Chehalis Basin Strategy

Water Quality Studies Completed in 2013-2015 Biennium

Presented by Bob Montgomery, P.E.
Anchor QEA
September 22, 2015

Data Gaps Identified in the 2012 Chehalis River Fish Study

- Additional water quality characterizations beyond total suspended solids and BOD
- A need for improved characterization of thermal and nutrient loads from tributaries
- A need for improved characterization of groundwater's contribution to stream temperature
- Lack of riparian shading assessment
- Meteorological data lacking in upper reaches

Water Quality Work Performed

- Continuous temperature monitoring
  - 12 locations overall
  - Covers mainstem Chehalis River and major tributaries
- Synoptic low-flow water quality surveys
  - Three surveys, 15 locations during each survey
  - Designed to measure nutrient and BOD loads
- Diurnal surveys at select locations
  - Characterizes daily fluctuations in temperature, DO, and pH
- Depth profiles of water quality parameters at select locations

Work Performed (cont.)

- Boat survey in Centralia Reach
  - Historically problematic reach with thermal stratification and low DO in summer
  - Characterization of the DO and temperature regime
- Winter water quality sampling at Pe Ell
  - To develop boundary conditions for reservoir model
- Groundwater temperature surveys
  - To provide an estimate of temperature mitigation in gaining reaches
  - Focus primarily on mainstem reach above Newaukum River confluence

Other Work Completed to Support Water Quality Modeling

- Riparian shade surveys
  - Review of existing LiDAR data to identify vegetation type and density
  - Field surveys in May 2014 to ground truth (using hemi-view) vegetation type and canopy density classifications
  - Assessments will provide inputs needed for temperature modeling

Other Work Completed to Support Water Quality Modeling (cont.)

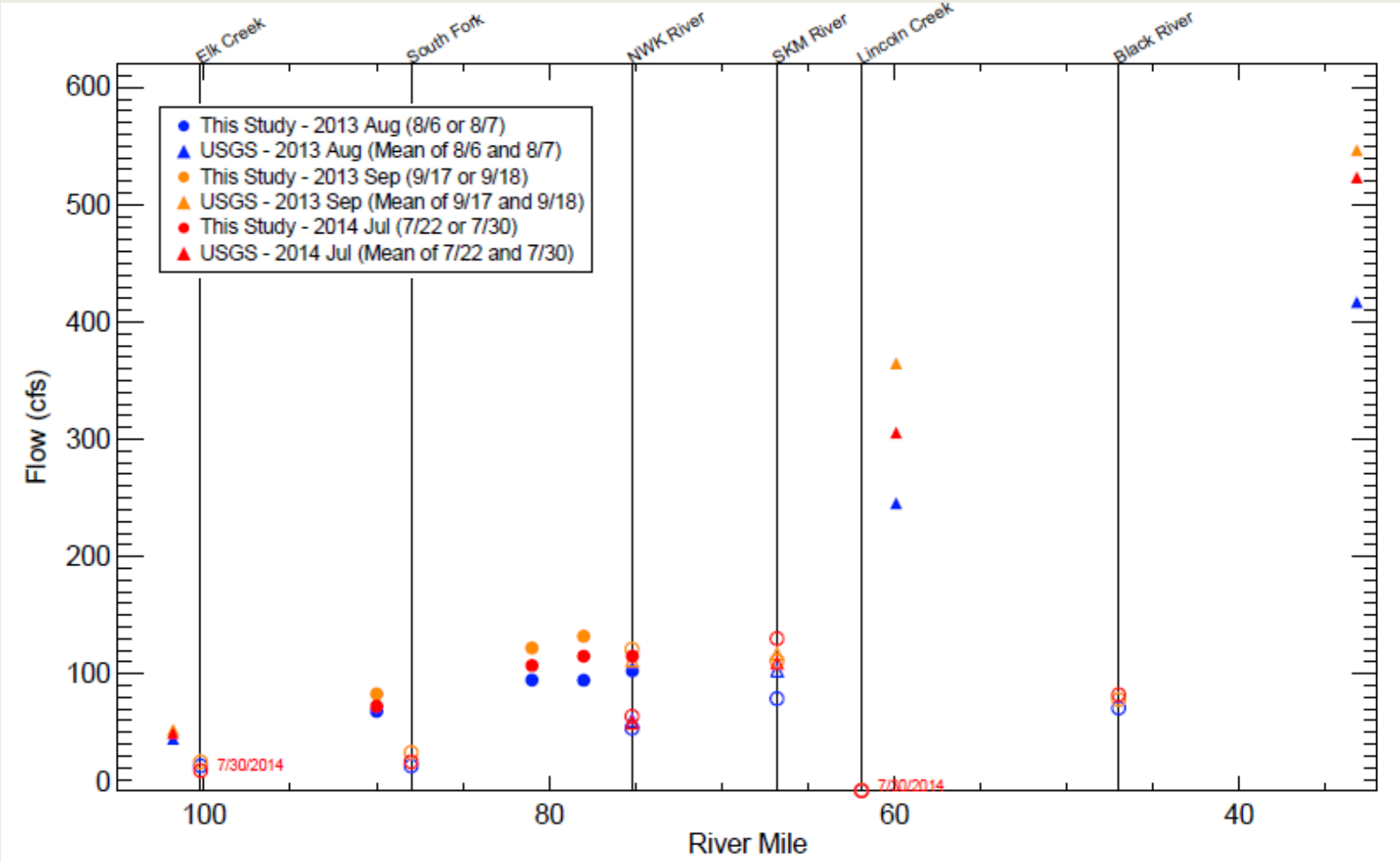
- Adding meteorological sensors to rain gage on Chehalis River near Thrash Creek
  - Will provide wind speed and direction, dew point temperature and incident solar radiation
  - Data available to public through early warning system website
- FLIR Systems thermal imaging

Monitoring Locations

- Surface water monitoring locations
- Boat survey
- Groundwater monitoring locations

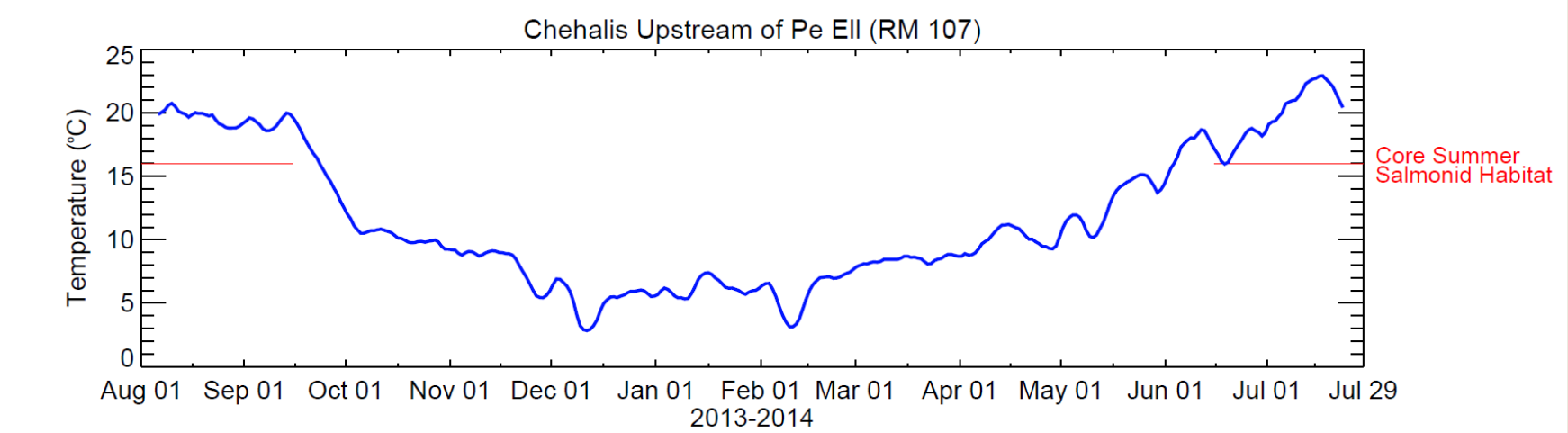
Water Quality Monitoring Results

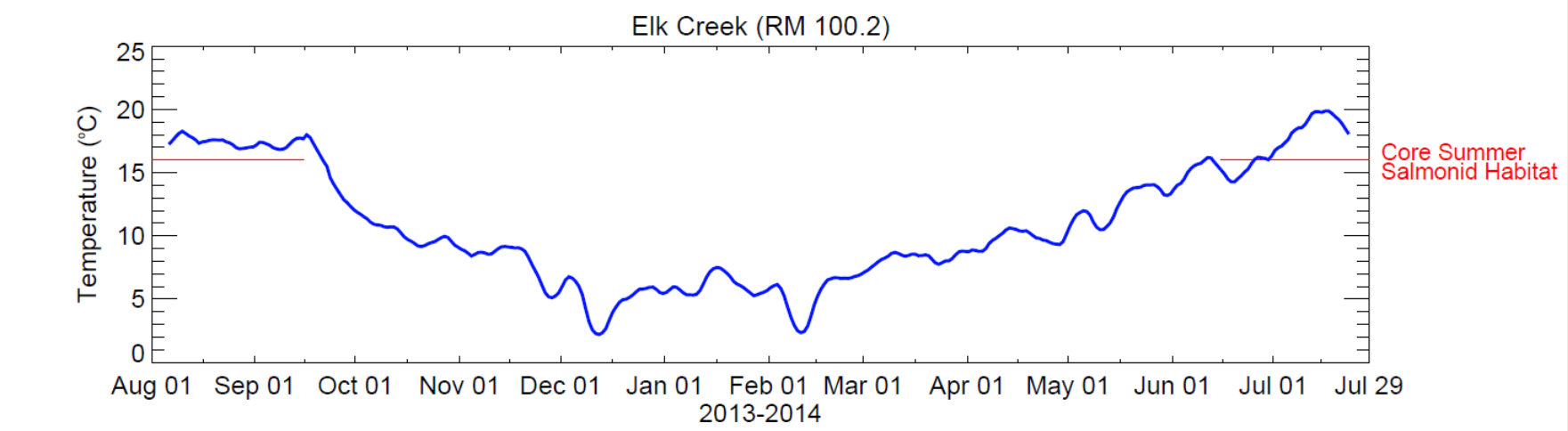
Flows Measured During Summer Low-Flow Surveys



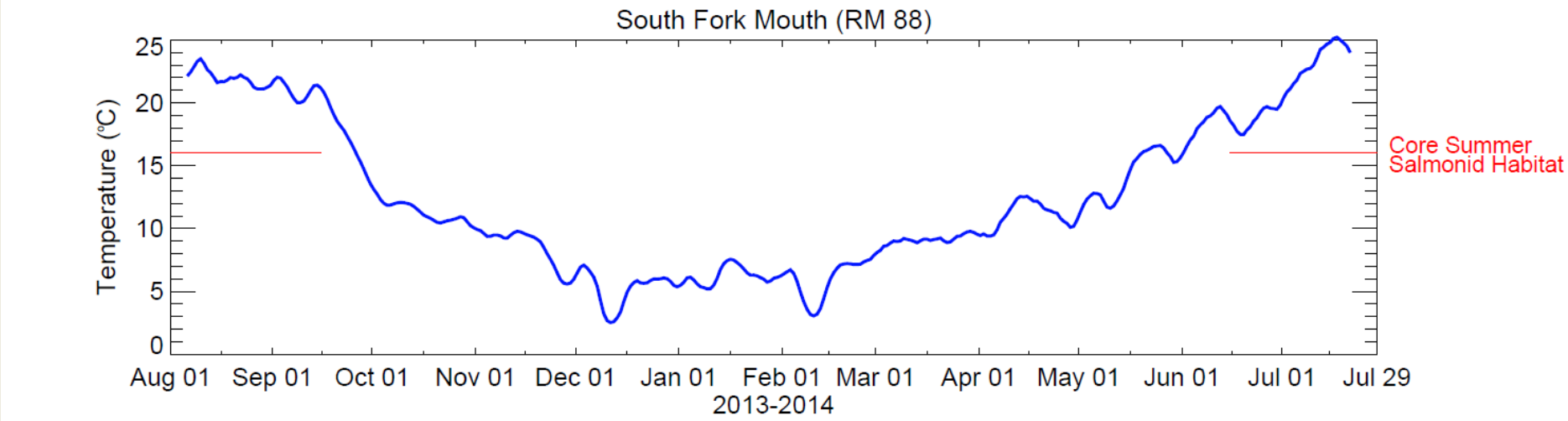
Long-term average flow at Doty for July, August, and September are 70, 46, and 67 cubic feet per second, respectively.

