Low flows in Glen Canyon: preliminary geomorphic analysis of the potential effects on fish and food base


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QUESTION:

HOW MUCH DO MINIMUM MLFF DAM RELEASES REDUCE AQUATIC HABITAT?

Recall: Water Depth Limits Light Penetration to the Bed - influencing aquatic food production (from Yard, 2003) & that channel geometry controls depth, wetted area, etc.

How much shoreline area gets dewatered in the Glen Canyon Tailwater when dam releases are reduced from 8,000 to 5,000 cfs?
Stakeholder Concern: about whether HFEs and low minimum flows under the 1996 ROD of 5,000 cfs (142 m$^3$/s) between 07:00 p.m. and 07:00 a.m. (versus 8,000 cfs (227 m$^3$/s) might negatively affect the Lees Ferry fishery and foodbase?

Initially addressed by GCMRC (Kennedy & VanderKooi, 2012)

“It is our professional judgment that the effects on food base and rainbow trout of the two alternative flow regimes described above would be indistinguishable. Our judgment about minimal ecological effects is based largely on estimates of how much additional streambed is exposed when flows drop from 8,000 to 5,000 cfs. There are more than 20 cross-sections in Glen Canyon that have been monitored for geomorphic characteristics; the lower flows of 5,000 cfs only reduce the inundated area of the stream bed at these measured cross-section by an average of 5 percent (USGS unpublished data).”
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So, What’s Changed Since October 2012…?

…the minimum area estimated increase by 2X stream bed at these measured cross-section by an average of 10 percent (USGS unpublished data).”

PRELIMINARY DATA DO NOT CITE
Only a limited subset of the existing channel cross sections are located across such low-angle shorelines as seen below, but those that do, such as at -14.4 (below Pumphouse Bar), show much greater than a 5% wetted width reduction between 8,000 and 5,000 cfs.

6 of the 24 Existing Cross Sections were deemed to be representative of low-angle channel habitats and were assessed for habitat area dewatering in 5 study segments between river miles -03.1 and -14.4 [total subsample of 4 km]
Many Factors May Influence Aquatic Productivity in the Tailwater

- Canyon/Channel Geometry (*Water Depth & Aspect [light]*)
- Lake Powell Quality of Water (nutrients, DO, Temp)
- Annual Thermal Regime (variations related to above)
- Turbidity (total suspended sediment & dissolved organics)
- Channel Bed Substrate (bedrock or gravel vs. sand or finer)
- Dam Operations (*monthly to seasonal high & low-flow patterns*)
- Wetted Channel Area (*and its variations related to above*)
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These three elements might be important, but not the most important parameters to consider regarding questions about what primarily limits aquatic invertebrate diversity & abundance?
There are Clear Longitudinal Variations in Aquatic Resources
(likely related, in part, to channel characteristics)

Drifting midge larvae concentrations
~ 8,000 cfs, May 2013 relative to channel-bed shear stress
Data: Muchlbauer & Kennedy et al. unpublished

Why are “Hot Spots” hot…

… and why are others not?

Rainbow trout catch per 250-m shoreline segment
Pre- vs. Post-2012 HFE below Glen Canyon Dam
Data: Yard & Korman et al. unpublished
Recall that Depth Matters in Light Attenuation & GPP
X-Sections that Would Ideally Represent some of the Other Low-Angle Habitats in Glen Canyon
Site Characteristics for Five Segments Evaluated
(Δ’s in shoreline area inundated from 8,000 to 5,000 cfs)

