How do you account for fish habitat with a total station?

2015 CHaMP Camp
Cove, Oregon – June 1st, 2015

Presenter:
Joe Wheaton (USU)
OUTLINE

HOW DO YOU ACCOUNT FOR FISH HABITAT WITH A TOTAL STATION?

I. Background
II. Painting a Picture of Habitat – Topographically
III. Quantifying Habitat – From Topography
   I. Hydraulics
   II. Geomorphology
   III. Fish Habitat
IV. Some Other Useful Byproducts of Topography
V. Take Homes
WHAT YOU’LL BE DOING THE NEXT 10 DAYS....

- If you’re a CHaMP Newbie
- If you’re a CHaMP Returnee
WHAT YOU’LL BE DOING AS A CHaMP CREW MEMBER

- Honing your skills as a topographic artist!
- Helping collect data that is actively being used to address KMQs related to salmon
- Contributing to building a rich archive of data that will be harvested for many years to come
MAKING PRETTY MAPS IS A BIG PART...

• You are both artists and technicians... you need to paint us a quantitative picture
YOU ARE NOT JUST SURVEYORS
YOU ARE ARTISTS...

• We define for you:
  • The subject matter
  • The medium
  • The pallet

Your canvas is the site extent
Your brush is the survey rod & prism
Your pallet of point codes
BUT, YOU ARE NOT ABSTRACT ARTISTS!

- Think of it as a pen & ink dot drawing....
- OR a detailed oil painting (when you connect the dots in GIS)
- NOT a watercolor
- NOT an abstraction
MODULES YOU’LL LEARN HOW TO DO THE PEN WORK (DOTS)

• Intro to Topography (Rod)

• Advanced Topography (Rod)
PURPOSE OF TALK

- Address:

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HOW DO WE CHARACTERIZE HABITAT?

• Can be done with stick & tape

• But when we do it with topography, we can support a richer range of more mechanistic analyses
BUILDING A TIN FROM XYZ Points

**Triangular Irregular Network (TIN):** the simplest and most common interpolation technique for building surfaces with irregularly spaced elevation data (McCullagh, 1981)

YOU TAKE OWNERSHIP OF THE DATA

Crews post process the data!
CONTOURS

• Lines of equal elevation... helps when draped over a 3D hillshade...
AN EXERCISE

• Elevations are real
  • Derived from 10 m DEM

• Integer Elevations
  • Rounded up elevations

• Context:
  • This is a peak where three ridges come together
  • Up between Big Cottonwood and Little Cottonwood Canyons in Wasatch Mountains

INSTRUCTIONS:
1. Connect all the dots to create a TIN
2. For each TIN edge, determine how many contours would intersect it at a 10 m contour interval (lightly label the contours)
3. Connect the contours up to draw a contour map
OVERVIEW

• We want to make a Contour Map from These Points
• Make a TIN first
• Divide up the tin lines by where our contour interval intersects them
• Connect the dots (those lines are contours)
• Label your Contours

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CONNECTING DOTS

• Start anywhere...
• Find three closest points
• Try and make your triangles as equilateral as possible...
• Careful with over interpolation

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A TIN to CONTOURS

- What is max elevation?
  - 2747 m

- What is minimum elevation?
  - 2657 m

- What is elevation range?
  - 2747 – 2657 = 90 m

- What is a good contour interval?
  - How about 10 m?
A TIN to CONTOURS

- Using a 10 meter contour interval... start with 2740 contour

1. Find **point(s)** higher then 2740

2. Find connecting **lower points**

3. Put equidistant 1 m contour ticks between lines from 2747 to nearest lower neighbors.

4. Count down 7 to 2740, and make bold

5. Connect dots (linearly or artistically)
1. Put ticks where 10 m contours would be

2. Between 2747 and 2732 how many 10 m contours?
YOUR CONTOURS?

• Here’s the ArcGIS derived TIN shown w/same 10 m contour interval you should have used

• How close does yours look to this?

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Here’s what the actual 10 m contours look like for this location

Hillshade shown in background

Both derived from USGS NED 10 m DEM

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COMPARED

• Reasonably close...
• Why are they different?
• How many points did we use (i.e. sample)?
• How many points were used for brown contours?
• What is difference between contour interval, pixel resolution and point resolution?

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WHAT DO YOU DO WITH TOPO SURVEY?

1. Build TIN
2. Convert to DEM
3. Detrend
4. Morphology Pops out
5. Flood....
MODULES YOU’LL LEARN HOW TO CONNECT THE DOTS

• Intro to GIS

• Advanced GIS
WHAT WE DO WITH TOPO SURVEY?

