The future of the fishes of the Colorado River and it’s tributaries

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Colorado River Basin

“Our nation’s most endangered river” (2013)
Colorado River Basin

4 federally listed (ESA) endangered, endemic fishes
Native Fishes of the CRB

PROTECTED ‘Three Species’

4 ENDANGERED Fishes of the Colorado River

Humpback Chub
Gila cypha

Bonytail
Gila elegans

Colorado Pikeminnow
Ptychocheilus lucius

Razorback Sucker
Xyrauchen texanus
Colorado River Basin

- Body morphology
- Wide physical tolerance
- Longevity
- Fecundity
- Life-history expression
- Movement
- Opportunistic feeders
- Depauperate
Future?

History: A natural landscape (fish-scape)

- diverse
- heterogeneous,
- varies in space
- it varies in time
Dynamic

Drought & drying

Monsoon desert flood
• Complementary habitat types
• Movement among patchily distributed resources
• Re-colonization after local extinction
• *Genes to individuals to meta-populations*
Robust Metapopulation Structure

Time 1
Robust Metapopulation Structure

Time 2

colonization > extinction
Contemporary Fishscape
Dramatically Altered Hydrology (‘lost’ spring, snow melt flood)

Dramatically Altered Physical template = Degraded fish habitat
Autumn       Winter       Spring       Summer

Mean daily discharge (cfs)

1910-1918

- Snow melt run-off
- High discharge, longer duration
- High power, channel reorganization
- Flushing of sediment
- Queued native fish
  life-history expressions
Not Dynamic
Not heterogeneous

Simplified, homogenous
“run” habitat (lower river)

Jack and colleagues
Not connected at large scale
Tagged in White River in 2007
Travelled 282 km from June to July “sampled” 2 tributaries.
Not connected at small scale

Hatt’s Ranch – San Rafael River

~60 km of dry river – San Rafael R

Farnham Diversion – Price River
Non-native, invasive species

- ~40 non-natives fishes introduced
  - ALSO non-native plants, mollusks, invertebrates, & disease
- Competitors
- Predators
- Altered Food Web
  - Flow of energy
- Single biggest threat?
- Synergistics!
- May be better adapted to altered physical template
- Never be completely eliminated
- Not a big threat when recovery planning was first underway

Photo by Tom Chart
Contemporary Fishscape/Ecosystem

- Completely altered flow and sediment regime
- Homogenous and degraded habitat
- Fragmented at landscape and local levels
  - Intermittent drying
- Lentic (lake) habitat in what was Lotic (riverine)
- Climate is getting warmer and drier
- Wildfires are increasing
- Non-native, invasive fishes are ubiquitous
- Non-native, invasive fishes often have the advantage given above
Future? Novel Ecosystem

Anthropogenic biomes tell a completely different story, one of “human systems, with natural ecosystems embedded within them”. This is no minor change in the story we tell our children and each other. Yet it is necessary for sustainable management of the biosphere in the 21st century.

Ellis and Ramankutty 2008

- Lack natural analogs
- The historical state is largely unachievable
- Physical and biological processes do not obey laws of nature
Novel Ecosystems may require Novel Solutions

- Embrace opportunity
- Targeted management
- Prioritizing efforts
Accept Ecosystem as Novel
Embrace Opportunity: 3 case studies/scenarios

1) Contemporary Connectivity: Lake Powell/San Juan Razorback Sucker
2) Water management across years. Planned releases and mini-floods in tributaries
3) Targeted non-native removal and translocations in tributaries
1) Contemporary Connectivity: Lake Powell/ San Juan Razorback Sucker

- Arose ~5 million years ago...
- Up to 1 meter, 40 years
- Listed under ESA
- Sustained largely through stocking from hatcheries
- Loss of complimentary habitats
- Predation of juveniles by non-natives
- “New” population
- Reproducing in the wild
- Reaching large size
- Likely Highly Fecund
- “Unusual”, “not typical”, “not riverine enough”? 
The graph shows the elevation changes of Lake Powell from 1980 to 2019. The elevation is measured in feet, and the data points indicate a fluctuating pattern over the years. The inset diagram illustrates the geological features around Lake Powell, including the delta and river deposits.
Piute Farms Waterfall

- More than 1000 endangered RZB trying to ascend and presumably spawn
- 10-15 year old fish
  - ~as many 50,000 eggs
600 mile voyage
Lake Powell:
Novel habitat RZB (“atypical”?)
More than 1/3 of SJ population
Full of invasive non-native sport fishes

San Juan River:
Spawning grounds for RZB
Relatively few non-native, invasive fishes
Refuge for young natives

Management paradox?

