WY22 Scott Creek Lagoon Bathymetric Survey

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2023-09-29‘

Contents

1 Introduction

In August 2020, the CZU Lightning Complex fires burned more than 350 km2 (86,500 acres) of coastal forests and hills in the Santa Cruz Mountains region (Santa Cruz and San Mateo counties, California). Among the watersheds severely affected by wildfire was Scott Creek, a small (70 km2) coastal basin ~80 km south of San Francisco Bay.

The Scott Creek watershed is of special management concern as it supports the southernmost extant population of coho salmon (*Oncorhynchus kisutch*; Central California Coast [CCC] evolutionarily significant unit) in North America, as well as federally threatened CCC steelhead (anadramous *O. mykiss*). Scott Creek is also the location of a salmonid life cycle monitoring station operated jointly by NOAA's Southwest Fisheries Science Center (FED project website) and the University of California, Santa Cruz Fisheries Collaboration Program (FCP project website). Extensive physical, chemical, and biological monitoring conducted throughout the Scott Creek watershed since 2002 provides a unique opportunity to rigorously examine the direct and indirect effects of wildfire on salmonid productivity and carrying capacity.

Water Year 2023 (WY23) had large flushing flows which moved large amounts of sediment throughout the mainstem. We believe coarse sediment reached the Scott Creek Estuary/Lagoon whereas most fine sediment reached the area in WY2022 (right figure shows fine sediment deposition in the estuary 30 November 2021). This repository focuses on data collected on 22 September 2023 in the Scott Creek Estuary/Lagoon and a separate repository is dedicated to the WY2022 data. Our goal was to survey the estuary using RTK

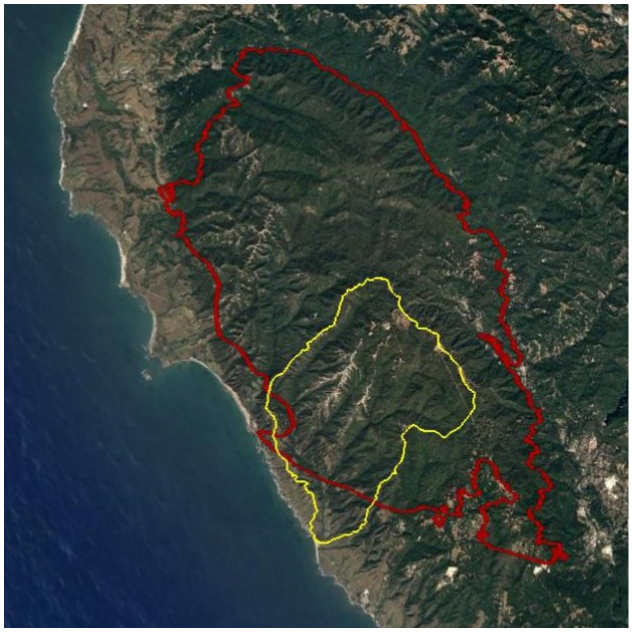

Figure 1: Fig. 1 Approximately 87% of the Scott Creek Watershed (yellow outline) was within the CZU Lightning Complex fire perimeter (red outline).)

Figure 2: Fig. 2 Fine sediment deposited on the margins of the Scott Creek Estaury/Lagoon (Photo: November 2021).

GPS and create a bathymetric surface. Ultimately we hope to track how this habitat changes over time and answer the question “How much has the Scott Creek estuary/lagoon filled in with fine sediment and re-scoured compared to pre-fire conditions?”.

2 Workflow Summary

The general workflow is:

1. Collect topo and echo sounder points.
2. Extract data from the R10s ~~and correct raw data with OPUS output~~.
3. ~~Correct echosounder point depths to account for “draft”~~ (Done).
4. Remove bad topo points and echo points that are too shallow or have low accuracy.
5. Calculate bed surface elevation (BedSE) from echosunder points (Note: topo points are corrected in step 4).
6. Calculate water surface elevation (WaterSE) from echosounder points.
7. Make Corrected Output Files.
8. Share with collaborators.

2.1 Dataset Descriptions

The *Data* folder contains all of the rtk datasets used in this repository. The raw and output datasets can be found in their corresponding folders.

