Development of New Information to Inform Fish Passage Decisions at the Yale and Merwin Hydro Projects on the Lewis River

Robert Al-Chokhachy (USGS)*, Dave Beauchamp (UW), Mark Sorel (UW), and Chris Clark (MSU)
Outline

1. Project objectives

2. Task-by-task description of methods and preliminary results

3. Future modeling efforts target overarching questions
Scope of Work: project tasks

1. Review information regarding fish transport into Lake Merwin and Yale Lake
2. Habitat assessment of tributaries to Yale Lake and Lake Merwin
3. Assessment of adult potential for spawning success
4. Assess juvenile production potential and emigration success
5. Evaluation of Lake Merwin predator impacts
6. Assess anadromous/resident interactions
Scope of Work: project tasks

1. Review information regarding fish transport into Lake Merwin and Yale Lake
2. Habitat assessment of tributaries to Yale Lake and Lake Merwin
3. Assessment of adult potential for spawning success
4. Assess juvenile production potential and emigration success
5. Evaluation of Lake Merwin predator impacts
6. Assess anadromous/resident interactions
Scope of Work: project tasks

1. Review information regarding fish transport into Lake Merwin and Yale Lake
2. Habitat assessment of tributaries to Yale Lake and Lake Merwin
3. Assessment of adult potential for spawning success
4. Assess juvenile production potential and emigration success
5. Evaluation of Lake Merwin predator impacts
6. Assess anadromous/resident interactions
Task 2: Habitat assessment of tributaries to Yale Lake and Lake Merwin

- Study tributaries
Task 2: Habitat assessment of tributaries to Yale Lake and Lake Merwin

• Objectives and methods
  1. Quantify the extent of habitat within the tributaries
  2. Quantify flow and thermal regimes in tributaries
  3. Assess tributary habitat and riparian conditions
  4. Rerun EDT model with quantitative field-bases measures of habitat
Task 2: Habitat assessment of tributaries to Yale Lake and Lake Merwin

2. Quantify flow and thermal regimes in tributaries
   • Methods:
     – Install pressure transducers at top and bottom of tributaries
     – Quantify stage-discharge relationships
Task 2: Habitat assessment of tributaries to Yale Lake and Lake Merwin

3. (and 4) Assess tributary habitat and riparian conditions
   • Methods:
     • Utilize existing habitat protocols within the PNW (CHaMP)
     • Continuous habitat surveys
       – Given site-site variability in reach-based assessments
Channel unit attributes

- Habitat attributes
  - Bankfull width, wetted width, depth
  - Substrate
  - Channel units
  - Large woody debris
  - Gradient
  - Riparian condition
- All georeferenced
- Collected specifically for parameterizing EDT model
## Task 2: Habitat assessment

<table>
<thead>
<tr>
<th>Stream</th>
<th>Length (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lake Merwin</strong></td>
<td></td>
</tr>
<tr>
<td>Brooks Creek/B1</td>
<td>4.1</td>
</tr>
<tr>
<td>Buncombe Hollow Creek</td>
<td>1.1</td>
</tr>
<tr>
<td>Cape Horn Creek</td>
<td>0.5</td>
</tr>
<tr>
<td>Indian George Creek</td>
<td>1.5</td>
</tr>
<tr>
<td>Jim Creek</td>
<td>0.5</td>
</tr>
<tr>
<td>Lower Speelyai</td>
<td>0.3</td>
</tr>
<tr>
<td>Rock Creek</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8.2</strong></td>
</tr>
<tr>
<td><strong>Yale Lake</strong></td>
<td></td>
</tr>
<tr>
<td>Cougar Creek</td>
<td>3.9</td>
</tr>
<tr>
<td>Dog Creek</td>
<td>0.3</td>
</tr>
<tr>
<td>North Siouxon Creek</td>
<td>0.7</td>
</tr>
<tr>
<td>Ole Creek</td>
<td>1.7</td>
</tr>
<tr>
<td>Panamaker Creek</td>
<td>0.4</td>
</tr>
<tr>
<td>Siouxon Creek</td>
<td>6.1</td>
</tr>
<tr>
<td>Speelyai Creek</td>
<td>6.0</td>
</tr>
<tr>
<td>Swift Bypass Channel</td>
<td>6.5</td>
</tr>
<tr>
<td>W. Fork Speelyai Creek</td>
<td>1.3</td>
</tr>
<tr>
<td>W. Tributary Speelyai Creek</td>
<td>1.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>28.0</strong></td>
</tr>
</tbody>
</table>
Task 2: Habitat assessment of tributaries to Yale Lake and Lake Merwin