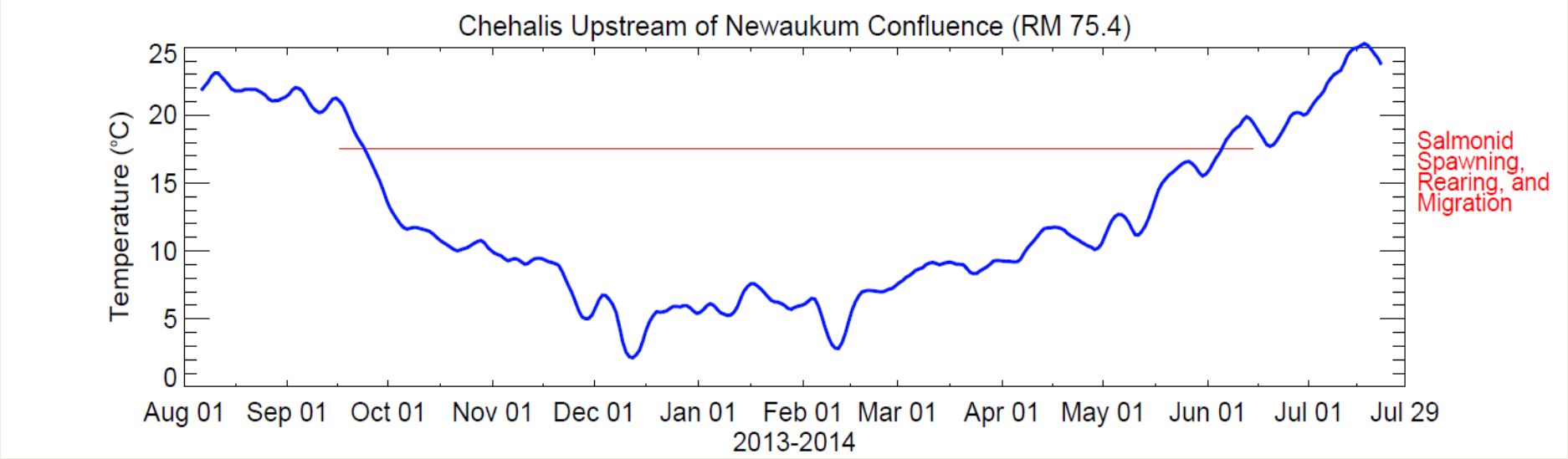
7-Day Average of Daily Maximum





7-Day Average of Daily Maximum



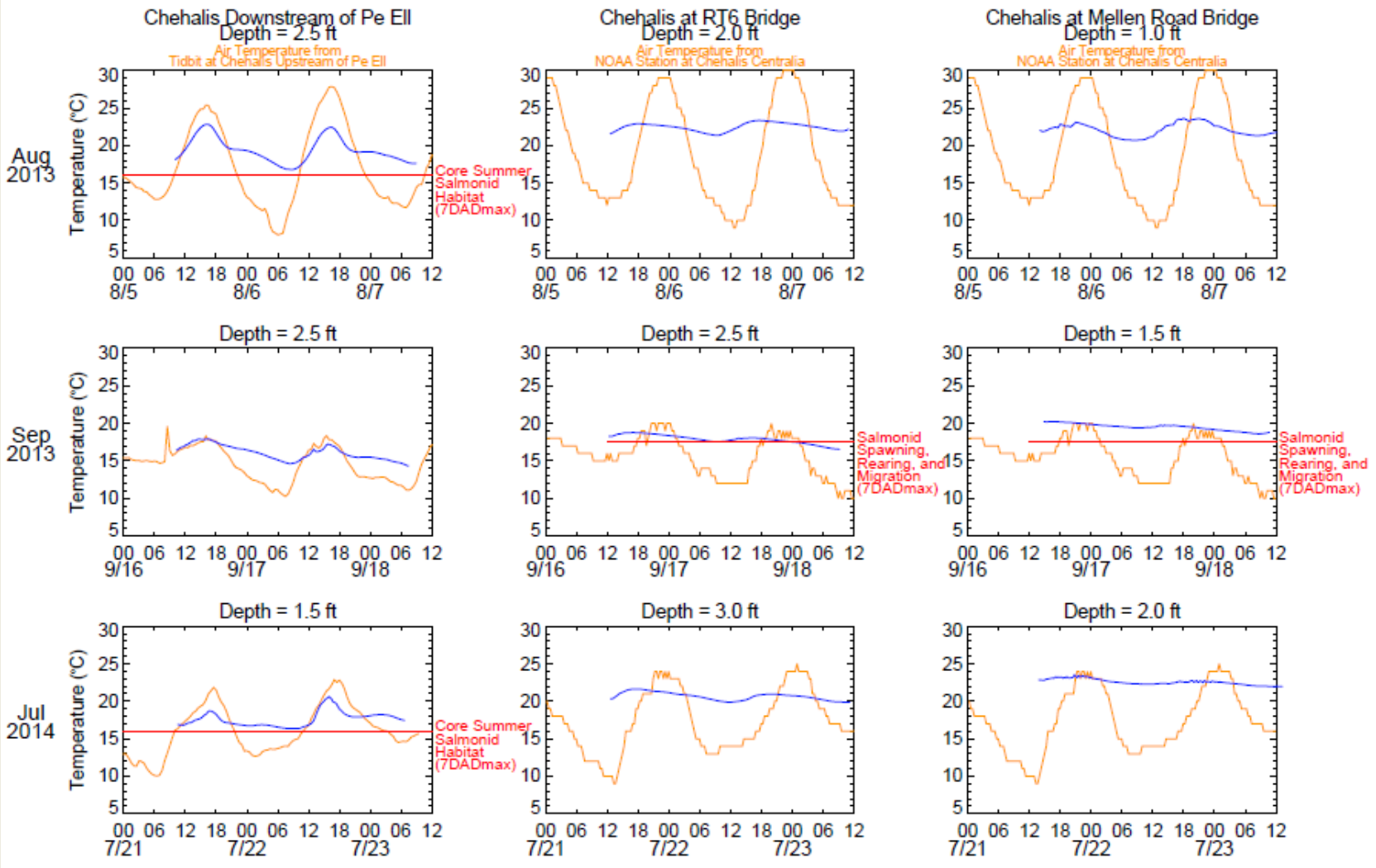


Temperature Exceedances

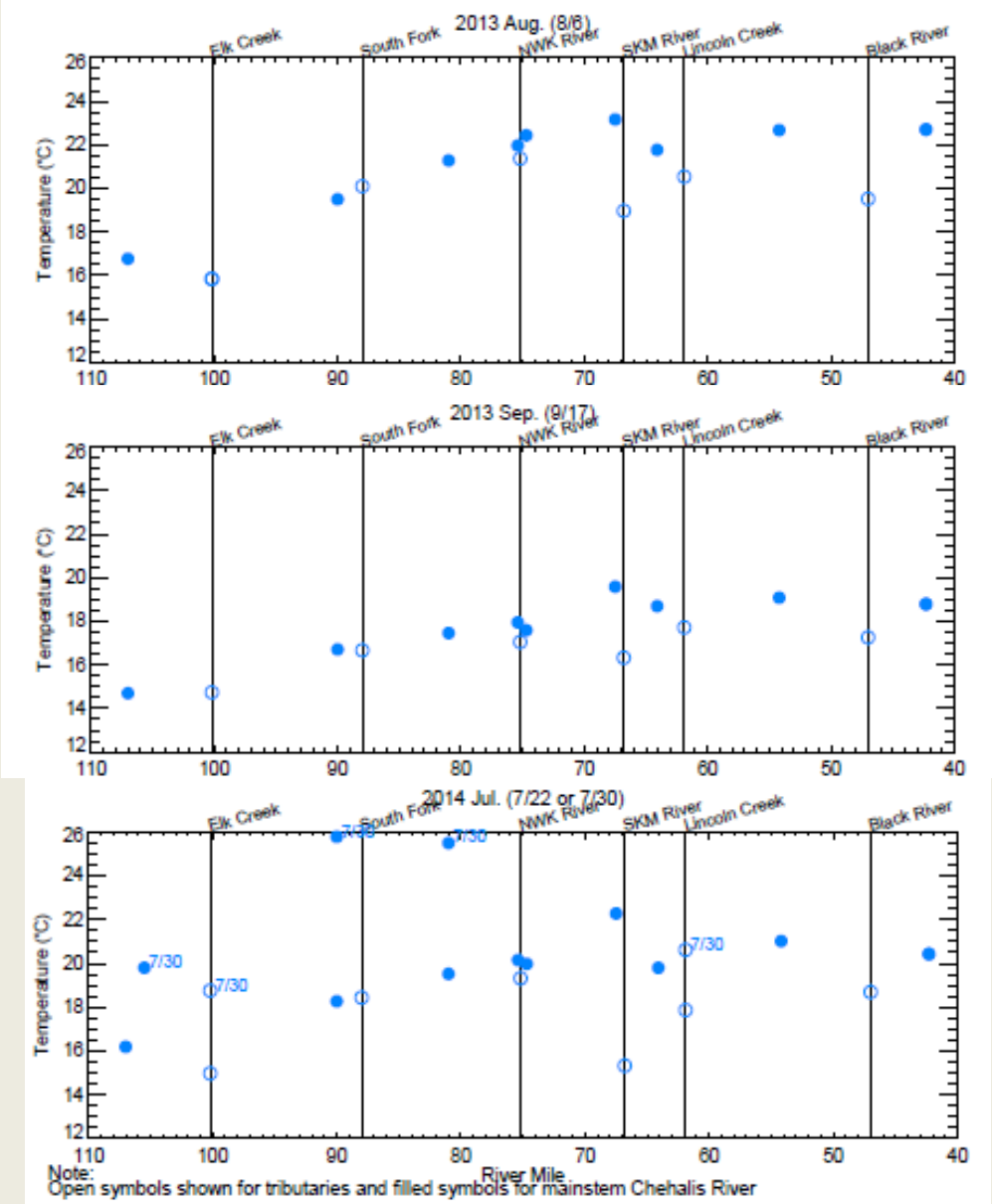
Station ID	River Mile	Number of Days (8/1/2013 to 7/29/2014)			Applicable Criteria
		When Criteria Applies	Data Available over Criteria Period	Temperature > Criteria	
CHL-PEL-US_TB	107	91	85	84	Core summer salmonid habitat[1]
CHL-PEL-DS	105.5	91	91	70	Core summer salmonid habitat[1]
ELK-CRK	100.2	91	85	75	Core summer salmonid habitat[1]
SF-CHL-MOUTH_TB	88	91	83	83	Core summer salmonid habitat[1]
CHL-ADNA	81	272	272	18	Salmonid spawning, rearing, and migration[2]
CHL-US-NWK	75.4	272	272	18	Salmonid spawning, rearing, and migration[2]
NWK-MOUTH_TB	75.2	91	37	37	Core summer salmonid habitat[1]
SKM-MOUTH	66.8	91	6	6	Core summer salmonid habitat[1]
CHL-GLV_TB	64.1	272	272	17	Salmonid spawning, rearing, and migration[2]
CHL-US-BLK	54.2	272	272	19	Salmonid spawning, rearing, and migration[2]
BLK-RT12	47	272	268	6	Salmonid spawning, rearing, and migration[2]
CHL-OAK	42.3	272	268	18	Salmonid spawning, rearing, and migration[2]

1. Core summer salmonid habitat = 7DAD temperature shall not exceed 16 degrees Celsius from June 15 to September 15
2. Salmonid spawning, rearing, and migration = 7DAD temperature shall not exceed 17.5 degrees Celsius from September 16 to June 14