Uncorrected Base Station Files:

1. The *Raw_Data/Scott_Blue_230922.csv* datafile contiants the keyed in base station point (based on WY22 OPUS correction, see field notes below).
2. The *OPUS/727726251.o* datafile is the *uncorrected* base station RINEX file that can be submitted to OPUS for double checking the correction.

Uncorrected Rover Files:

3. The *Raw_Data/Scott_Grn_230922.csv* datafile consists of the *uncorrected* green rover topo points.
4. The echosounder points were broken into *two* job files to reduce file size (this was a challenge in WY22). *Scott_Red_230922.csv* and *Scott_Red2_230922.csv* datafiles consists of the *uncorrected* red rover topo and echosounder points. The depth and accuracy fields were extracted by L. Harrison using Trimble Business Center software.

Corrected Rover Files:

5. The *Output_Data/OUT.FullDataset_Corrected_20230929* datafile is the full (all rtk points) dataset. It can be used as a starting point for any analysis.
6. The *Output_Data/OUT.BedSurface_Corrected_20230929* datafile is the bed surface input file (topo, wse, and echosounder point) for making TIN and raster files. Note the WaterSE column has been removed (not needed).
7. The *Output_Data/OUT.WaterSurface_Corrected_20230929* datafile is the water surface input file (wse and echosounder point) for making TIN and raster files. Note the BedSE column has been removed (not needed).

3 1. Field Notes

On 22 September 2023, R. Bond and A. Hay surveyed the estuary with three RTK units (Trimble R10's). Each unit has its own raw data file (described above) which are used in the workflow (steps above). A google-drive folder with a scan of the field notebook and photos can be found here.

Survey Notes:

- Survey Units: Meters.
- Horizontal Datum: NAD83 10 North.
- Vertical Datum: Conus GEOID12A.
- Survey extent: Scott Creek State Beach inland to Queseria Creek confluence. Most topo points were collected from the beach to the north marsh area (bad signal just upstream of the Lagoon PIT antenna array). Echosounder points focused on the main channel from the beach (downstream side of Hwy 1 bridge) to Queseria Creek confluence.
- Blue Unit - Base station.
  - Settup on ESA CP02 and ran for ~5 hours (same point as WY22).
  - Antenna height to quick release = 1.5m.
  - Job Name: Scott_Blue_230922.
  - "Keyed in" base coordinates based on WY22 OPUS correction and 1cm added to elevation (Z) to account for slightly different GEOID models (OPUS used CONUS2018 and we used CONUS2012).
    - N = 4099614.797m
    - E = 568610.850m
    - Z = 8.382m
  - OPUS was run to double check base point and results looks good so no correction needs to be applied to this dataset.
- Green Unit - Rover collecting topo points
  - Antenna height to quick release = 2.0m (one rod = 1.05m).
  - Job Name: Scott_Grn_230922.
  - Shot to ESA CP01 for check point.
  - Started topo survey at point #7.
  - Raw Data Corrections:
    - Delete points 793 (bad wse).
- Red Unit - Rover collecting echosounder points (Sonarmite; wet areas with depth).
  - Antenna height to quick release = 1.252m.
  - Job Names: Scott_Red_230922 & Scott_Red2_230922.
  - Sounder depth in water (a.k.a. "Draft") = 0.27m. Draft was keyed into the unit so the software applied this amount to the depth measurements. Therefore the draft correcting step is not needed.
  - Code = echo.
  - Job 1: Started at point number 1000 and stoped at point 5446.
  - Job 2: Started st point number 5500 and stoped at point 7022. (Used same antenna height and draft as Job 1).
- Survey Codes:
  - levee - top of levee.
  - topo - combination of wet and dry topographic points.
  - rock - armouring at Hwy 1 bridge ("Jacks")
  - wse - Water Surface Elevation at the edge of bank (transition from wet to dry).
  - echo - wet echosounder point (need to incorperate depth measurments to elevation to get BSE).

