DSS SHOULD INCORPORATE SEVERAL CAPABILITIES
- COST ASSESSMENTS
- BENEFIT ASSESSMENTS
- ASSESSMENT OF RISK
- EVALUATION OF UNCERTAINTY
- TRADEOFF ANALYSIS
- EASE OF USE AND UNDERSTANDING

SA ASSESSMENT APPROACH
- LITERATURE AND USER REVIEW
- CRITERIA FOR COARSE SCREENING, SELECT 4-8 METHODS IN CURRENT USE
- REFINE EVALUATION CRITERIA AND SELECT 2-4 METHODS FOR ANALYSIS
- EVALUATE APPLICATION TO AMP
- FINAL REPORT TO TWG: SUMMER 2011