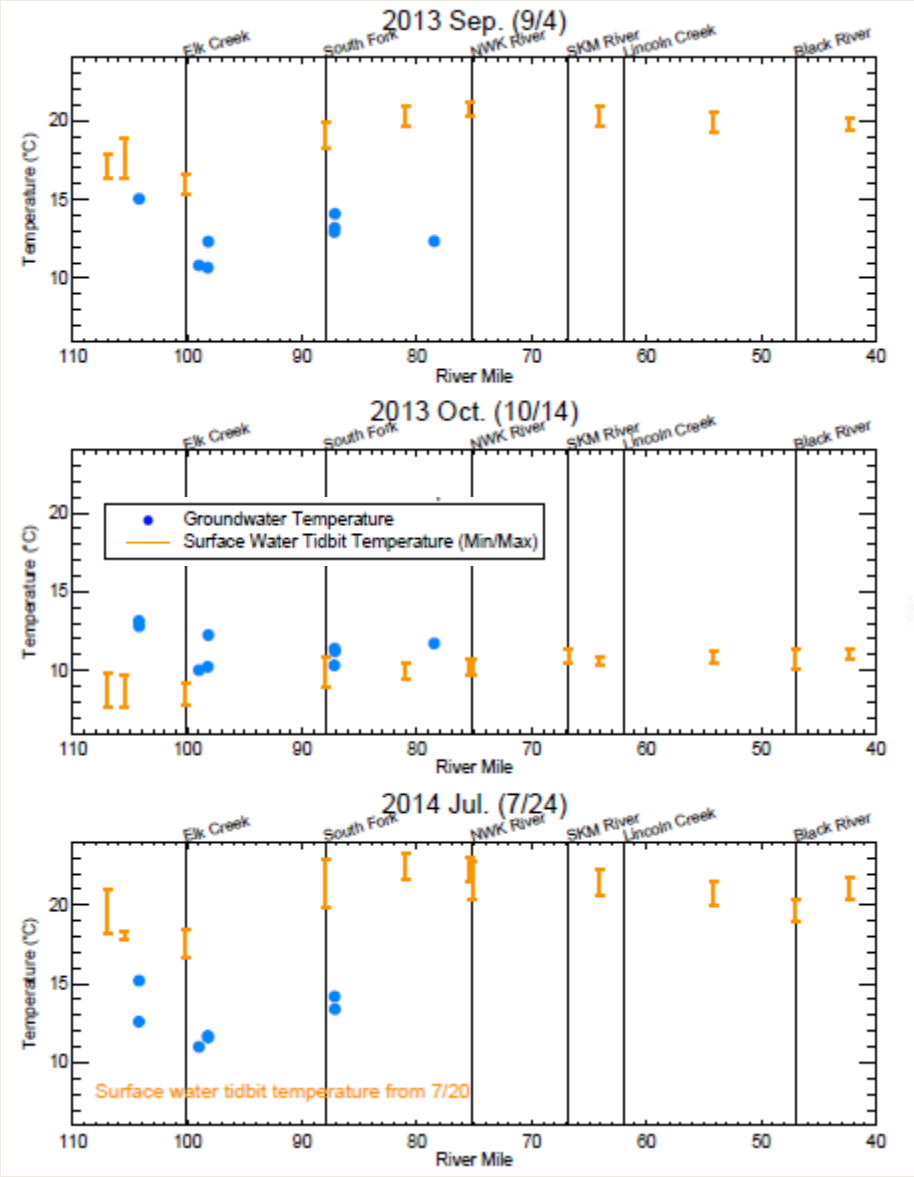
Diurnal Patterns in Temperature



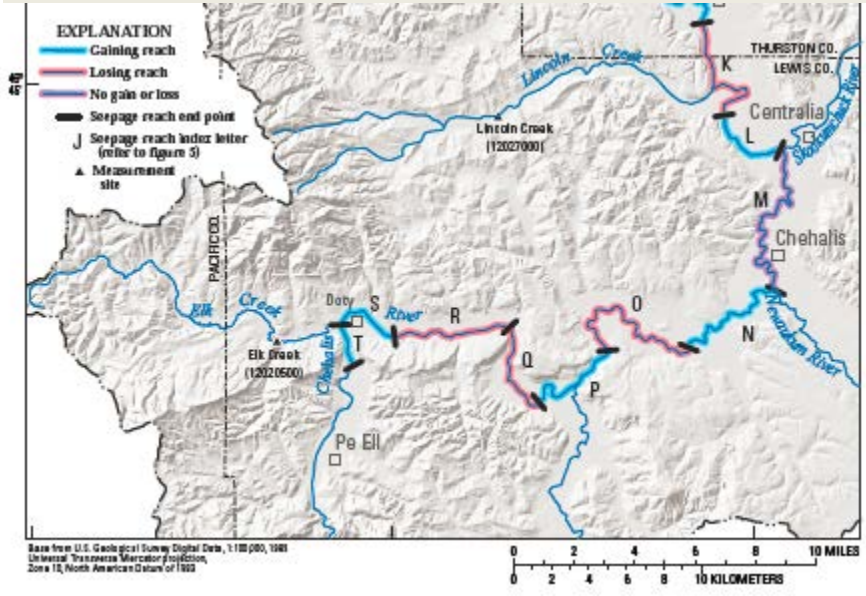
Spatial Patterns in Temperature



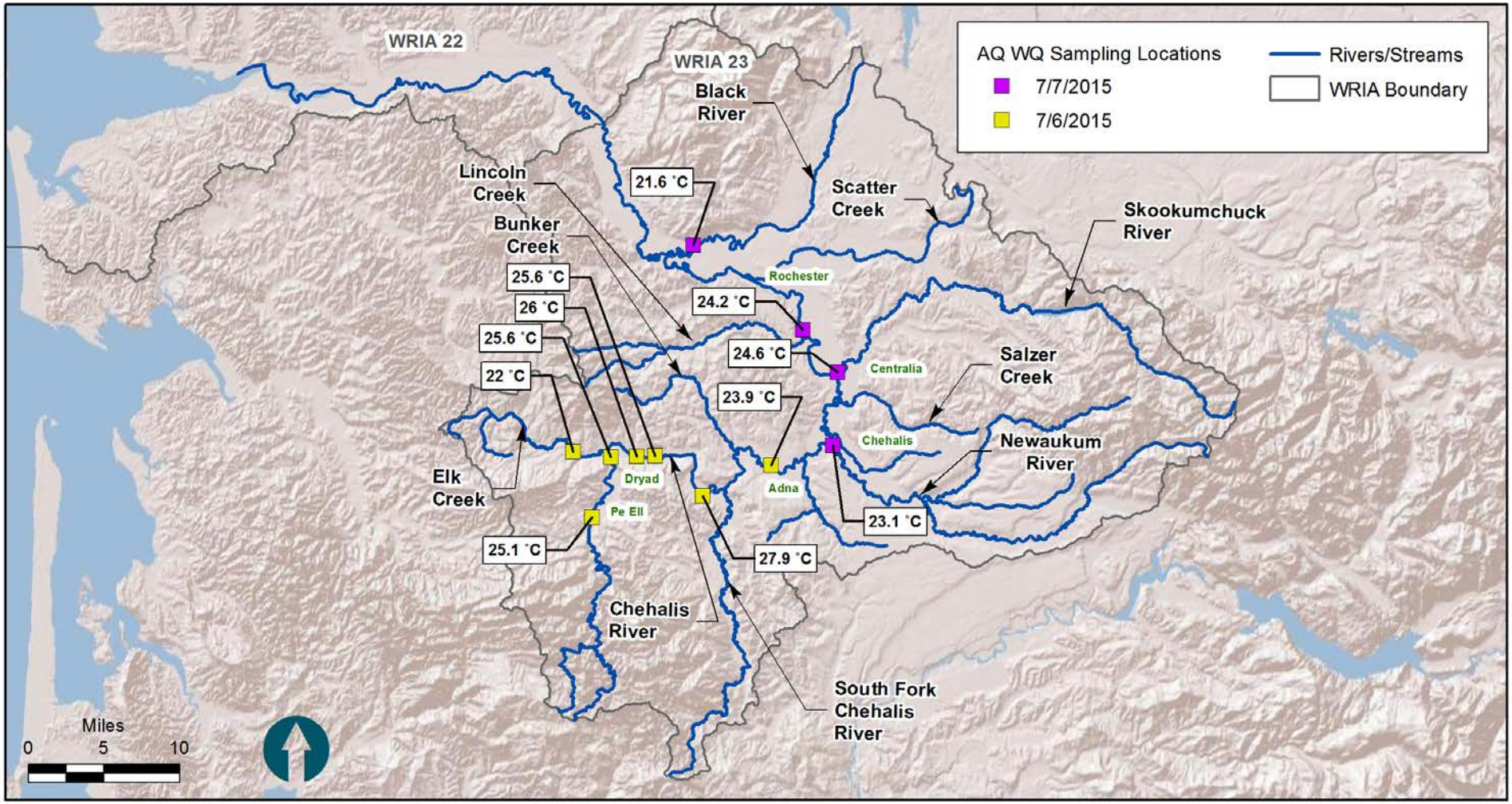
Groundwater Temperature



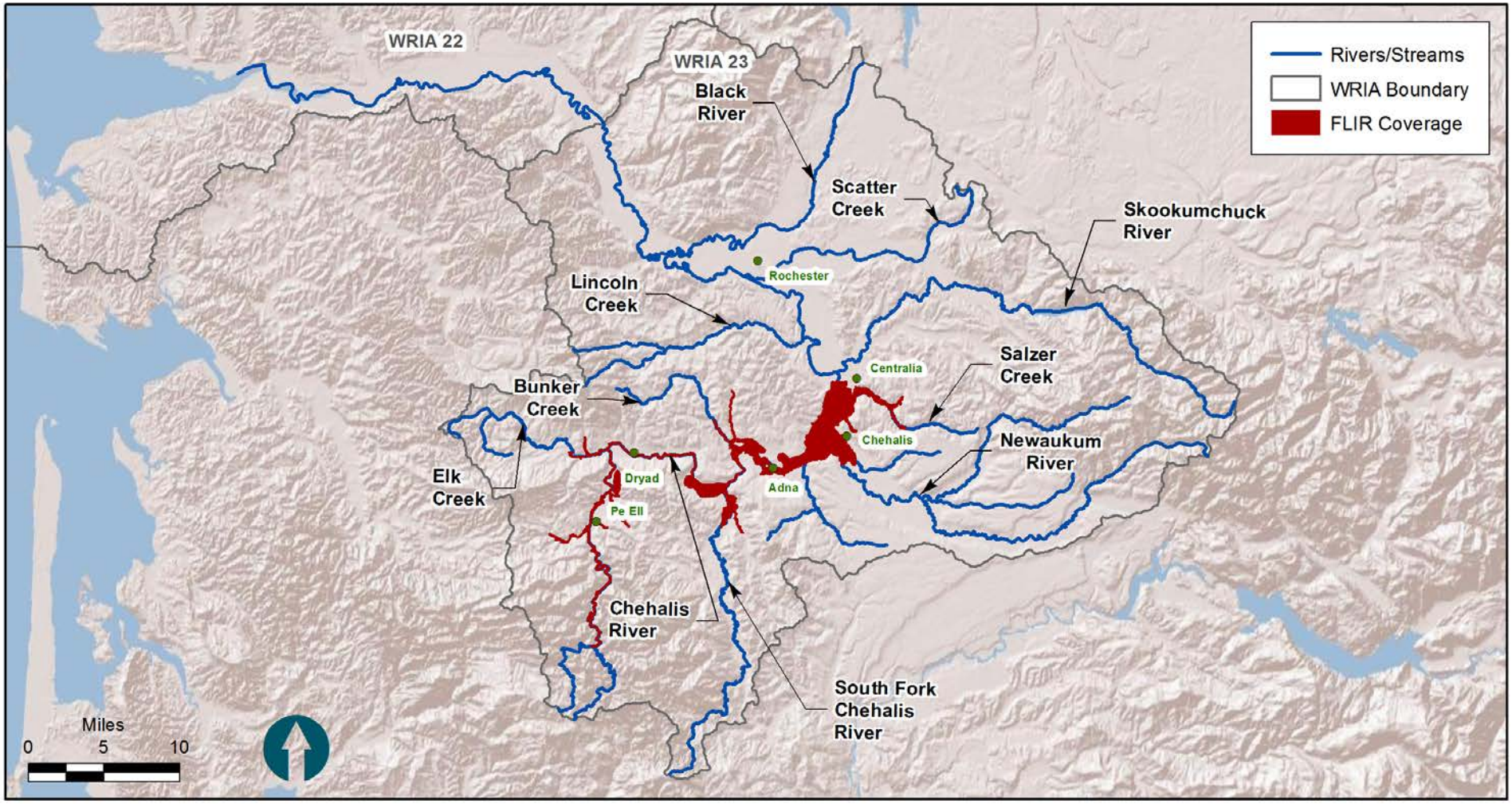
- USGS Study (Ely et al. 2008) identified losing and gaining reaches
- Groundwater warmer in losing reaches (near SF confluence) and cooler in gaining reaches (near Elk Creek)