- The mouth was open during the survey (so reffering to estuary rather than lagoon). Mouth runs north to blufs and spills onto the reef. There is a mudstone ledge that is acting as an elevation control (despite water being able to still flow out). The wetted area and depth looks comparable to previous water years. The mouth *finally* closed on 26 September 2023.
- The North Marsh and South Pond were wet during the survey (pre-fire times this was rare in the late summer).
- Sediment within the survey area was a mixtrure of mudstone cobble, gravel, and sand. (More coarse then previous years).

4 2. Raw Data Corrections

When starting the base station we "keyed in" the point using WY22 OPUS correction (coordinates above).

```
#Load packages
library(ggplot2)
library(dplyr)
library(lubridate)
library(patchwork)

options(digits = 10) #Global option so you can see the entire number for Northings and Eastings.


#### Goal: Correct raw data with OPUS correction.

#Read in RTK files
Green.dat <- read.csv('Data/Raw_Data/Scott_Grn_230922.csv', sep = ",", header = T) # Topo points (796 o
Red1.dat <- read.csv('Data/Raw_Data/Scott_Red_230922.csv', sep = ",", header = T) # Echosounder points
Red2.dat <- read.csv('Data/Raw_Data/Scott_Red2_230922.csv', sep = ",", header = T) # Echosounder points

#Join Echosounder points together and remove extra columns
Red.dat <- full_join(Red1.dat, Red2.dat) %>%
  select(-GPSweek, -Seconds, -SurvMeth, -NumSat, -PDOP, -HDOP, -VDOP, -RMS, -NumPosUsed, -Latency,
         -Battery.Voltage, -Quality, -Flags)#5972obs of 8 var.

#Make sure the data are loaded correctly
str(Green.dat)
str(Red.dat) #Looks Good.

#Note: OPUS Correction wasn't applied (needed) for this survey since it was "keyed in".
```

5 3. ~~Correct echosounder point depths to account for "draft".~~

The sounding instrument is mounted slightly into the water. This little bit of depth, known as "draft", typically needs to be added to all of the depth values to get total water depth (d in figure to the right). NOTE: Draft was "Keyed in" (entered) into the TSC3 and has already been applied to the water depths. Therefore this step was skipped for this (WY2023) survey.

6 4. Remove bad topo points and echo points that are too shallow or have low accuracy.

Point filters:

- Topo points were removed based on fieldnotes.
- Echosounder points were removed based on a vertical precision threshold = 0.03cm and sounding depths less than 0.4m (the shallowest depth a return could be detected by the Sonarmite).

```
#### Goal: Correct topo and echosounder points based on field notes and echo sounder point accuracy.

#Topo points:
Green.cor <- Green.dat %>%
  mutate(BedSE = Elevation) %>% #Renaming since these topos are bed surface elevation.
  select(-Elevation) %>%        #Removing old named column.
  filter(Pt.name != "BASE",
         Pt.name != 793)  #Remove two points (795 obs of 5 var).

#Corrected topo point dataset:
# write.table(Green.cor, file = 'Data/Output_Data/OUT.Green_Corrected_20230929.csv', sep = ',', row.nam

#Remove echosounder points based on vertical precision threshold of 0.03m and depths less than 0.4m.
Red.cor <- Red.dat %>%
  filter(Code == "echo",  #Remove non-echo points. #5969 obs
         VertPrec < 0.03, #Remove points based on vertical precision threshold #5507 obs
         Depth > 0.4) #Remove shallow points #5393 obs

#5393 obs of 8 var.
```

7 5. Calculate bed surface elevation (BedSE) from echosounder points.

BedSE = OPUS corrected elevation + draft corrected depth.

```
####Goal: Combine elevations with depth to get BedSE.

Red.cor2 <- Red.cor %>%
  mutate(BedSE = Elevation + Depth)

#5393 obs. of 9 var.
```

8 6. Calculate water surface elevation (WaterSE) from echosounder points.

Water SE (for the echosounder points) = Elevation - draft (0.27m).

