Welcome to the Conservation Lecture Series

www.dfg.ca.gov/habcon/lectures

Questions? Contact margaret.mantor@wildlife.ca.gov
Lecture Schedule

Rare Plants in Pine Hill, Dr. Debra Ayres
   January 22, 1:00-3:00, Sacramento

Bighorn Sheep, Dr. Jeff Villepique
   February 4, 1:00-3:00, Ontario

Tricolored blackbird, Dr. Robert Meese
   February 4, 1:00-3:00, Sacramento

Invasive Watersnakes, Dr. Brian Todd
   March 12, 1:00-3:00, Sacramento

White-nose Syndrome in Bats, Dr. David Wyatt
   April 14, 12:00-1:30, Sacramento
From algal food-web ecology to dam management:
Connecting the dots one tadpole at a time

Sarah Kupferberg, McBain Associates

Scott McBain, Steve Bobzien, Alessandro Catenazzi, Joe Drennen, Paula Furey
Amy Lind, Wendy Palen, Mary Power, Sarah Yarnell
SFPUC, California Energy Commission
• 15% of California’s electricity from hydropower
• CA >2x the dams of any other state
• Highest biodiversity in the US
• Mediterranean climate supply in winter, demand in summer
Many large projects being relicensed

Competing demands for water

Utilities, municipal water districts, agricultural users, recreational boaters, sport fishers, commercial and native salmon fishers, wildlife

Opportunity for science to inform

- Large-scale water policy
- Long term 30+ yrs impact

Viers et al. 2007
Example of conflict: dams block fish migration

- Frogs move opposite direction of salmonids
- Frogs vs. fish when migration blocked
Altered versus natural flow regime
- flat line
- pulsed flows for boating
- power peaking
- rapid cessation of spill
AQUATIC, VULNERABLE TO FLOW FLUCTUATION

Amphibious, Resistant

Gravid yr 3

Yrs 1,2

Hatching, wk 2

Stranded clutches

Amplexus

Mo 4

MISMATCH impaired conditions / adaptations

Mo 2
Recapture of NF Feather female by Garcia & Assoc indicates longevity ≥ 12 yrs.
Hydrologic alteration has impacts across scales

- **Stage-based hydro impacts** (minutes - months - yrs)
- **Individual population trajectories** (5-20 yrs)
  - time series analysis
- **Range-wide changes** (25-50 yrs)
  - historic vs. modern status
  - average density reg vs. unreg
Range-wide changes over 50 yrs.

Evaluated modern status compared to known historic locations
- Landscape features
- Dam attributes (e.g. size, distance, number)

Absent from >50% of historic sites

Absent localities had:
- more large dams upstream \( (p<0.1) \)
- greater height of dams \( (p<0.05) \)
Population density and trends
Regulated vs Unregulated

Compiled breeding survey records for 27 populations
- compared average #/km
- monitored temperatures in 6 locales

- N. Fk. Trinity / Trinity
- N. Fk. Feather / M. Fk Feather
- N. Fk. of M. Fk. American / Rubicon
- S. Fk Eel / Eel
- Clavey / Tuolumne
- Alameda Ck. below Calaveras / upstream of Calaveras

Bar chart showing:
- Regulated vs Unregulated egg masses / km
  - n=16 for Regulated
  - n=11 for Unregulated
Population trends in relation to multiple stressors

a) S Fk Eel

b) N Fk Feather

- Regulated by Poe Dam
- Regulated by Cresta Dam

Alameda Creek

- unregulated
- regulated
Hypolimnetic releases

N. Fk. Trinity / Trinity
S. Fk Eel / Eel
N. Fk. Feather / M. Fk Feather
N. Fk. of M. Fk.
American / Rubicon
Clavey / Tuolumne
Alameda Ck. below Calaveras / upstream of Calaveras
Realized thermal niche

Regulated vs Unregulated

Sierra

Coast / Cascade

Tuolumne
American
Feather
>5 clutches/km
absent

Warmest 30 day mean temp

°C

Realized thermal niche

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War
Hydrologic alteration has impacts across scales

Small

Stage-based hydro impacts
(minutes - months - yrs)

Rearing experiments
- Thermal performance
- Growth / food quality

Large

Population and range wide status
Decades

Spatial Scale
Algal succession during summer low-flow

Great tadpole food
*Cladophora* with heavy epiphyte load

Often “rusty-red” in the field
Foothill yellow-legged frog tadpoles are incredible periphyton scrapers

Convert algae into snakes and other consumers
Reared tadpoles at different temperatures
Water temperature x food quality

Daily mean water temperature in July (°C)