2015 Summer Temperature Snapshot

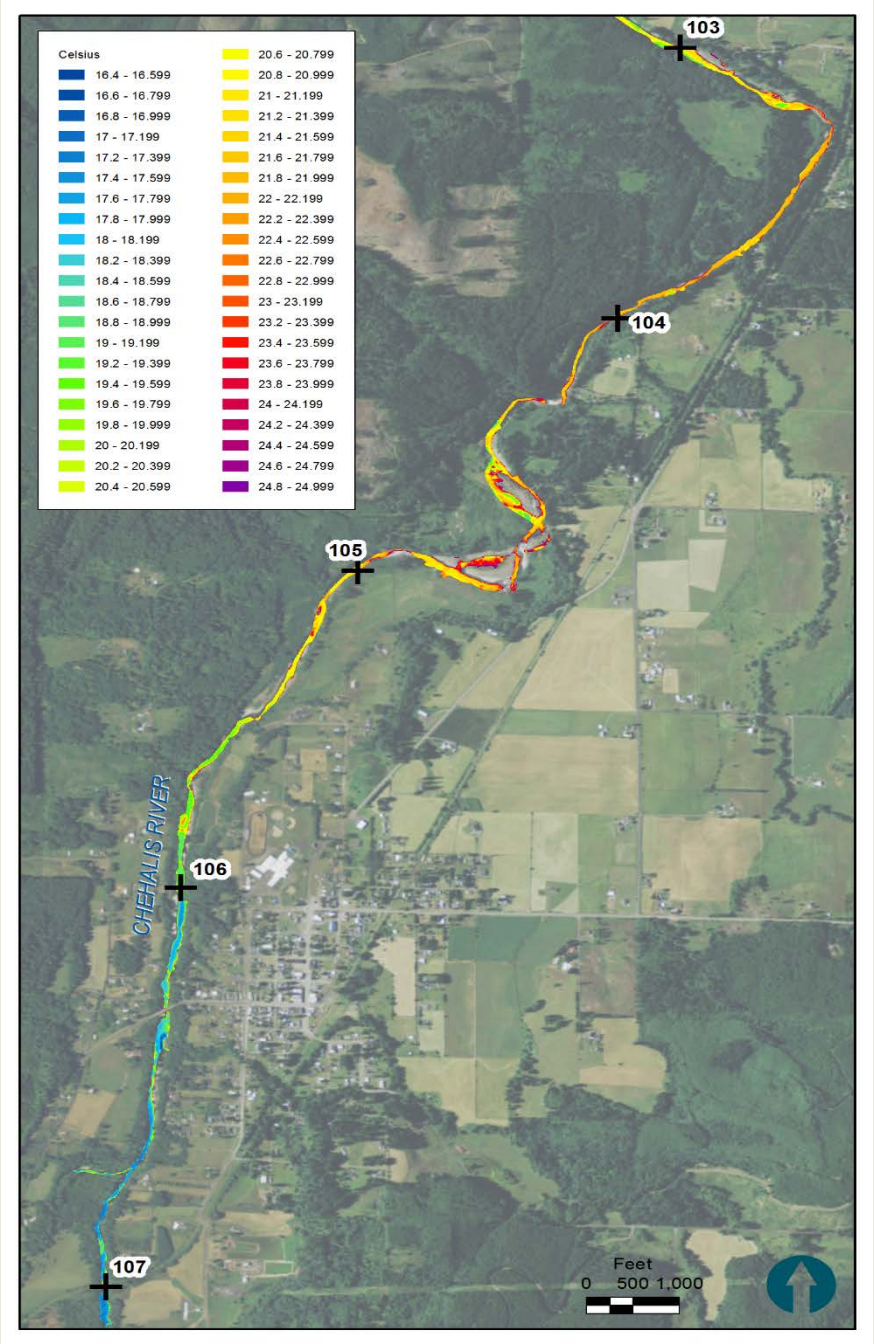


FLIR – Flown September 2013

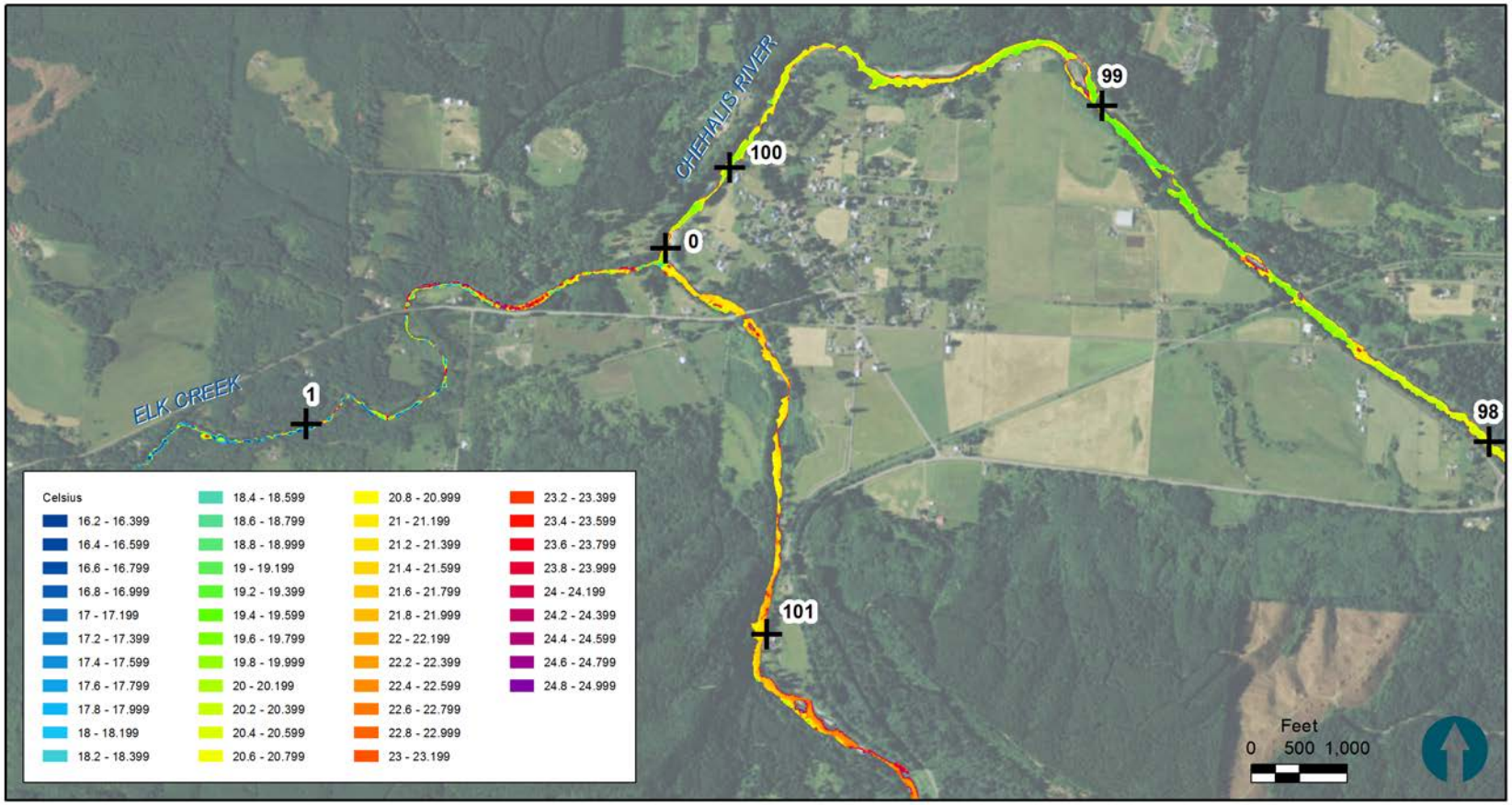


FLIR Results at Pe Ell

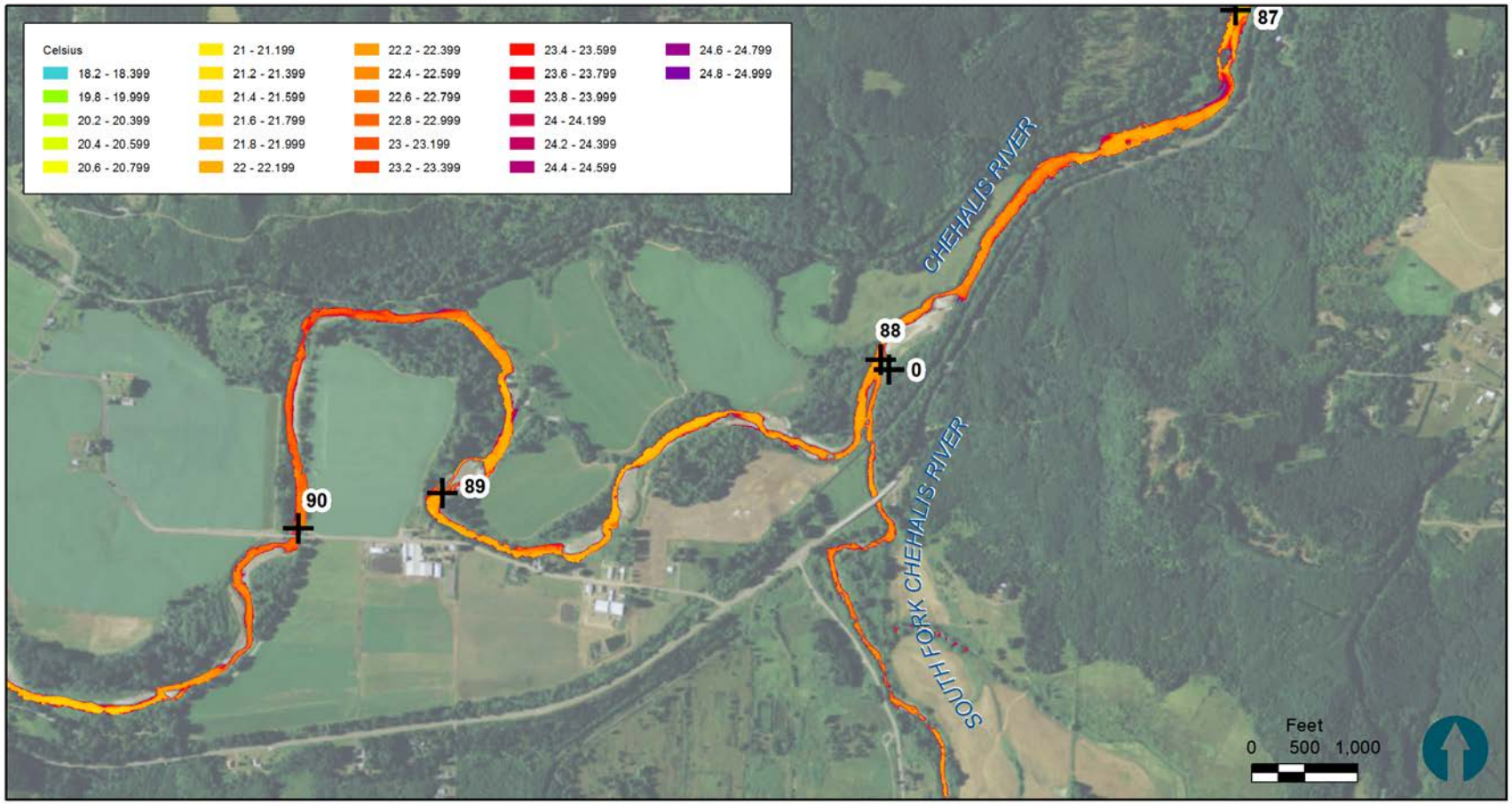
- Flight September 2013
- Warming downstream
- Cooler Ground Water Inputs
- Cooler Tributary Inflows