- Echosounder points can be used as water surface elevation refrences (i.e., Z point used in water surface TIN).
- "wse" points (collected by the green rover) indicated the wetted margin on the bank (i.e., X,Y,Z can be used in bed and water surface TINs). The wse points are important for creating the wetted boundary within the lagoon.

```
Red.cor3 <- Red.cor2 %>%
  mutate(WaterSE = Elevation - 0.27) %>%
  select(Pt.name, North, East, BedSE, WaterSE, Depth, Code, VertPrec) #remove old elevation column.
```

```
#5393 obs. of 8 var.

#Corrected echosounder dataset:
# write.table(Red.cor3, file = 'Data/Output_Data/OUT.Red_Corrected_20221005.csv', sep = ',', row.names =
```

9 7. Corrected Output Files

```
####Goal: Join the RTK data together into a single dataset.

#Pull out topo WSE points and put them into the WaterSE column.
Green.cor.wse <- Green.cor %>%
  filter(Code == "wse") %>%
  mutate(WaterSE = BedSE) # Make bed = water surface elevation since this is the wetted margin (used fo
#91 obs of 6 var.

Green.cor.topo <- Green.cor %>%
  filter(Code != "wse") #704 obs of 5 var.

Green.join <- full_join(Green.cor.topo, Green.cor.wse) #rejoin topo points #795 obs of 6 var.

#### OUTPUT - Full Dataset Output ####
RTKData <- full_join(Green.join, Red.cor3) %>%
  select(Pt.name, North, East, BedSE, WaterSE, Depth, Code, VertPrec) #join topo and echosounder points

#Full corrected dataset:
# write.table(RTKData, file = 'Data/Output_Data/OUT.FullDataset_Corrected_20230929.csv', sep = ',', row

####  OUTPUT - Bed Surface TIN layer ####
BedData <- RTKData %>%
  filter(Code != "cp01") %>% #removing extra points that only matter to the base settup.
  select(North, East, BedSE, Code, Pt.name, VertPrec) #Don't need these columns for bed TIN.

#6186 obs of 6 var.

#Bed Surface Points Only (Topo, echo, and wse = basic channel bed TIN for making ArcMap raster)
# write.table(BedData, file = 'Data/Output_Data/OUT.BedSurface_Corrected_20230929.csv', sep = ',', row.

####  OUTPUT - Water Surface TIN layer ####

WaterData <- RTKData %>%
  filter(Code == "wse"| Code == "echo") %>% #only water points.
  select(North, East, WaterSE, Code, Pt.name, VertPrec) #5484 of 6 var.

#Water Surface Points Only (wse and echo = basic water surface TIN for visualizing depths in ArcMap ras
# write.table(WaterData, file = 'Data/Output_Data/OUT.WaterSurface_Corrected_20230929.csv', sep = ',',
```

Some summaries:

```
#Goal: Summarise point types and range of depths.

RTKData.sum <- RTKData %>%
  filter(Code != "cp01") %>%
```

```r
  group_by(Code) %>%
  summarise(n())

Depth.plot <- ggplot(RTKData, aes( x = Depth)) +
  geom_histogram(binwidth = .25)+
  theme_classic() +
  scale_x_continuous("Depth (m)", limits = c(0.25,2.5), expand = c(0,0))
# ggsave("Figures/Depth_Histogram_20230929.jpg", width = 5, height = 3, units = "in", dpi = 650, device
```

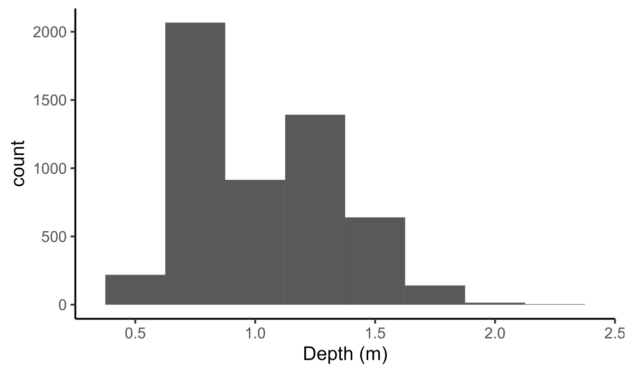

Figure 3: Fig. X Histogram of echosounder depths after post-processing (Min = 1.66ft, Max =5.8ft).

10 8. Share with Collaborators.

Share with CSUMB.