- For Physical Habitat, I will talk to you about:
  - Hydraulics, Geomorphology leads to fish habitat

- For why fish might care, Pete will talk to us about more specifically what fish need out of their habitat

- For upscaling these results to address Key Management Questions, Chris will talk to us about Survey Design & Extrapolation for Life Cycle Modelling
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ADD WATER DEPTH – TEMPLE FORK, UT

From field data... survey of waters edge...

½ A HYDRAULIC MODEL

Water Depth
Depth (m)
0 - 0.05
0.05 - 0.1
0.1 - 0.15
0.15 - 0.2
0.2 - 0.25
0.25 - 0.3
0.3 - 0.35
0.4 - 0.45
0.45 - 0.5
0.5 - 0.55
0.55 - 0.6
0.6 - 0.65
0.65 - 0.7
0.7 - 0.75

Detrended DEM (m)
High : 102.34
Low : 99.28

Water Extent
10 cm Contours
RIVER BATHYMETRY TOOLKIT

• Poor Man’s Hydraulic Model...

RBT: http://essa.com/tools/rbt/

McKean et al. (2009)
DOI: doi:10.3390/rs1041065
DEPTH HETEROGENEITY

- Use depth distributions to look at one form of diversity of hydraulic habitat
- Comparison of restoration treatment (using beaver) & controls
TOPO SUPPORTS: HYDRAULIC MODELS

- Can be 1D, 2D or 3D...
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GEOMORPHOLOGY?

• The study of landforms (e.g. geomorphic units) and the processes that shape them?
  • The landform bit we can describe as a snapshot (status)
  • The processes play out over time (trend)

• What processes specifically?
  • Erosion and Deposition
DERIVE HABITAT UNITS FROM TOPO & WD

• More refined boundaries than in field alone
• Transitions emerge as important...
GUT - BLENDING WITH REMOTE SENSING

- Using CHaMP topography to derive in-channel geomorphic units & LiDaR to Derive out of-channel geomorphic units - GUT
DYNAMIC STREAMS = HEALTHY ECOSYSTEMS

• We believe this...
• Lots of cool studies showing feedbacks and links...
• We know that heterogeneity is linked to dynamism

• How do we monitor and describe such dynamics?
WAYS A RIVER CAN ADJUST LOCALLY

• Adjustments (Erosion/Deposition)
  • Channel morphology
    • Channel Size
    • Channel Shape
  • Bed Character
  • Planform
  • Arrangement of geomorphic units

• An adjustment is not a *change* in river type!
• “River *behavior* equates to adjustments around a characteristic assemblage of geomorphic units”
• Geomorphologists have lots of special names for things...

• Basically, all expressions or special cases of erosion or deposition

From Brierley & Fryirs (2005)
NATURAL CAPACITY FOR ADJUSTMENT

• Plausible limits on what adjustments are possible

• Geomorphic context matters
  • Confinement
  • Sediment Supply
  • Flow Regime
  • Vegetation
  • Land use
  • History

From Brierley & Fryirs (2005)
WHAT IS DEM-BASED GCD?

A little background...

- DEM -> digital elevation model
- GCD -> geomorphic change detection
- Of everything that CHaMP measures, GCD is one of most sensitive to the quality of the data and influences like crew variability
GCD RUNS AUTOMATICALLY ON CM.ORG

• GCD Projects Run Centrally
• Detailed DoD output map & reports
• Summary Results for:
  • Bankfull Union of Surveys
  • By Channel Units
• You can download *.gcd file to:
  • Visualize output
  • Perform additional analysis
GCD TO DESCRIBE BEHAVIOR... IN A POOR CONDITION VARIANT

DYNAMIC RIVER BEHAVIOR
CHANGES CAPTURED WITH CHaMP

Before (2011)

Flow

Chute Scour
Point Bar Development

Minor Downcutting

After (2013)

Champ Site: Tucannon River, WA ID: CBW05SS3-386091

Changes with less than a 95% probability of being real
Deposition
Erosion

Changes with Elevation Change

Elevation Change (m)

> -2.5  -2.5
Erosion
Deposition
GCD TO DESCRIBE BEHAVIOR... IN A GOOD CONDITION VARIANT

DYNAMIC RIVER BEHAVIOR
CHANGES CAPTURED WITH CHaMP

Changes with less than a 95% probability of being real

Changes with less than a 95% probability of being real

Elevation Change (m)

> -2.5
Erosion

-2.5
Deposition

Elevation Change (m)

Volume

Deposition

Erosion
IN A PERFECT WORLD...

• The signal (the change we’re trying to detect) is much greater than our noise....

\[
\frac{\partial z}{\partial t} \gg \delta(z)
\]

• In many instances, the noise is of similar magnitude to our noise...

\[
\frac{\partial z}{\partial t} \approx \delta(z)
\]

• Better in places where vertical changes are large!