Novel environment
Novel population of endangered fish
Novel feature
1) Contemporary Connectivity: Lake Powell/ San Juan Razorback Sucker

- Accept population for what it is...
  - “lava poured over the lip of the Grand Canyon would have dammed the river, forming a large lake-JS”

- Embrace novel opportunity

- Restore ‘selective’ connectivity
  - Selective fish barrier

- Allow RZB go up to spawn
  - Block non-natives

- Cost Benefit Ratio
  - Compare to recovery efforts elsewhere in CRB...$$$
  - Maybe good for other spp., pikeminnow too

I have demonstrated I am a good fish, why not let me go do what I know how to do?
2) Water management across years. Planned releases and mini-floods in tributaries.
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Tributaries of the Green and Colorado Rivers:

- No flood (no habitat)
- Drying in dry years (fish mortality)
- Larvae and Juveniles = more sensitive to threats and poor habitat
- Good year followed by drying the next year obliterates any contribution of the good year
- Negative feedback loop on willingness of irrigators to cooperate
2) Water management **across** years. Planned releases and mini-floods in tributaries.

Tributaries of the Green and Colorado Rivers:

- Wet years: coordinated and timed ‘sequential’ hold and release – mini flood
2) Water management across years. Planned releases and mini-floods in tributaries.

Tributaries of the Green and Colorado Rivers:

- Wet years: ‘sequential’ hold and release – mini flood
- Agree minimum flows for 1-2 years post mini-flood
  - Allows fish to mature to ”smarter” and more mobile young adults
- Good year class could trickle through next 10-15 years
- Don’t request water in “other” years
- Generation retiring – buy water rights
- Novel opportunistic approach
- Implications for mainstem?
3) Targeted non-native removal and translocations in tributaries

- Western Grand Canyon is now 95% native fishes (*BIO-West, Inc.*)
- Why?

*B. Healy and many partners*
3) Targeted non-native removal and translocations in tributaries

• Western Grand Canyon is now 95% native fishes (BIO-West, Inc.)
• Why?
• Temps post dam were cold and constant = unsuitable for native fishes

Provided by C. Yackulic
Sometimes nature throws us a bone and “opportunities”

- Grand Canyon is now 95% native fishes
- **Why?**
- Lake Powell low levels
  - water being released comes from “higher” elevations in the reservoir = warmer
Sometimes nature throws us a bone and “management opportunities”

- Grand Canyon is now 95% native fishes
- **Why?**
- Temperatures are now closer to historical temperatures optimal for natives
  - and not suitable for many non-natives

Provided by C. Yackulic
Sometimes nature throws us a bone and “management opportunities”

- Grand Canyon is now 95% native fishes
- **Why?**
- Difficult for non-natives to move from Lake Mead to GC as it also drops
- Pearce Ferry Rapid
Tributaries are key: selective removal of non-native trout

- Bright Angel Creek
  - Natural hydrograph and temperature regime
  - Home to many natives
  - Full of NN brown trout
    - Source to mainstem
- 2012 - NPS and cooperators began selective, mechanical removal of NN trout creekwide

Provided by B. Healy
Tributaries are key: selective removal of non-native trout

- Response:
  - Positive
  - Rapid
  - Unequivocal

- Native fishes have increased by several orders of magnitude

- Eliminated a likely source of brown in west CG mainstem

Provided by B. Healy
Joe Tomelleri Illustrations
Tributaries are key: translocations of humpback chub

- 2011-2016
- NPS and partners: Translocating HBC from The Little Colorado R. (LCR) to Havasu Creek
- Goal = establish 2\textsuperscript{nd} spawning population in Grand Canyon (about 100 miles downstream of LCR)
- Created a source to mainstem
Why is the GC now 95% native fishes?

- Embrace opportunity
- Recovery and persistence requires a targeted, multi-faceted approach
  - Time
  - Space

Lake Powell Drop
Warmer Temps

Tributary Removal of Non-natives

Native Fish

Lake Mead Reduced access

Tributary Translocations Natives

Photo by Bob Schelly
The future of the fishes of the CR and its tributaries requires a shift to a more landscape ("fishscape") approach to management

- Effective fish management must be integrated across time
  - Water comes and management occurs on an annual basis
    - These fishes live 20-50 years (not 1 year)
  - Cannot expect to see a response from a 1-year change
    - if the next year everything changes again
  - Opportunities exist, monopolizing on good water years and managing for 1-3 years that follow immediately thereafter
    - May be possible to do much less in "other" years
- Manage at a time scale more reflective of the life cycle of the organism we are trying to conserve and restore
The future of the fishes of the CR and it’s tributaries requires a shift to a more landscape (fishscape) approach to management.

- Effective fish management must be integrated across space
  - Native fishes swim hundreds of miles to utilize complimentary habitat types
  - Fishes don’t “know” where the anthropogenic boundaries are
    - State lines are meaningless
    - Basin boundaries are meaningless
    - If they can move, they will
  - Opportunities exist, selective fish barriers that restore connectivity where it matters most
    - And where success can be easily tracked
  - Tributaries are just as important as the mainstem, easier to work in
    - yet often overlooked not included in basinwide recovery programs
The future of the fishes of the CR and its tributaries...

uncertainty is no excuse for inertia

“The only real mistake is the one from which we learn nothing”

Riverwide coordinated experimental flood?
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