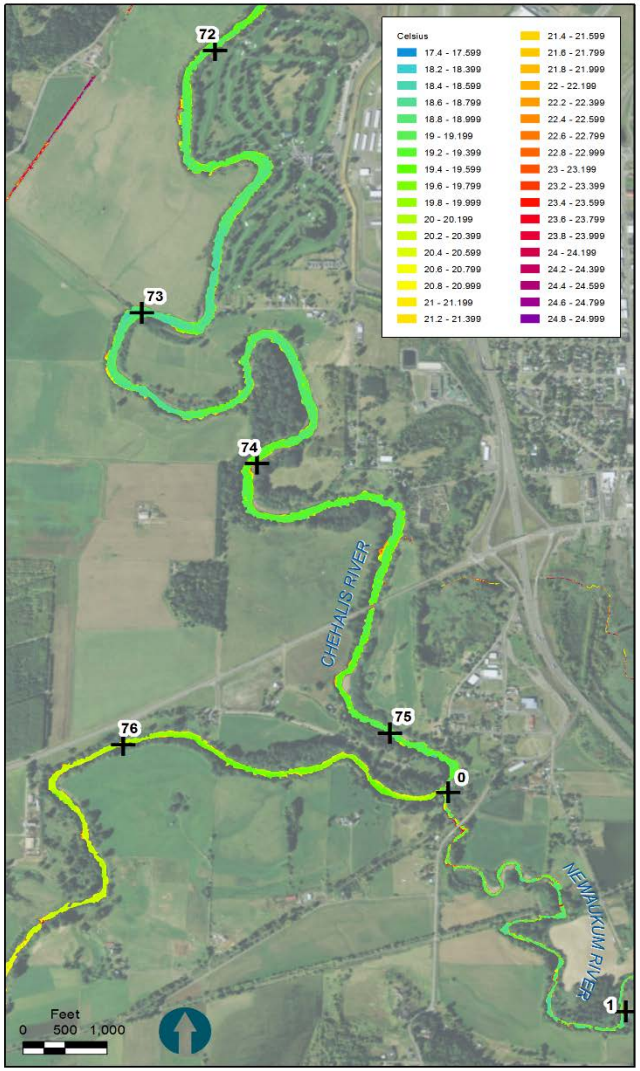
FLIR Results: Elk Creek

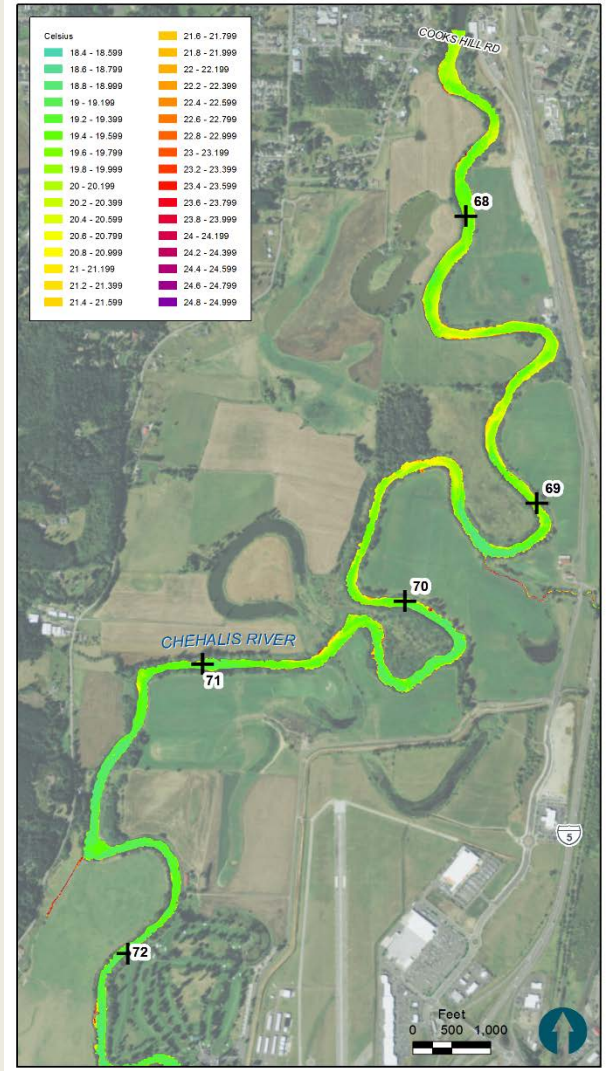


FLIR Results: South Fork Chehalis

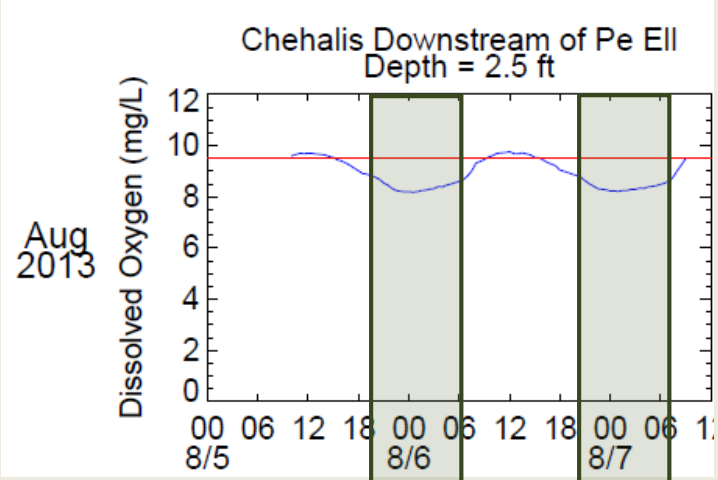


FLIR Results: Newaukum and Downstream Extent of Coverage

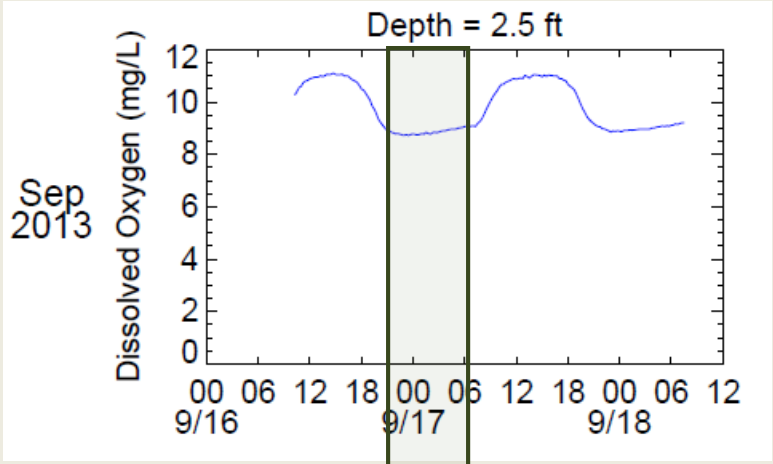


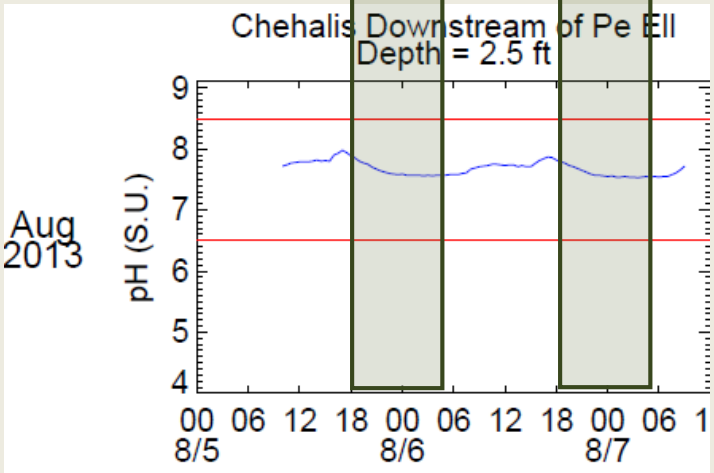


Diurnal Patterns in DO and pH



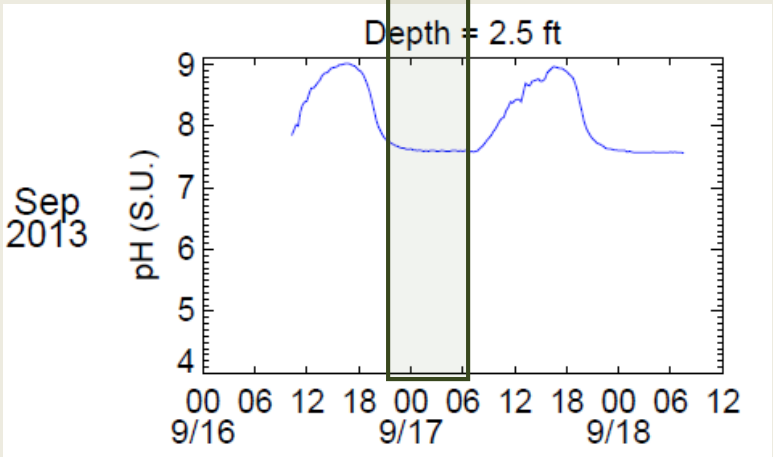
Core Summer Salmonid Habitat (Lowest 1-Day Min)





Core Summer Salmonid Habitat Upper Bound

Core Summer Salmonid Habitat Lower Bound



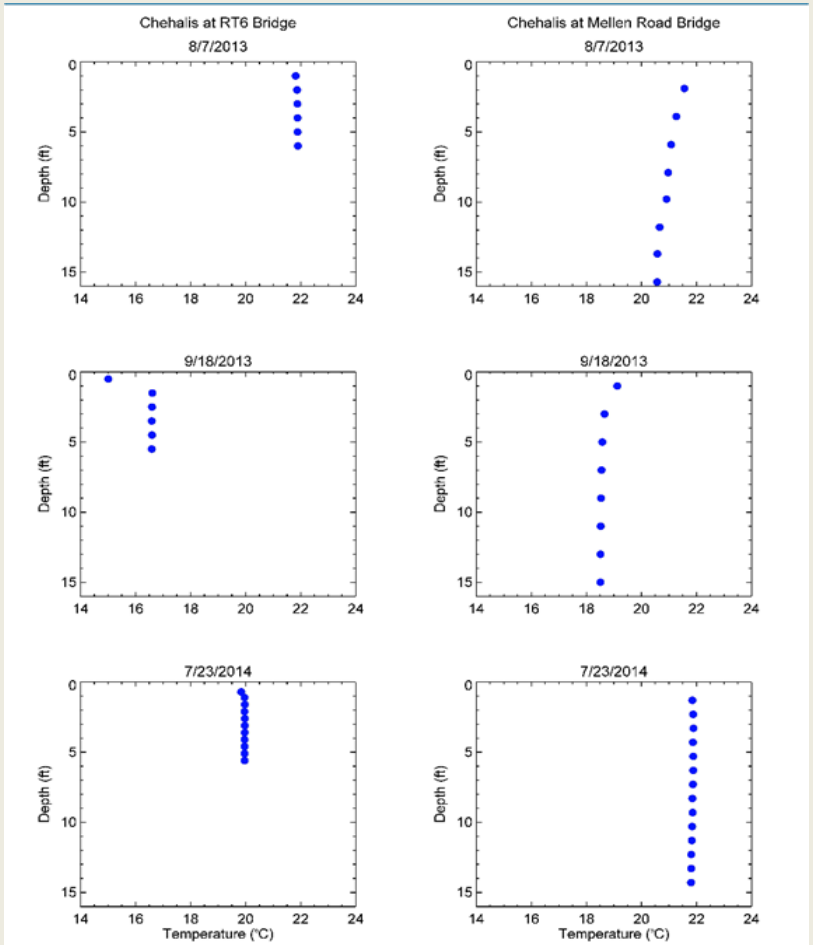
Diurnal Patterns

- Link to all figures

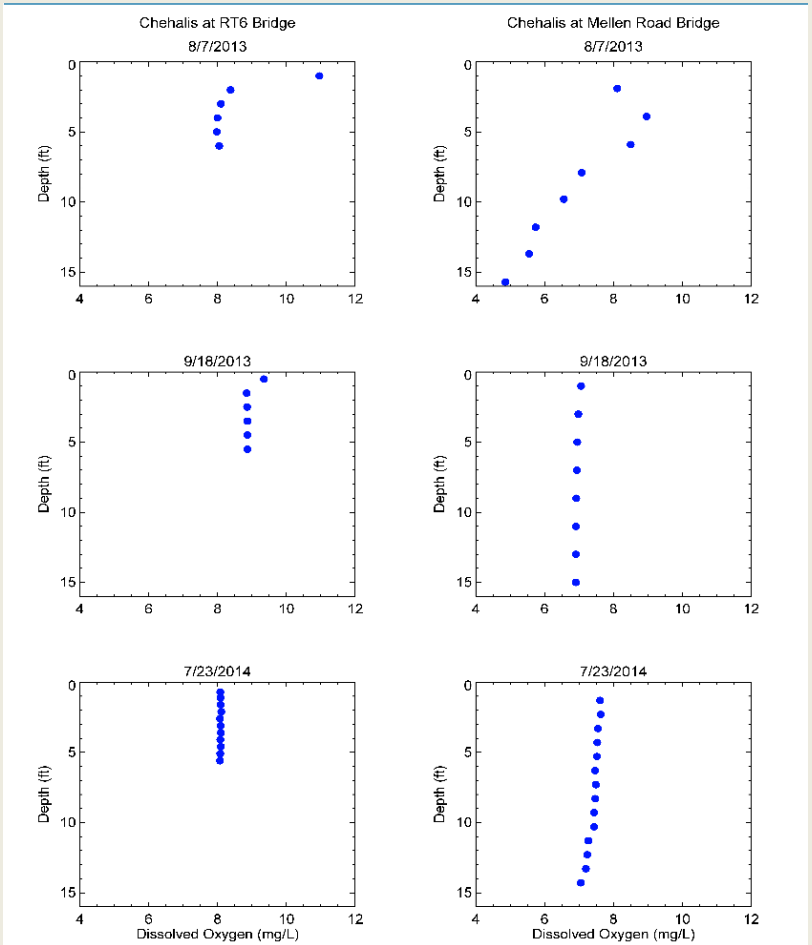
Low-Flow Survey: Depth Profiles of Temperature, DO, and pH