5. Rerun EDT model
   • Empirical habitat data used to rerun EDT models
   • Kevin Malone et al. DJ Warren
Scope of Work: project tasks

1. Review information regarding fish transport into Lake Merwin and Yale Lake
2. Habitat assessment of tributaries to Yale Lake and Lake Merwin
3. **Assessment of adult potential for spawning success in Yale and Merwin**
4. Assess juvenile production potential and emigration success
5. Evaluation of Lake Merwin predator impacts
6. Assess anadromous/resident interactions
Scope of Work: project tasks

1. Review information regarding fish transport into Lake Merwin and Yale Lake
2. Habitat assessment of tributaries to Yale Lake and Lake Merwin
3. Assessment of adult potential for spawning success
4. **Assess juvenile production potential and emigration success**
5. Evaluation of Lake Merwin predator impacts
6. Assess anadromous/resident interactions
Task 4: Assess juvenile production potential and emigration success

• Objectives and methods

1. Determine emigration timing into Swift Reservoir
2. Quantify behavioral relationships with streamflow, temperature, and interannual differences
3. Understand factors influencing tributary growth
4. Quantify travel times and survival to collection facility
5. Evaluate behavior near collection sites
Task 4: Methods-stream habitat

• Determine emigration and factors influencing emigration timing into Swift Reservoir
  – 2013 installed a Biomark, full duplex PIT-tag antenna with level reader and temperature logger in Clear Creek
Task 4: Methods-stream habitat

• Determine emigration timing into Swift Reservoir
  – Wild Coho
  – 20 reaches per year-5 km of habitat

• Marking fish with 12 mm PIT-tag
  – 2013 = 357 fish
  – 2014 = 883 fish
Task 4: Methods-stream habitat

• Determine emigration timing into Swift Reservoir
  – Wild Coho
  – Releases PIT-tagged acclimation Chinook
    • Acclimation ponds
  – Migration timing

<table>
<thead>
<tr>
<th>Year</th>
<th>Species</th>
<th>Clear Creek</th>
<th>Crab Creek</th>
<th>Muddy River</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>Chinook</td>
<td>1,750</td>
<td>750</td>
<td>1,750</td>
</tr>
<tr>
<td></td>
<td>Coho</td>
<td></td>
<td></td>
<td>2,000</td>
</tr>
<tr>
<td>2014</td>
<td>Chinook</td>
<td>7,576'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>Chinook</td>
<td>3,400</td>
<td>3,300</td>
<td>3,300</td>
</tr>
</tbody>
</table>
Task 4: Methods-stream habitat

- Understand factors influencing tributary growth of wild Coho
Task 4: Methods-stream habitat

- Understand factors influencing tributary growth of wild Coho
  - Early summer and fall sampling
  - Macroinvertebrate production
  - Thermal and hydrologic regimes
    - Temperature and streamflow loggers
- Tributaries
  - Clear Creek, Drift Creek, P3
Task 4: methods

• Quantify travel times and survival to collection facility
Task 4: methods

- Quantify travel times and survival to collection facility
  - Integrate individual-specific data from PIT-tags, screw trap, and collection facility for estimates of travel times
  - Survival in different phases (e.g., tributary, reservoir, etc.)
  - Overall downstream “survival”
Task 4: methods streams

- Quantify travel times and survival to collection facility
  - Wild Coho
  - Acclimation Chinook
Task 4: methods reservoir

- Evaluate travel behavior and near potential collection facilities
  - Yale Lake
  - Compliment PIT-tag data and previous radiotelemetry data for assessments of variability of travel times
  - Habitat use near dam~potential collection facility
Task 4: methods reservoir

• Evaluate travel behavior and near potential collection facilities
  – 2014 test release of 5,000 Coho smolts
• April 8\textsuperscript{th} at Yale Park
Task 4: methods reservoir

- Evaluate travel behavior and near potential collection facilities
  - 2014 (5,000 Coho smolts)
  - Hydroacoustic surveys (UW)
    - Pre-release
    - Day of release
      - Near Yale Park to identify targets
    - Post-release
Task 4: Hydroacoustic surveys