Surface Noise:

• LiDaR : +/- 10 to 25 cm (14 to 36 cm\_min\_LoD)
• Total Station: +/- 2 to 10 cm (3 to 14 cm\_min\_LoD)
SO PAY ATTENTION....

- How well you survey, determines our ability to detect real changes and distinguish these from noise!

- Will it *really* matter?
- If you’re not sure, ask!
OBVIOUS DATUM PROBLEMS...

Fly Creek, Grande Ronde Watershed, OR

Camas Creek, John Day Watershed
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ENERGY REFUGIA & SHEAR ZONES

A. Flow Direction
B. Flow Separation Point (AKA detachment point)
C. Reattachment Point
D. Shear Zone
E. Same Partially Submerged Boulder
F. Flow Seam
G. Minor Shear Zones from Bank Irregularities
H. Shear Zone (eddy)
I. Shear Zone (wake)

2D Hydraulic Model Results
THREE TYPES OF REFUGIA...

1. **Predation** Refugia – (Cover) Protection from Predation

2. **Energy** Refugia - Resting Areas (i.e. shear zones)

3. **Thermal** Refugia – Get away from the mean!

**Predation Refugia from:**
- Bank Vegetation
- LWD
- Boulders
- Deep Pools

**Energy Refugia from Shear Zones induced by:**
- Irregular Banks
- LWD
- Boulders
- Bed Forms
DEFINING HABITAT HETEROGENEITY - REFUGIA
IS HETEROGENEITY IMPORTANT TO A SPAWNING FEMALE SALMON?

Habitat Heterogeneity is usually assumed to support species diversity (assumed to be good).

What are specific ecological benefits of habitat heterogeneity to spawning salmonids?
FISH HABITAT MODELS...

• Pete will talk to us about two different flavors of FHM (there are many more)
  – Net Rate of Energy Intake (NREI) – Summer Juvenile
  – Habitat Suitability Index (HSI) – Adult Spawners

From LeClerc (2005)
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PRODUCTS

More strategic improvement actions could save millions through more realistic investment in actions more likely to work!
SUMMARY PRODUCTS

- Can be directly produced from CHaMP/ISEMP
- Still requires expert and stakeholder input (e.g. Atlas)
- Can be better informed by CHaMP/ISEMP/AEM
- Still requires expert designers...

Can be better informed by CHaMP/ISEMP/AEM
CHAMP DATA CAN BE USED AS BASEMAP & BASELINE FOR DESIGN

From Steve Fortney (Terraqua)
USING CHAMP SITES AS ANALOGS
ANALOGS FOR DESIGN

• Multi-threaded channel with diverse range of habitat serving critical functions for salmonids at various life stages

• The regular turn-over of this habitat is maintained by dynamic behavior (regular erosion and deposition).
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SO... PAINTING QUANTITATIVE PICTURES

• From Topographic Snapshot
  • Habitat Units
  • Habitat Heterogeneity
  • Hydraulic Models
  • Ecohydraulic Models
• Multiple Topos
  • Geomorphic Change Detection
2 PERSON CREW...

• Who’s the artist?

Dumb end of a stick?
MAIN TAKE HOMES

• Topography helps us paint a quantitative picture of habitat
• Topography derivatives:
  • Habitat Units
  • Hydraulic Models
  • Habitat Suitability Models
• Repeat topography helps quantify processes that create, maintain & destroy habitat
• Useful not just in status & trend monitoring, but also restoration design and effectiveness monitoring
MANY PLACES IN CRB

• Riparian not all that bad... compared to some places
• Nothing like what it once was
• Habitat highly simplified
  • Armored
  • Few pools / Not much large wood
  • Few active bars
TYPICAL STRUCTURES
SIMPLE PALS HYPOTHESESIZED RESPONSE

Initial Condition

Design Placement

Dynamic Response

**LEGEND**

- **Velocity Vectors**
- **Wooden Posts (driven into bed)**
- **Wooden debris of various sizes, shapes & complexity**
- **12” to 18” diameter logs (variable length of 4’ to 6’ and can be handled by two people)**
PILOT OR AEM TESTING VS. DESIGN STAGE

• Do we have to build it to test it?
A DESIGN HYPOTHESIS TEST...

Existing Topography

Simulated Change

- Simulated Erosion
- Simulated Deposition

Wood Structures
DOES DESIGN PRODUCE INTENDED BENEFIT FOR FISH?

NREI Before LWD Structures

Potential NREI

Flow

Wood Structures

NREI

Good

Poor

0 5 10 meters