- Link to depth profiles

Low Flow Survey Results



Temperature Depth Profiles at Two Locations on the Mainstem Chehalis River

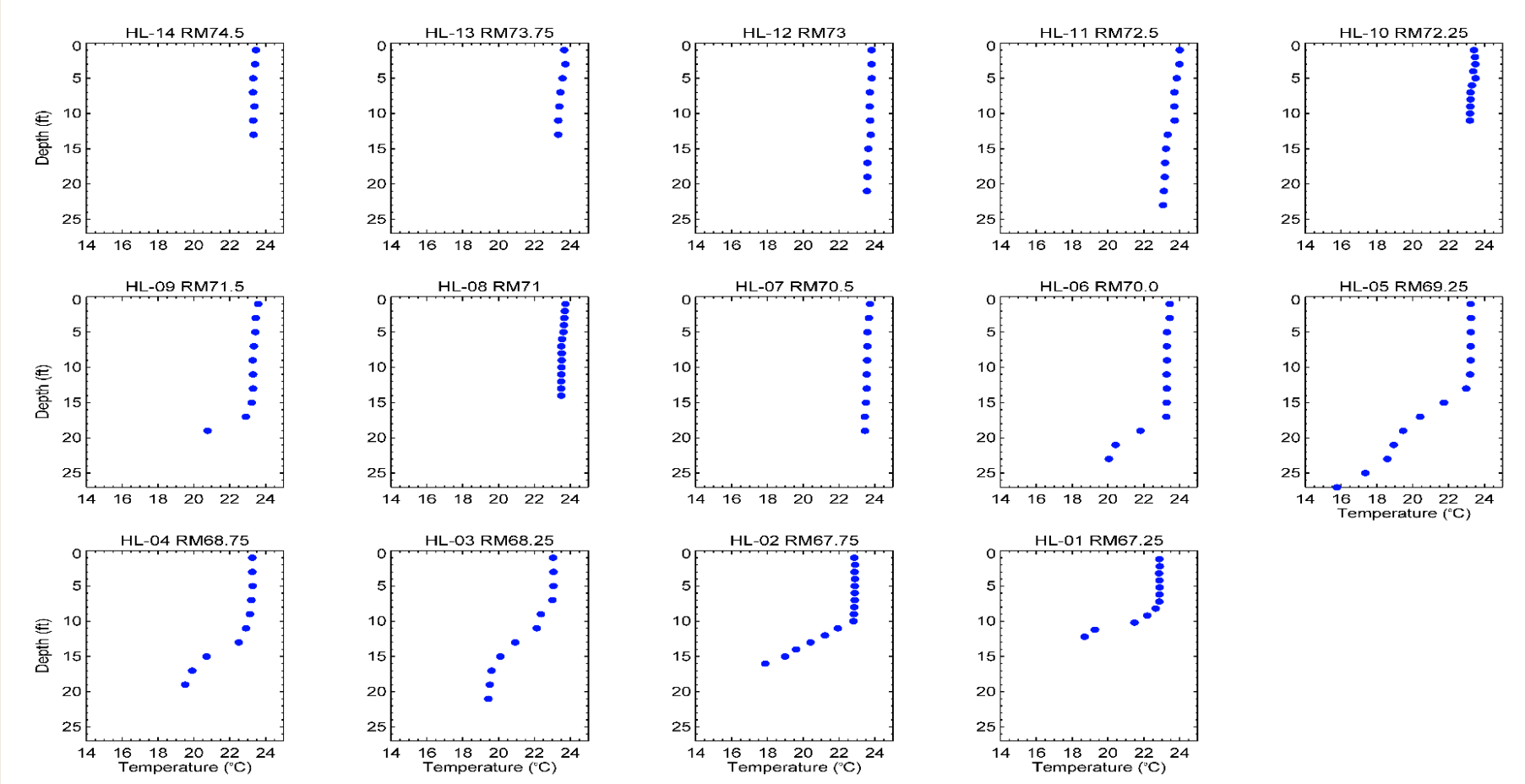


Dissolved Oxygen Depth Profiles at Two Location on the Mainstem Chehalis River

Low-Flow Synoptic Surveys: Spatial Patterns

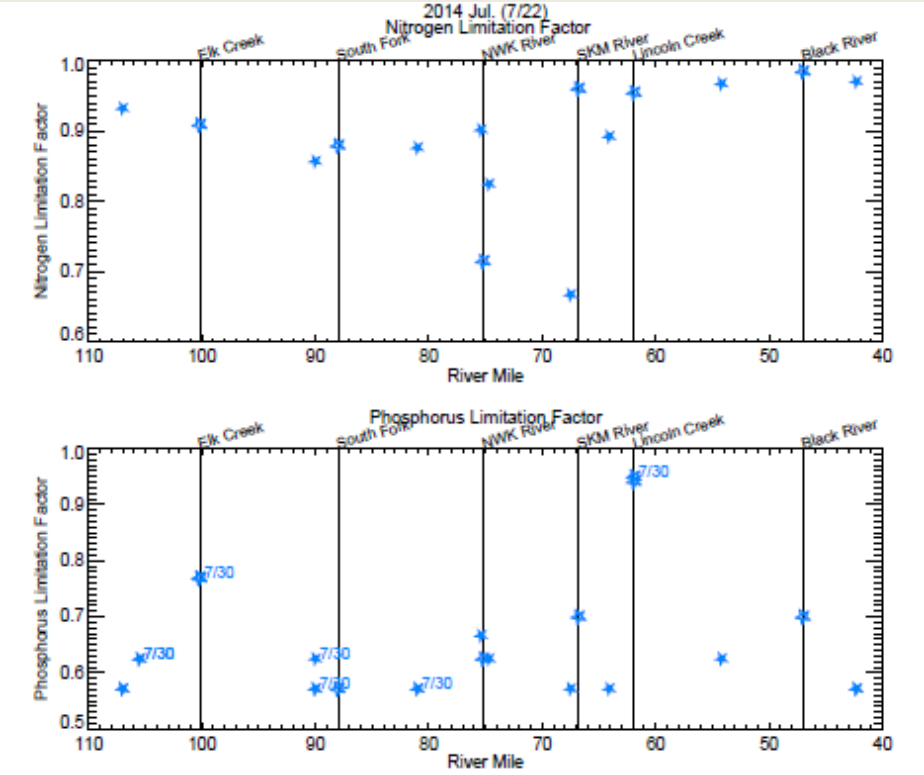
- Link to field and lab parameters

Low Flow Depth Profile - Mainstem

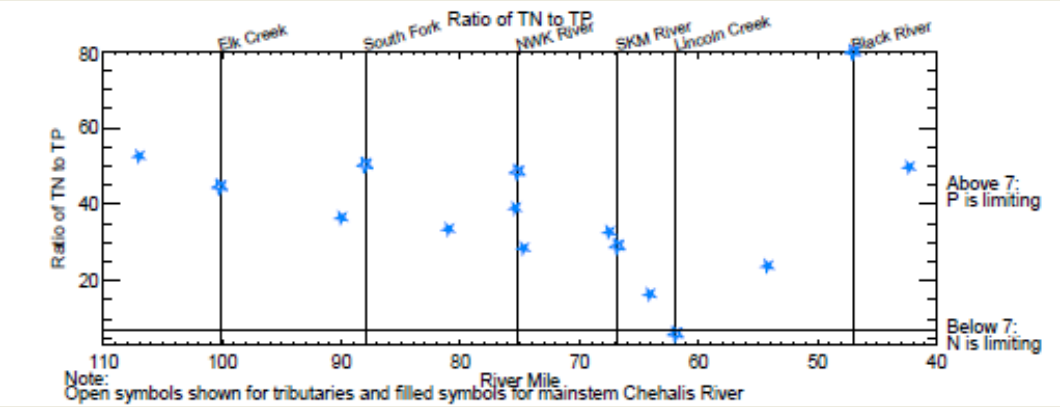


Depth Profiles of Temperature in the Centralia Reach
Depth profiles were collected on 7/31/2014

Nutrient Availability



- Chehalis River is moderately P-limiting
- Low turbidity and chlorophyll-a indicates no light limitation almost throughout the river
- Low-flow or quiescent conditions could promote (attached) algal activity



Centralia Reach Boat Survey

- Link to Field Parameter Depth Profiles

Summary

Temperature Summary

- Upper reaches consistently showed exceedances over criterion
  - Temperature at tributary mouths also warm
  - Data indicates that thermal refuge available to aquatic species is limited in the upper watershed
  - Riparian study indicates only limited shading available in upper reaches (consistent with Ecology's TMDL, which calls for more shading)
- Conditions in fall generally below applicable criterion
- Thermal stratification observed in Centralia Reach

Exceedances in Other Parameters

- DO potentially problematic in upper reaches in summer
  - Evidence of (attached) algal activity
  - pH swings correspond to DO swings, but no excursions noted during study
- DO very low in lower waters of stratified portions of Centralia Reach
  - Particularly from River Miles 68 to 70
  - SOD is likely cause
  - pH also affected in bottom waters, likely from sediment redox activity
- No excursions in turbidity

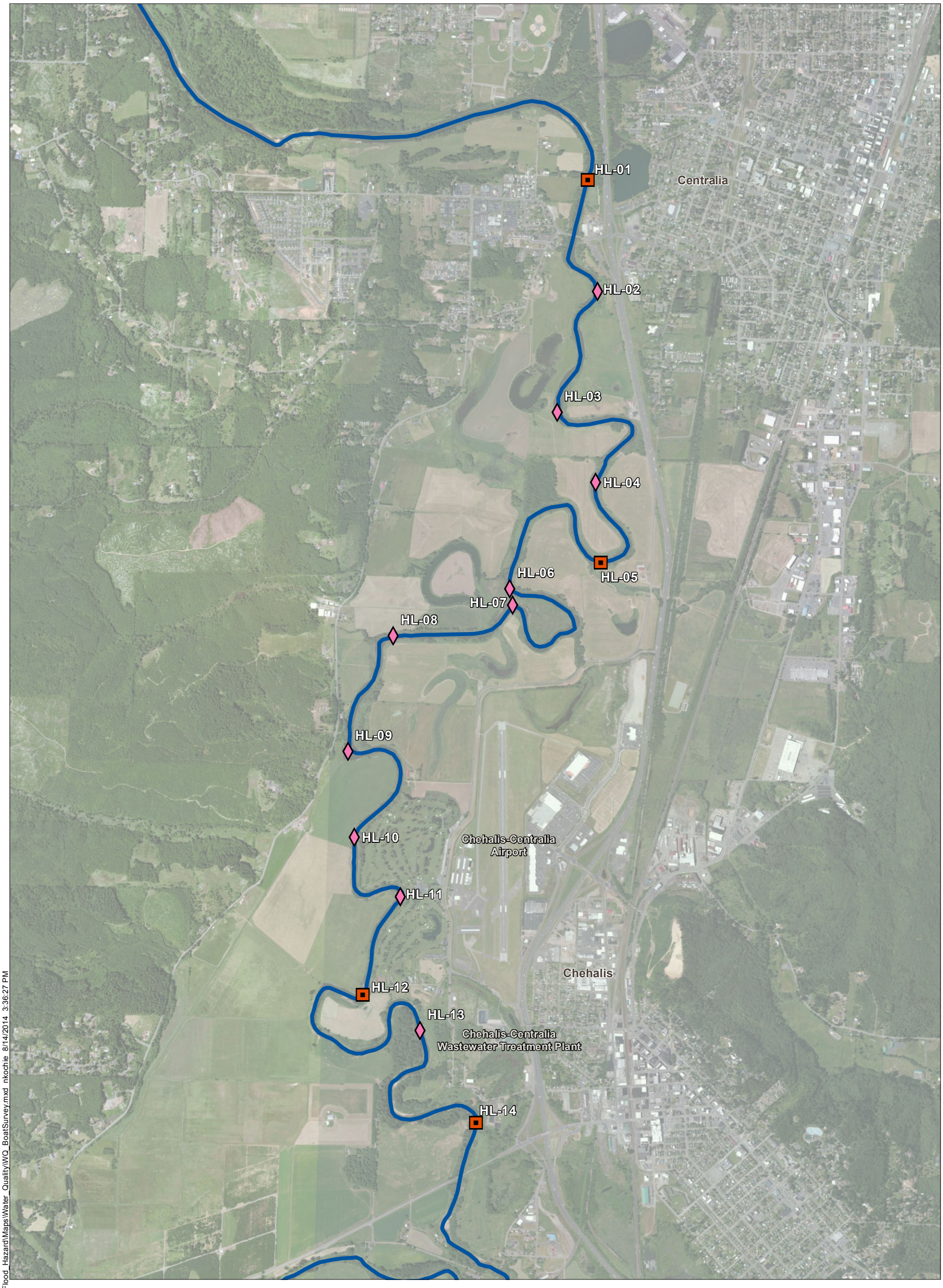
Conclusion

- Water quality study has collected data consistent with the objectives
  - Establishes baseline conditions
  - Data sets for developing temperature and water quality models
- Continued data collection will help establish inter-annual trends
  - Data set collected is over 12-month period covering two summers and one winter

Questions/Discussion

Figure 1
Proposed Flow Measurement, Water Quality Sampling, and Temperature Probe Locations
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

ANCHOR QEA



Water Quality Sampling and Depth Profiling

Water Quality Depth Profiling Only

Chehalis River

Feet

0 2,000 4,000

NOTE:
Depth profiling was performed at all sampling stations.

Q:\Jobs\131023-01.01_Chehalis_Basin_Flood_Hazard\Maps\Water_Quality\WQ_BoatSurvey.mxd nkochie 8/14/2014 3:36:27 PM

ANCHOR QEA

Figure 2
Water Quality Depth Profiling and Sampling Locations in the Centralia Reach Boat Survey
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

Q:\Jobs\131023-01.01_Chehalis_Basin_Flood_Hazard\Maps\Water_Quality\WQ_Groundwater_Wells.mxd nkochie 8/14/2014 3:55:09 PM

ANCHOR QEA

Figure 3
Groundwater Monitoring Locations
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