- Quantify Coho density and abundance
- Depth interval

Thermocline
Task 4: Results
Task 4: Results-Coho

- Distribution of wild Coho sampled in Clear Creek
Task 4: Results - Coho

Emigration timing varied considerably across years
- 2013-high flow event
- 2014-mixed results

- Association with high flow events similar to Pess et al. (2011)
- Influence of low-flow -
  - More time in reservoir?
Task 4: Results-Coho

- Emigration timing
  - Tagging = Late August and early September
  - Early fall and late spring
  - Bimodal is consistent with Pess et al. (2011)
Task 4: Results-Coho

- Timing to collector
  - Similar for wild and hatchery Coho
  - May
Task 4: Results-Coho

- **Total time from marking to the FSC**
  - Wild Coho (top)
    - 7-8 months
    - After emigration from Clear Creek
      - Median = 121 days in Swift
      - Range = 27 – 347 days
  - Different results from test release of Coho (2013)
Task 4: Results-Chinook

- Acclimation Chinook in Clear Creek
  - Direct and acclimation pond releases (2014 – 2015)
  - ~60% emigrate within a week
  - 98% within 60 days
Task 4: Results

Acclimation Chinook (Clear Creek) time in Swift after passing antenna

- Median days = 69
- Range = 5 – 320 days
Task 4: Results

- All acclimation Chinook
  - From release
    - Crab Creek, Muddy River, Clear Creek
  - Bimodal
    - Apparent differences across sites and years
Task 4: Results

- Fish reaching the FSC in Swift Reservoir
- As May 31, 2015 focusing specifically on PIT-tagged fish:
  - Coho
    - 14% of hatchery Coho (2013) were collected at the FSC
    - 8% of 2013 wild fish tagged in Clear Creek
    - 5% of 2013 and 2014 fish combined (early estimate*)
  - Acclimation Chinook
    - 1.4% (2013)
    - 2% (2014)
    - 1.7% (2015)*
Task 4: methods reservoir

- Hydroacoustic survey
  - Pre-release
  - Day of release
  - Post-release
- Zones
- Paths
Task 4: Reservoir Results

- **Hydroacoustic results**
  - Smolts relatively rapidly move downstream to collector
  - **Progress downstream**
  - Use of upper water column
  - **Side-looker data**
Task 4: Summary

- Emigration success
  - In-river survival not yet computed, but expected to be high
  - Residence time in Swift Reservoir from PIT-tagged data for Coho = ~4 months, Spring Chinook = > 2 months

- Test release data suggest relatively rapid migrations
  - Radiotelemetry data
    - 5.2 km/day travel rate
  - Hydroacoustics, Yale
    - Yale Park – Dam = ~7 km

- Together results suggest difficulties of fish “finding” collector
Scope of Work: project tasks

1. Review information regarding fish transport into Lake Merwin and Yale Lake
2. Habitat assessment of tributaries to Yale Lake and Lake Merwin
3. Assessment of adult potential for spawning success
4. Assess juvenile production potential and emigration success
5. Evaluation of Lake Merwin predator impacts
6. Assess anadromous/resident interactions
Task 5: Evaluation of Lake Merwin predator impacts

Objectives and methods

1. Estimate abundance and size structure of predators
2. Quantify predator-prey interactions and evaluate if predation will be a limiting factor for anadromous populations
3. Quantify spatial and temporal distributions of predators, which may provide information for potential control efforts, if needed
Task 5: Evaluation of Lake Merwin predator impacts: methods

- Estimate abundance and size structure of predators
  - Northern Pikeminnow

- Seasonal sampling
  - Gill nets
    - Variety of gill net sizes
    - Mesh sizes 2.5 – 15.2 cm stretch
    - Perpendicular to shore
    - 24-hour sets
Task 5: Evaluation of Lake Merwin predator impacts: methods

Depth-Stratified Sinking Gill Nets in Littoral and Slope Zones
Task 5: Evaluation of Lake Merwin predator impacts: methods

- Opportunistic sampling
- Gill nets
- Traps
- Angling
- Minnow traps
Task 5: Evaluation of Lake Merwin predator impacts: methods

- Estimate abundance and size structure of predators
  - Gill netting
    - Mark-recapture study to estimate abundance (2013 – 2014)
    - External floy tags
    - Chapman estimator
Task 5: Biological and diet data