Proportion surviving

supplemented *Cladophora / Epithemia*

ambient periphyton only
Thermal preference, performance, population abundance aligned.
Mechanistic approach to determine model reproductive success rather than habitat

weighted usable area

streamflow
Frog Reproduction Model-what it is

- Excel spreadsheet
- Cross section based, 1-dimensional
- Daily time step
- Start at breeding, end at overwintering
- Uses multi-yr time series of daily data
- Assesses fate of eggs and tadpoles each year
- Predicts changes in reproduction success as function of:
  - discharge
  - water temperature
  - channel geometry
  - egg laying depth
  - breeding dates ...and other parameters
Computational process for immobile stages

Left bank looking downstream

Breeding Day 1
Breeding Day 6
Breeding Day 30

Water surface on day 1 of breeding

0.5 ft below water surface

Right bank looking downstream

3/4/2009 Water Surface (Q=842 cfs)
3/18/2009 - Water Surface (Q=14 cfs)
5/14/2009 - Water Surface (Q=3.2 cfs)
3/18/2009 - Ground Surface

Distance from left bank pin (ft)
Simplified channel shape ↓
topographic diversity
  ◦ Less habitat for breeding
  ◦ Less lateral warming
  ◦ Steeper stage-discharge rating curves
1. Model assesses if days of inundation > time needed for embryos to develop

Mean days for egg hatching
Mean daily temperature during embryo development (degrees C)
2. Model assesses survival based on empirical scour relationship

Alameda Creek (n=15 yrs)
3. Model assesses time to metamorphosis using field rearing experiments

\[ y = -5.5467x + 192.02 \]

\[ R^2 = 0.814 \]
Primary performance metrics

% of clutches avoiding desiccation

% avoiding scour (based on $Q_{\text{max}}/Q_{\text{min}}$ relationship)

time for post-metamorphic growth
Site-specific Input variables (default values)

- Rating curve
- Daily average streamflows
- Daily average water temperatures
- Breeding trigger (11.5°C) and/or date
- Breeding season duration (30 days)
- Egg laying depth (0.5 ft)
- Duration of immobile tadpole (7 d)
- Duration front limbs to full metamorphosis (10 d)
- Lower limit of tadpole thermal niche (16.5°C)
- Onset of winter (November 15)
Example of Alameda Ck output (2009)

Observed

Proposed future flow

No change in survival to hatching
Cold water releases from Calaveras Dam

Calculated monthly mean for July -- Future Impaired

- Water temperature (°C)
- River Mile

- Calaveras Ck. confluence (node 3)
- Below Welch Ck. confluence (node 4)
- Current FYLF spatial distribution
- Thermal preference range
- Survival optimum
- Alameda Ck. Diversion Dam

Graph shows temperature changes from 1996 to 2009, with specific points marked for different nodes and water bodies.
Alameda Ck predictions

- Avg. risk of strand and scour similar across flow scenarios
- future impaired flow regime may cause water temperature reductions that will be below the lower limit for tadpoles
Contrast to Trinity desiccation

17 JULY 06 965 cfs
24 JULY 06 508 cfs
31 JULY 06 489 cfs

Field data
Jamie Bettaso, USFWS
Tuolumne River

*R. boylii*

rare relative to Clavey
Were historic conditions more favorable?

### Existing to Calculated Unimpaired Comparison

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<thead>
<tr>
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<tbody>
<tr>
<td># of days with survival to hatching</td>
<td>+20</td>
<td>+22</td>
<td>-6</td>
</tr>
<tr>
<td>Days of post-metamorphic growth</td>
<td>+61</td>
<td>+64</td>
<td>+57</td>
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Unimpaired Snowmelt hydrograph → 20 days of stranding
Summary of model uses

- Conduct gaming of alternate flow / thermal regimes
- Evaluate responses to change in channel geometry (i.e. restoration)
- Predict % of successful breeding years
- Use output as input for a population viability analysis
- Examine if unimpaired conditions would have been suitable
- Many opportunities to expand model
  - 2-D hydraulic model rather than 1-D cross section based
  - Incorporate physically-based egg mass scour thresholds
  - Incorporate site specific information about food quality
Connect hydrologically and thermally driven changes in periphyton to effects on tadpoles as grazers.

![Images of periphyton and tadpoles](image)

### Tadpole Growth (mg change/mg tadpole)

- **Epithemia**
  - 18 C day, 14 C night: -0.3
  - 21.5 C day, 17.9 C night: -0.1

- **Didymosphenia geminata**
  - 18 C day, 14 C night: 0.0
  - 21.5 C day, 17.9 C night: 0.2

- **Other stalked spp.**
  - 18 C day, 14 C night: 0.3
  - 21.5 C day, 17.9 C night: 0.4
Summary

Spatial Scale

- small
- large

Stage-based hydro impacts (mo - yrs)
- Individual population trajectories (5-20 yrs)
- Range-wide changes (25-50 yrs)

Survival linked to hydrologic variability, temperature, food
- Eggs & larvae most sensitive stages

Greater hydro. modification = declining/diverging population trends

Absent from sites with largest influence by dams
- Regulated sites generally colder and smaller frog populations
Questions?