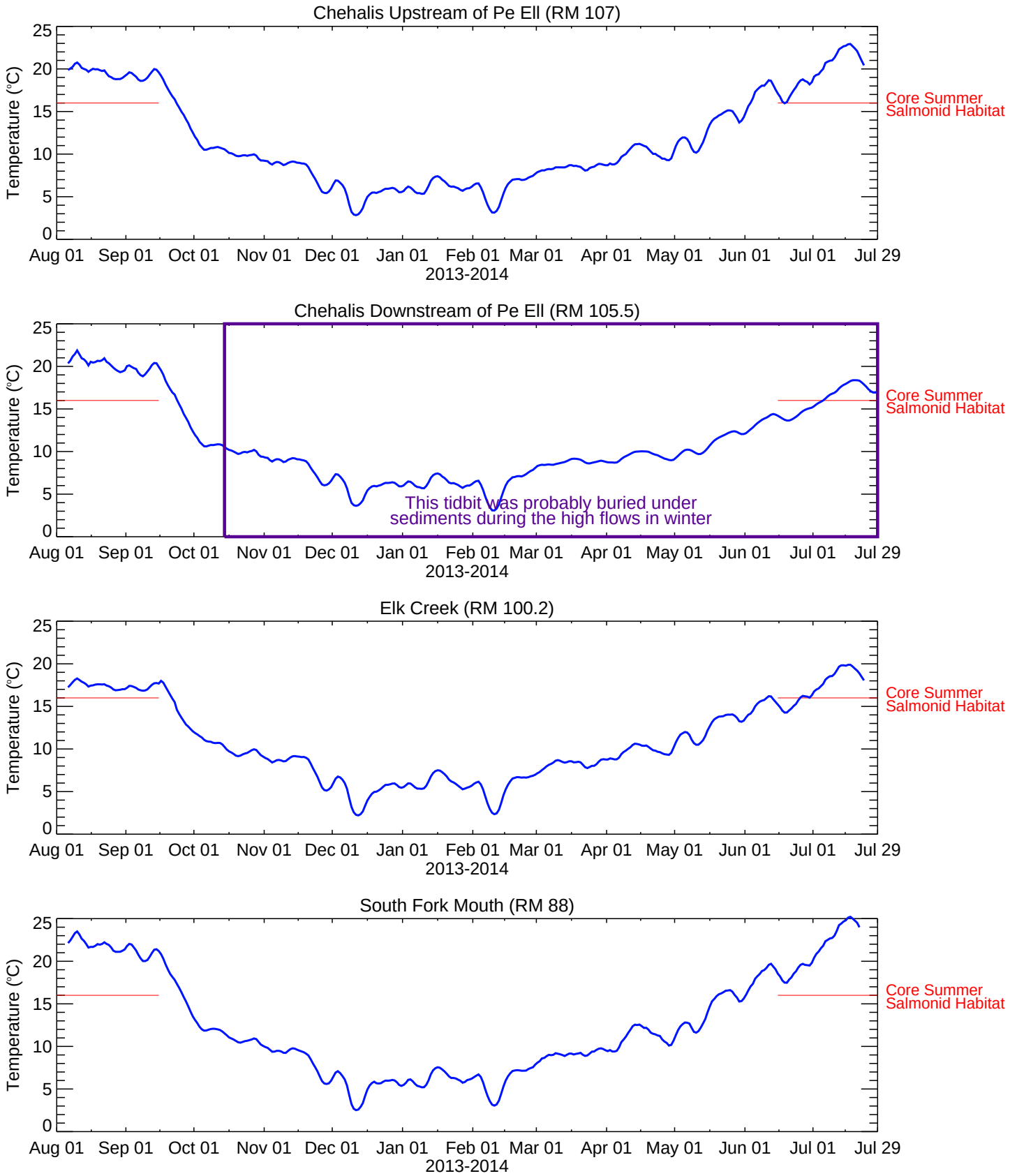


Figure 9

Temporal Trends in Temperature in the Chehalis River and its Major Tributaries

Tidbit data measured every 30 minutes and shown as 7DADmax

ANCHOR QEA

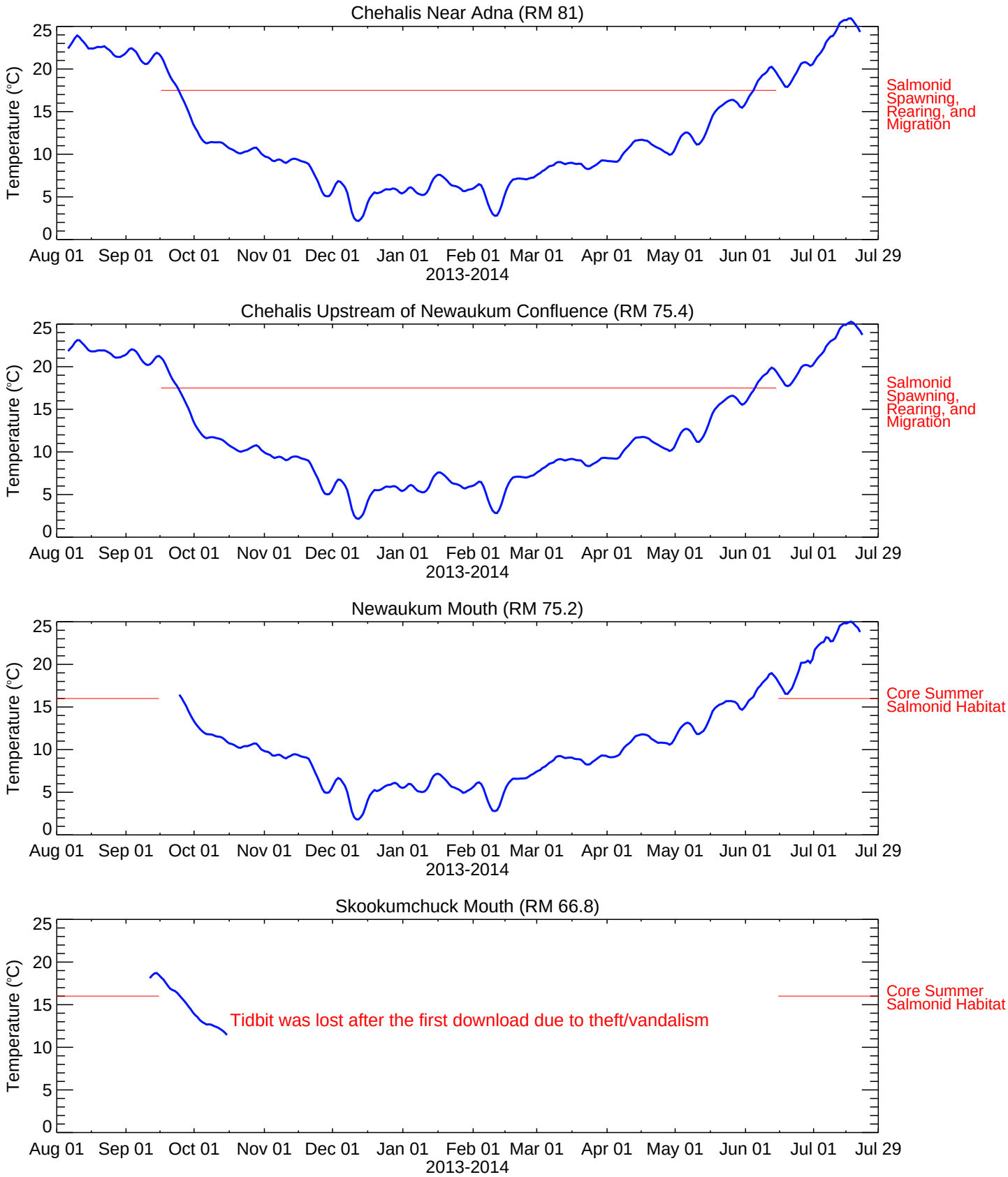


Figure 9 (continued)

Temporal Trends in Temperature in the Chehalis River and its Major Tributaries

Tidbit data measured every 30 minutes and shown as 7DADmax

ANCHOR QEA

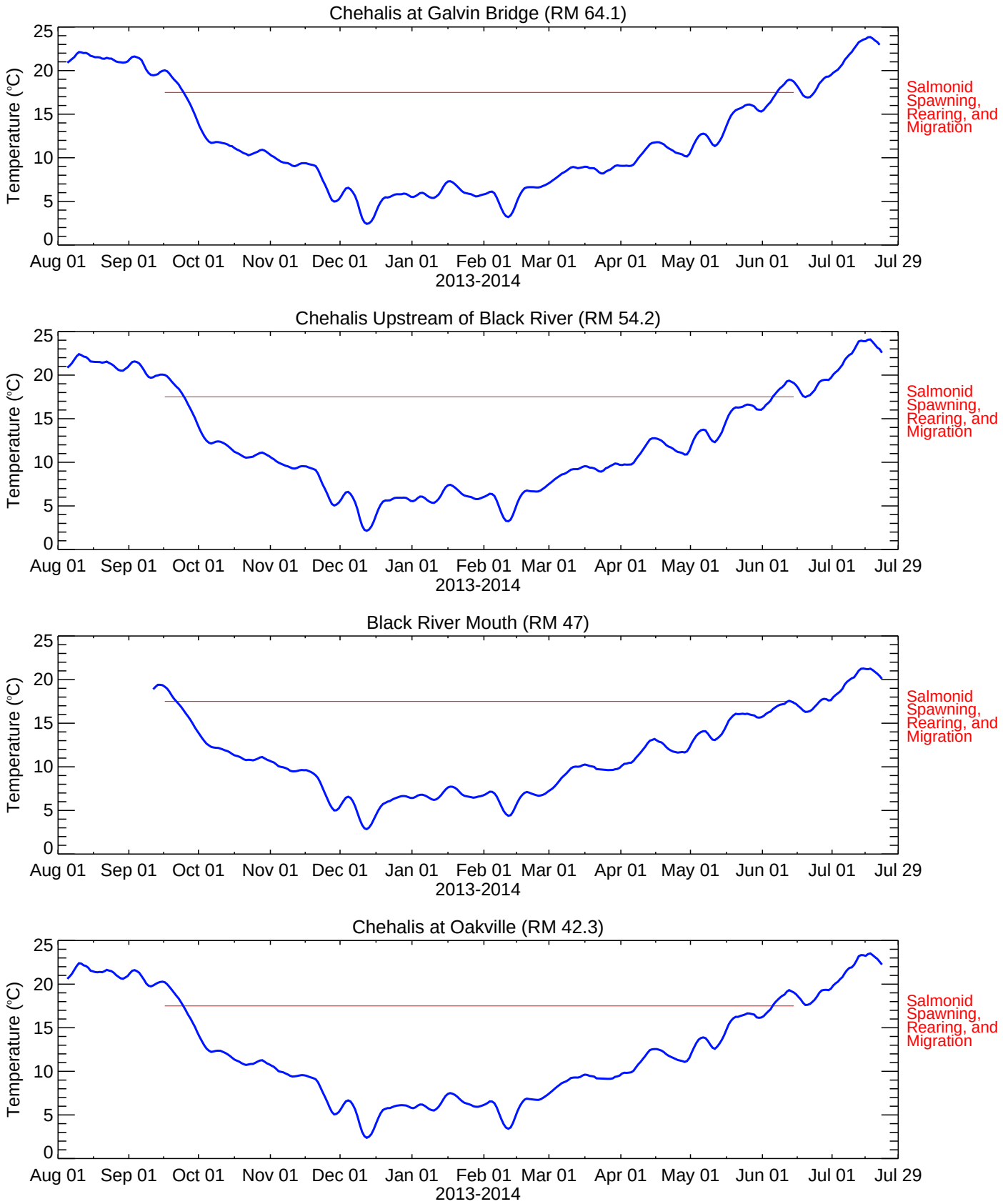


Figure 9 (continued)

Temporal Trends in Temperature in the Chehalis River and its Major Tributaries

Tidbit data measured every 30 minutes and shown as 7DADmax

ANCHOR QEA

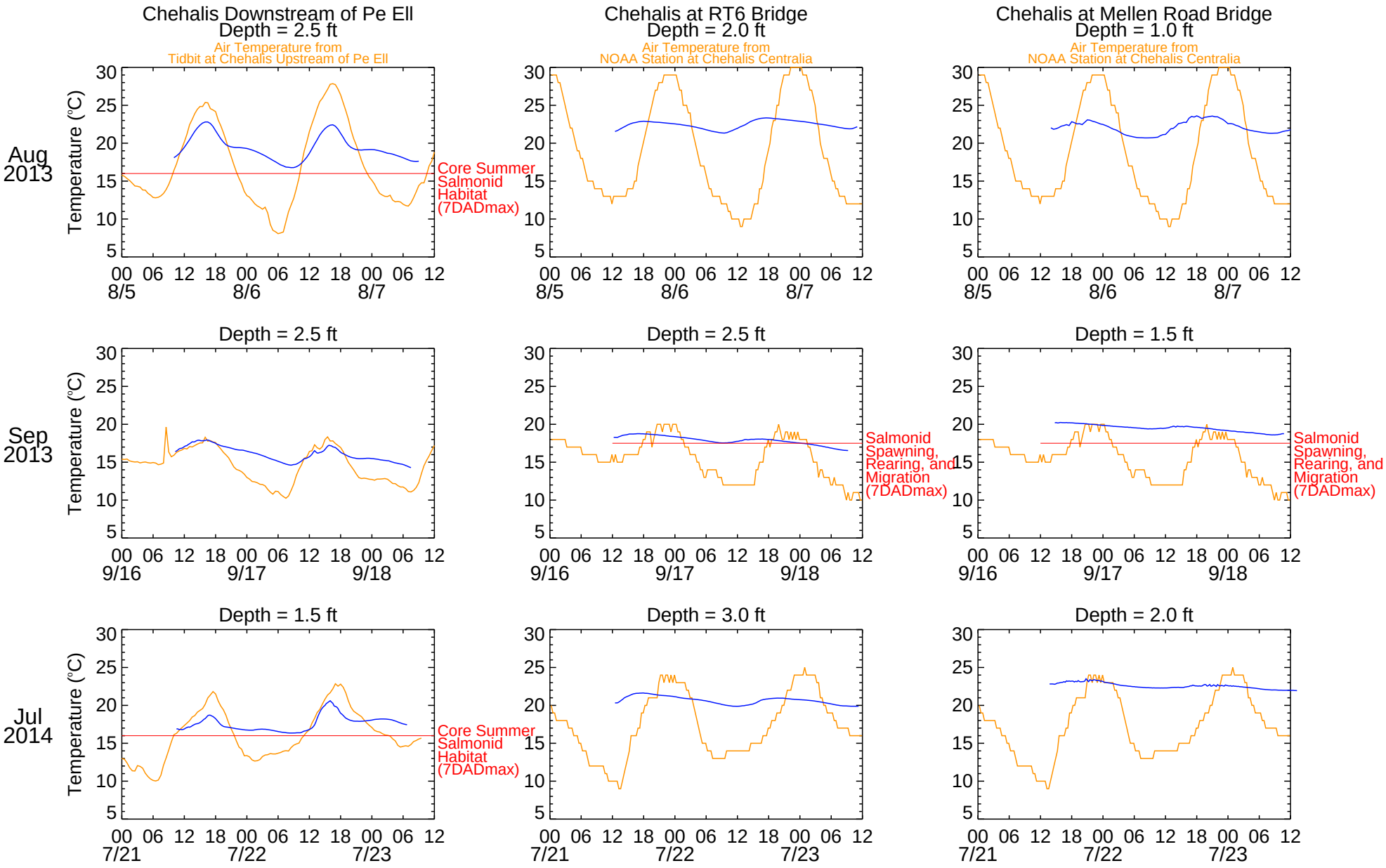


Figure 12

Diurnal Trends in Temperature Recorded at Three Locations on the Mainstem Chehalis River