<table>
<thead>
<tr>
<th>STUDY SITE NAME</th>
<th>FOUR-MILE BAR (-04.1 to -03.1)</th>
<th>9-MILE DRAW &amp; HORSESHOE BEND (-10.6 to -09.1)</th>
<th>PROP BAR (-12.4 to 11.8)</th>
<th>POWERLINE BAR (-13.9 to 13.5)</th>
<th>FOURTEEN-MILE BAR (-14.5 to -14.0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approximate Site Length (m)</td>
<td>1000</td>
<td>1500</td>
<td>600</td>
<td>400</td>
<td>500</td>
</tr>
<tr>
<td>X-Section(s) &amp; (River Miles) for study of low-angle shorelines</td>
<td>R-5 (-04.4) R-4 (-03.2)</td>
<td>R-13 (-10.6) R-12 (-10.2) R-11A (-09.6) R-11 (-09.1)</td>
<td>R-15 (-12.4) R-17 (-13.8) R-18 (-14.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vert. Elev. Δ from 227 to 142 m³/s (2000 era) in meters</td>
<td>R-5 (0.39 m) R-4 (0.20m)</td>
<td>R-13 (0.30 m) R-12 (0.30 m) R-11A (0.34 m) R-11 (0.33 m)</td>
<td>R-15 (0.36 m) R-17 (0.38 m) R-18 (0.41 m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Historic Vertical Scour 1965-2000 (m) ~ 150 m³/s stage</td>
<td>R-5 (0.70 m) R-4 (0.60 m)</td>
<td>R-13 (2.20 m) R-12 (2.15 m) R-11A (1.30 m) R-11 (2.0 m)</td>
<td>R-15 (2.05 m) R-17 (2.20 m) R-18 (2.25 m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study Segment Aspect (annual solar insolation)</td>
<td>NW-SE &amp; E-W (less variable)</td>
<td>E-W &amp; N-S (less variable)</td>
<td>E-W (more variable)</td>
<td>E-W (more variable)</td>
<td>NE-SW (less variable)</td>
</tr>
</tbody>
</table>

The 6 X-Sections used in the assessment were not optimally located over “low-angle” [11 percent slopes] habitats of most interest, but were all that exist at present.

~49% (12 km) of tailwater has “low-angle” habitat – (4 km of that was subsampled)
Preliminary Low-Flow Habitat Area Assessment Results
(Δ’s in shoreline area inundated from 8,000 to 5,000 cfs)

16 hectares is an Area Equal to ~35 NFL Football Fields...

Again, this is about 2X the area initially estimated by Kennedy & VanderKooi in 2012...

It is still not possible to estimate what low-flows to 5,000 cfs mean relative to fish and food base...

Operations in fall months have already been as low as 6,000 cfs...

Summer 2013 sand inputs & NOV HFE might also be confounding influences

This Estimate is about 10X larger than one made by Yard Initially - 1994
Low-Flow Inundation - Site Responses

(Δ’s in area/unit length (100 m) - 8,000 to 5,000 cfs)

Responses Vary by Site - Most Low-Flow Sensitive Sites Upstream – Most Robust Downstream

Lees Ferry → DOWNSTREAM

1/7th Effect

UPSTREAM → Dam

7X Effect
Historical Channel Incision in Response to Dam Operations Increased Low-Flow Areas Upstream

Vertical $\Delta$ from 5-8 kcfs is a 2X larger near dam than at Four-Mile Bar (from Grams et al. 2007)

Vertical & Lateral Erosion Expanded Width of X-Sectional Low-Flow Area

Fourteen Mile Bar (14.4-R)

Cross-Section Just Below Duck Island – 9.9-I
Consider Implications of Higher Flows on Habitat
(Δ’s in shoreline area inundated Above 8,000 cfs)

WY 2008 Spring HFE & Equalization Operations in WY 2011 Increased Trout Survival (after Korman et al. 2011)

Four-Mile Bar
X-Section R-4
River mile -3.2

Fourteen Mile Bar
X-Section R-18
river mile -14.4

Perhaps Aquatic Habitats (cobble bars) could also be Individually Evaluated for Flows above 8,000 cfs?
Estimating Shorelines w/o a Flow Model

8,000 to 45,000 cfs

FOUR-MILE BAR (-4.1 to -3.1)

Estimating shorelines over range of releases may be critical to planning future managed flows & experiments?

FOURTEEN MILE BAR (-14.4-R)

Higher Elevation Bars have become More Vegetated under Lower Volumes?
Preliminary Concluding Thoughts

- Flows at 5,000 cfs have rarely occurred since 1996 (mostly 2003-6 testing)
- No food base monitoring data were collected when they did occur (ugh)
- Wet channel area is reduced in low-angle habitats by ~10% (8 to 5 kcfs)
- This area reduction consists of about 16 hectares or 1,700,000 sq. ft.
- Habitat sensitivity to low-flow changes is highly site dependent
- Sites nearer to the dam appear to be most sensitive to these changes
- More detailed channel geometry data is needed for areas not assessed
- Scientists unlikely to detect effects of daily flows at 8,000 vs. 5,000 cfs

Perhaps Seasonal Timing of Low vs. Higher Flows & Temperature is the ???