- Biological data
  - Size, age, growth, diet, energetic, trophic & reproductive status

Gut contents
- Diet

Muscle tissue:
- Stable isotopes

Scales & Otoliths:
- Age & Back-calculated size-at-age
Task 5: Thermal Environment

- Limnological and thermal data collected
Task 5: Lake Merwin predation potential

Temporal Diet Composition
Thermal Experience

Consumer Growth

Predator Energy Density
Prey Energy Density

Bioenergetics Model

Consumption Estimate

Population Consumption

Consumption as % of Prey Biomass or Production

Biomass of Exploitable prey

Consumer Size Structure & Abundance
Task 5: Results
Task 5: Results

- Abundance
  - Northern Pikeminnow
    - Tagged > 2,000 fish
    - Abundance > 200 mm = 314,000 (95% CI 175,000 – 583,000)
    - Abundance >300 mm = 5,200 (95% CI = 2,200-13,900)
  - Preliminary estimate of >300 mm NPM
    - Low
    - Bias correction, gear
    - Spatial variability in sampling
Task 5: Results

- **Distribution**
  - Majority of NPM in upper 15 m during stratification
  - High predation potential during all seasons, but particularly during spring/summer
Task 5: Results

- Size distribution
  - Northern Pikeminnow
- Tiger Muskie controls
  - Fewer >250mm fish
  - Artifact of matching up comparison
Task 5: Results

- Stable isotope data
  - Substantial differences in trophic level and forage
    - NPM
      - >300 mm
      - <300 mm
    - Tiger Muskie
Task 5: Results

- NPM length-isotope
  - Strong relationships with size
    - Forage base
    - Trophic structure
Task 5: Results

• Bioenergetics simulations
  • In progress
    – Estimate potential consumption of salmonids
    – Cannibalism
    – Tiger Muskie-controls
Scope of Work: project tasks

1. Review information regarding fish transport into Lake Merwin and Yale Lake
2. Habitat assessment of tributaries to Yale Lake and Lake Merwin
3. Assessment of adult potential for spawning success
4. Assess juvenile production potential and emigration success
5. Evaluation of Lake Merwin predator impacts
6. **Assess anadromous/resident interactions**
Next steps

• Finalize fieldwork-related to emigration, instream survival, final isotope data collection, lab work
Next steps

• Finalize fieldwork-related to emigration, instream survival, final isotope data collection, lab work

• Integrate field data from Task 6 to model potential effects of Coho on existing bull trout populations
  – Yale, Swift
Individual-based model

- Small population in Swift/Yale
  - Enables tracking of individuals
  - Averages for small populations not applicable (e.g., matrix models)
  - Local, empirical data

![Diagram of fish life cycle](image)
Individual-based model

- Small population in Swift/Yale

-Negative effects of superimposition

Mature bull trout

Competitive interactions

-Competitive interactions
-Growth, fecundity
Individual-based model

- Small population in Swift/Yale
  - Empirical estimates of growth, life-history, etc.
- Likely risk to populations
Next steps

• Finalize fieldwork-related to emigration, instream survival, final isotope data collection, lab work

• Integrate field data from Task 6 to model potential effects of Coho on existing bull trout populations

• Assess feasibility of reintroductions in Yale and Merwin
Reintroduction feasibility

• Integrate results different field components
• Modeling framework
Reintroduction feasibility

- Modeling framework
Reintroduction feasibility

- Integrate different field components

![Map with river system and points indicating juvenile production and travel times and reservoir rearing]
Reintroduction feasibility

- Integrate different field components

Juvenile production

Predation and bioenergetics

Travel times and reservoir rearing
Reintroduction feasibility

• Integrate different field components

- Collection efficiency
- Predation and bioenergetics
- Travel times and reservoir rearing
- Juvenile production
Reintroduction feasibility

- Integrate different field components

Ocean survival and return

Collection efficiency

Predation and bioenergetics

Travel times and reservoir rearing

Juvenile production
Reintroduction feasibility

- Integrate different field components

Ocean survival and return
Collection efficiency
Predation and bioenergetics
Travel times and reservoir rearing
Density dependence
Juvenile production

Ocean survival and return
Collection efficiency
Predation and bioenergetics
Travel times and reservoir rearing
Density dependence
Juvenile production
Questions