Identifying future threats to salmon populations in the Copper River watershed, Alaska

Derek B. Booth, Frank K. Ligon, Matt R. Sloat, Byron Amerson, and Stephen C. Ralph

Stillwater Sciences
Seattle, WA
Arcata, CA
Berkeley, CA

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River Restoration Northwest

Goal: to protect Copper River salmon populations from potential short- and long-term changes to the watershed.
What constitutes “restoration” in such a setting?

Correcting past damage by building something?

...or...

Protecting against future damage by anticipating change and preparing for it.

**Approach:**

- Define channel types and reference conditions for streams in glaciated watersheds.

- Characterize the reach-scale channel characteristics and key geomorphic determinants.

- Identify patterns of salmonid species and life-stage distribution, density, and habitat use.

- Predict patterns of salmonid usage, watershed-wide, using field-calibrated GIS-based techniques.

- Anticipate potential disturbances (e.g., changes in land use or regional climate) to landscape processes and thus salmon populations.

- Develop a monitoring plan to recognize those disturbances and their expression before salmon populations have responded.
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A varied geology is imposed on the topography of individual watersheds…

…giving rise to a tremendous variety in channel types and habitats.
Surface Geology
Copper River Watershed

Legend
surface geology
DEPOSIT NAME
- COASTAL
- FLUVIAL
- GLACIAL MORAINE & DRIFT
- GLACIOFLUVIAL
- GLACIAL-LACustrine
- ICE
- MOUNTAINALUVIUM & COLLUVIUM
- WATER

Copper River delta
Application to the Copper River Watershed

Tonsina River Watershed Case Study

Funding provided by the Copper River Watershed Project, Patagonia, Mountaineers Foundation, the Charlotte Martin Foundation, Ecotrust.
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Glacial-headwater channel of the upper Tonsina River:

- Tonsina Lk.
- Tonsina River
- Copper River
- Tonsina Watershed
- Modern glaciers
- Bedrock
- Relict glacial lake deposits
- Moraine
Terrain-traversing course of Greyling Creek:

Tonsina Lk.

Copper River

Tonsina River
Unconfined valley, Greyling Creek

Confined valley, Greyling Creek
Sediment-delivery processes in portions of the confined-valley reach

High terrace

Low terrace

Modern floodplain

Sediment-dominated channel morphology at the mouth of Greyling Ck.
Tonsina Lk.

Tonsina River

Copper River

Lower Tonsina River

Note relict dead-ice topography

Tonsina Lake
DISTINCTIVE CHANNEL TYPES IN THIS WATERSHED:

• Channels that flow down the axis of once-glaciated valleys (“axial channels”)—confined and unconfined

• Channels that flow across those valleys as sidehill tributaries—with or without a low-gradient, valley-floor reach.
CHANNEL TYPES

Sidehill tributary channel without valley-floor reach: lower Hurtle Creek

CHANNEL TYPES

Confined axial channel: lower Greyling Creek

Note confining terrace
Approach:

- Define channel types and reference conditions for streams in glaciated watersheds.
- Characterize the reach-scale channel characteristics and key geomorphic determinants—channel dimensions & gravel size.
- Identify patterns of salmonid species and life-stage distribution, density, and habitat use.
- Predict patterns of salmonid usage, watershed-wide, using field-calibrated GIS-based techniques.
- Anticipate potential disturbances (e.g., changes in land use or regional climate) to landscape processes and thus salmon populations.
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Field data-collection results:

- Drainage area vs. predicted bankfull depth (to calculate bankfull shear stress from DEM, watershed-wide)
- Shear stress vs. predicted median grain size (to predict spawning gravel distribution, watershed-wide)

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Importance of microhabitat for species presence and species overlap—i.e. *spatial scale* is important.
<table>
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<th>Transect</th>
<th>Habitat area (ft^2)</th>
<th>Mean depth (ft)</th>
<th>Velocity (ft/s)</th>
<th>Substrate embeddedness (percent)</th>
<th>Coho captured</th>
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<td>0-10</td>
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</tbody>
</table>

Complex valley-bottom habitat in the Tonsina River

Note that channel “types” are important to the conditions favoring microhabitat formation, but a gross classification scheme does not specify the details.
**Approach:**

- Define channel types and reference conditions for streams in glaciated watersheds.
- Characterize the reach-scale channel characteristics and key geomorphic determinants.
- Identify patterns of salmonid species and life-stage distribution, density, and habitat use.
- Predict patterns of salmonid usage, watershed-wide, using field-calibrated GIS-based techniques (i.e. at a coarse spatial scale).
- Anticipate potential disturbances (e.g., changes in land use or regional climate) to landscape processes and thus salmon populations.
- Develop a monitoring plan to recognize those disturbances and their expression before salmon populations have responded.

The geologic context will determine microhabitat formation. General patterns may be inferred, but they cannot be guaranteed, by using only gross relationships.
Channel gradient
Flat
Steep
(using 70-m USGS digital elevation model)

Grain size (mm)
Fine
Coarse
(prediction based on field measurements, extrapolated to entire channel network based on shear stress)
SUITABILITY FOR CHINOOK SPAWNING

- Grain size >80 mm
- Suitable reach

- Grain size <20 mm
- Suitable reach
SUITABILITY FOR CHINOOK SPAWNING

- Braided channels
- Suitable reach

Reach suitability for Chinook spawning:
- Suitable reach
- Braided channels

Channel too small

Reach suitability for Chinook spawning:
- Suitable reach
- Channel too small
- Braided channels

Water gaps between 20 and 40 mm

SUITABILITY FOR CHINOOK SPAWNING

- Braided channels
- Suitable reach

Reach suitability for Chinook spawning:
- Suitable reach
- Braided channels
- Channel too small

Water gaps between 20 and 40 mm
Sockeye competition

Suitable reach

SUITABILITY FOR CHINOOK SPAWNING

Potential Chinook spawning habitat (<10% of channel network)
ACTUAL CHINOOK SPAWNING

Actual Chinook spawning

Telemetry data courtesy of J. Saveriede, ADFG.

PREDICTED VS. OBSERVED—MISMATCHES

Present; not predicted

Predicted; not present
Potential Chinook rearing habitat
(at & downstream of spawning; exclusions based on grain size, barriers, channel size, Sockeye competition)

Potential Chinook rearing habitat
(additional exclusions based on steep channel gradients)
Potential Chinook rearing habitat
(additional exclusions based on coho rearing)

"FINAL" Potential Chinook rearing habitat
(all exclusions)
NEXT STEPS:

• Define channel types and reference conditions for streams in glaciated watersheds.

• Characterize the reach-scale channel characteristics and key geomorphic determinants.

• Identify patterns of salmonid species and life-stage distribution, density, and habitat use.

• Predict patterns of salmonid usage, watershed-wide, using field-calibrated GIS-based techniques.

• Anticipate potential disturbances to salmon populations—WITH A FOCUS ON KEY AREAS, AND THE GEOMORPHIC CONDITIONS THAT SUSTAIN THEM.

• Develop a monitoring plan to recognize those disturbances and their expression before salmon populations have responded.