ANCHOR QEA

BG - C:\D_Drive\WORK\Chehalis_Basin\IDL\Chehalis_Data_Plot__HLab_temporal.pro Mon Aug 18 09:50:41 2014

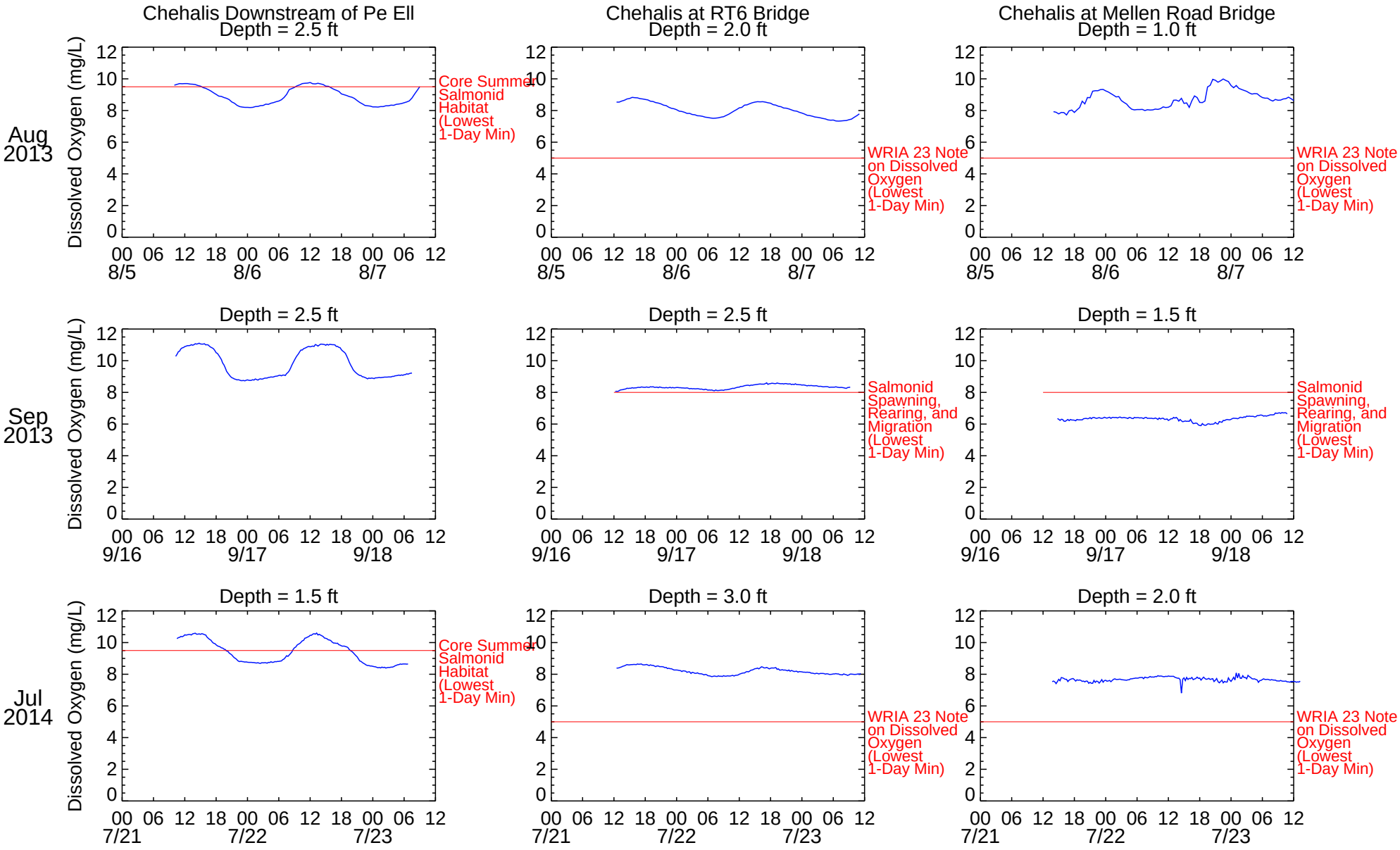


Figure 13

Diurnal Trends in Dissolved Oxygen Recorded at Three Locations on the Mainstem Chehalis River

Sept. data calibrated from raw measurements at 637 mmHg to values shown at 750 mmHg

ANCHOR QEA

BG - C:\D_Drive\WORK\Chehalis_Basin\IDL\Chehalis_Data_Plot__HLab_temporal.pro Mon Aug 18 09:50:41 2014

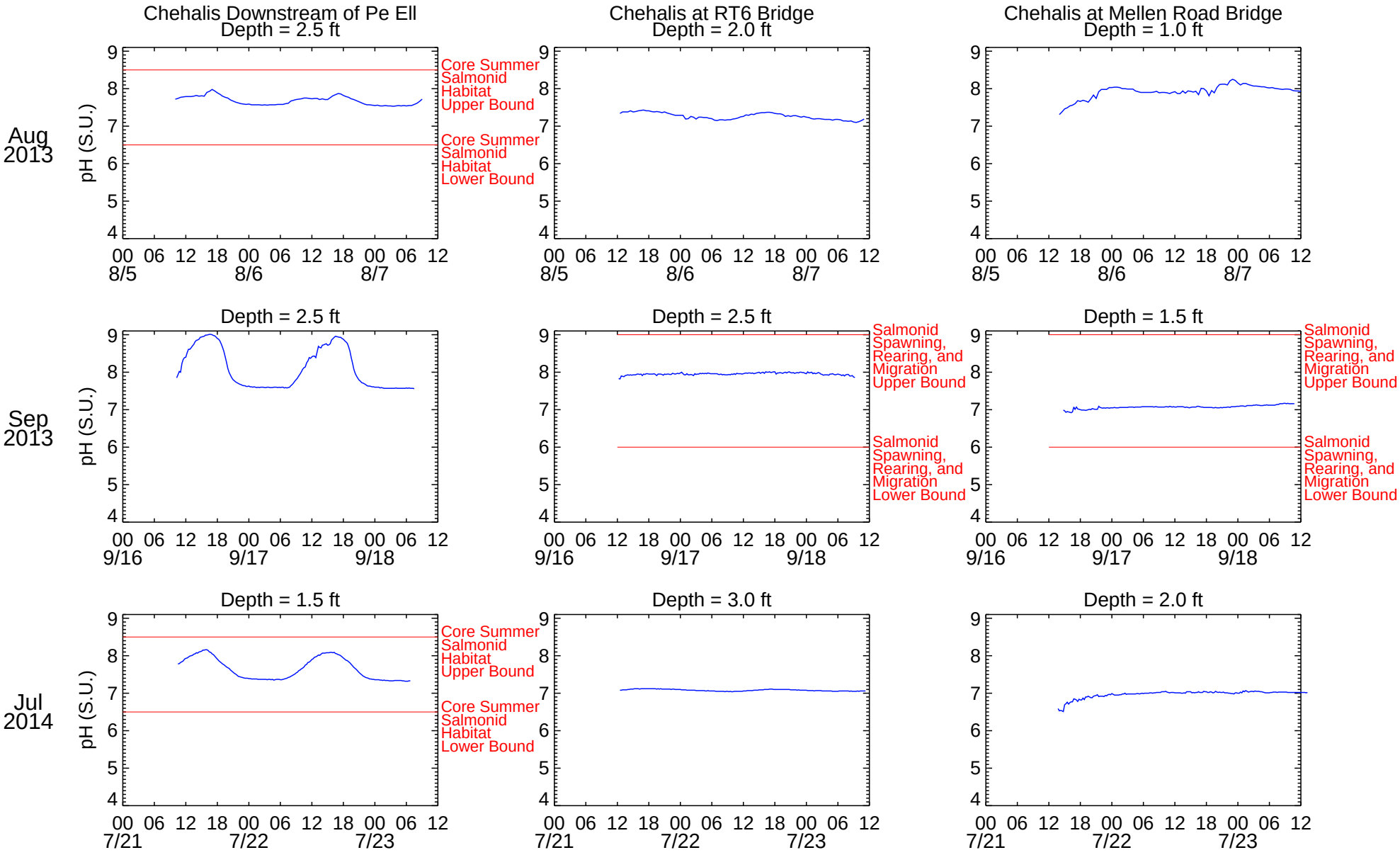


Figure 14

Diurnal Trends in pH Recorded at Three Locations on the Mainstem Chehalis River

ANCHOR QEA

BG - C:\D_Drive\WORK\Chehalis_Basin\IDL\Chehalis_Data_Plot__HLab_temporal.pro Mon Aug 18 09:50:41 2014

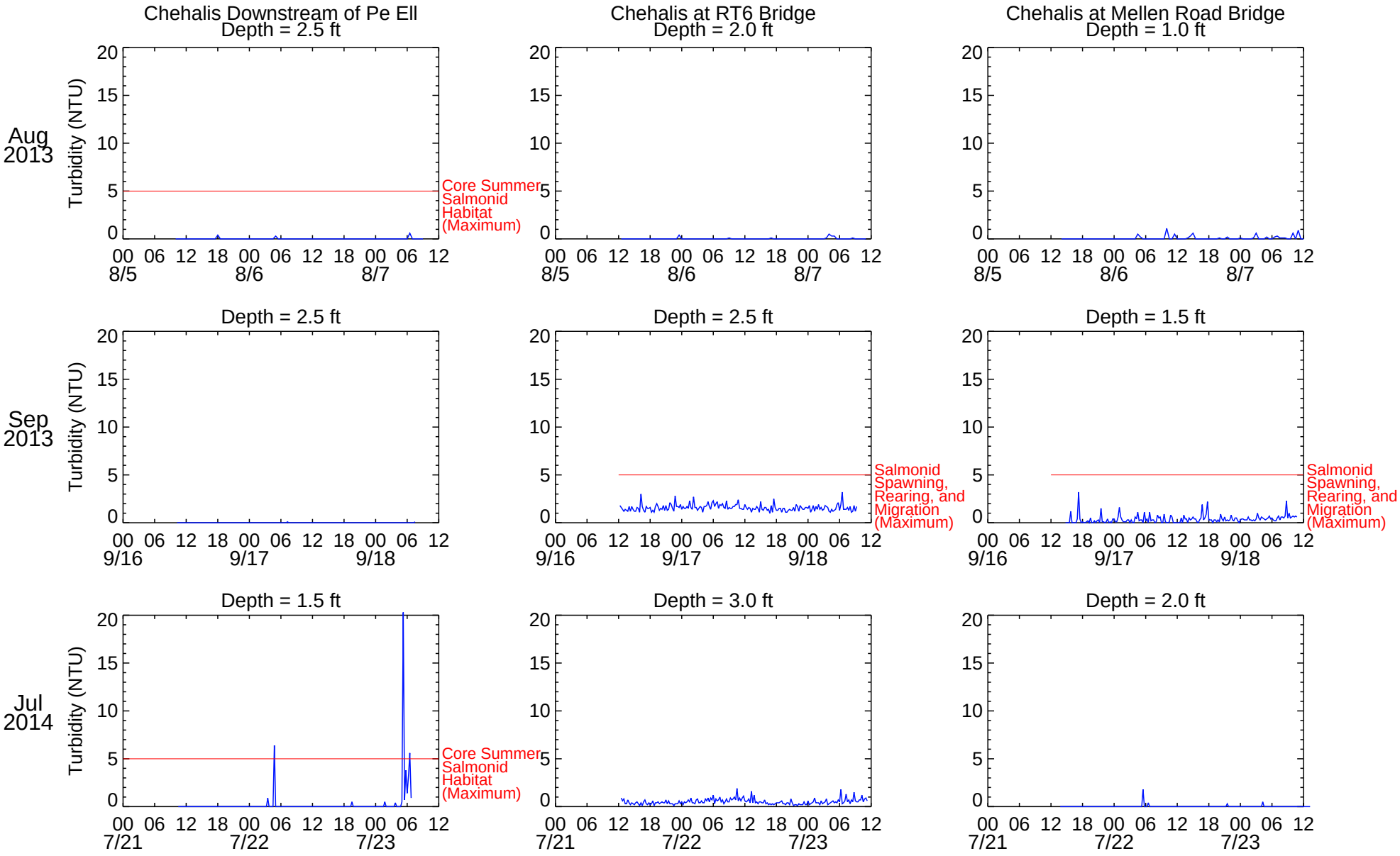


Figure 15

Diurnal Trends in Turbidity Recorded at Three Locations on the Mainstem Chehalis River

ANCHOR QEA

BG - C:\D_Drive\WORK\Chehalis_Basin\IDL\Chehalis_Data_Plot__HLab_temporal.pro Mon Aug 18 09:50:41 2014

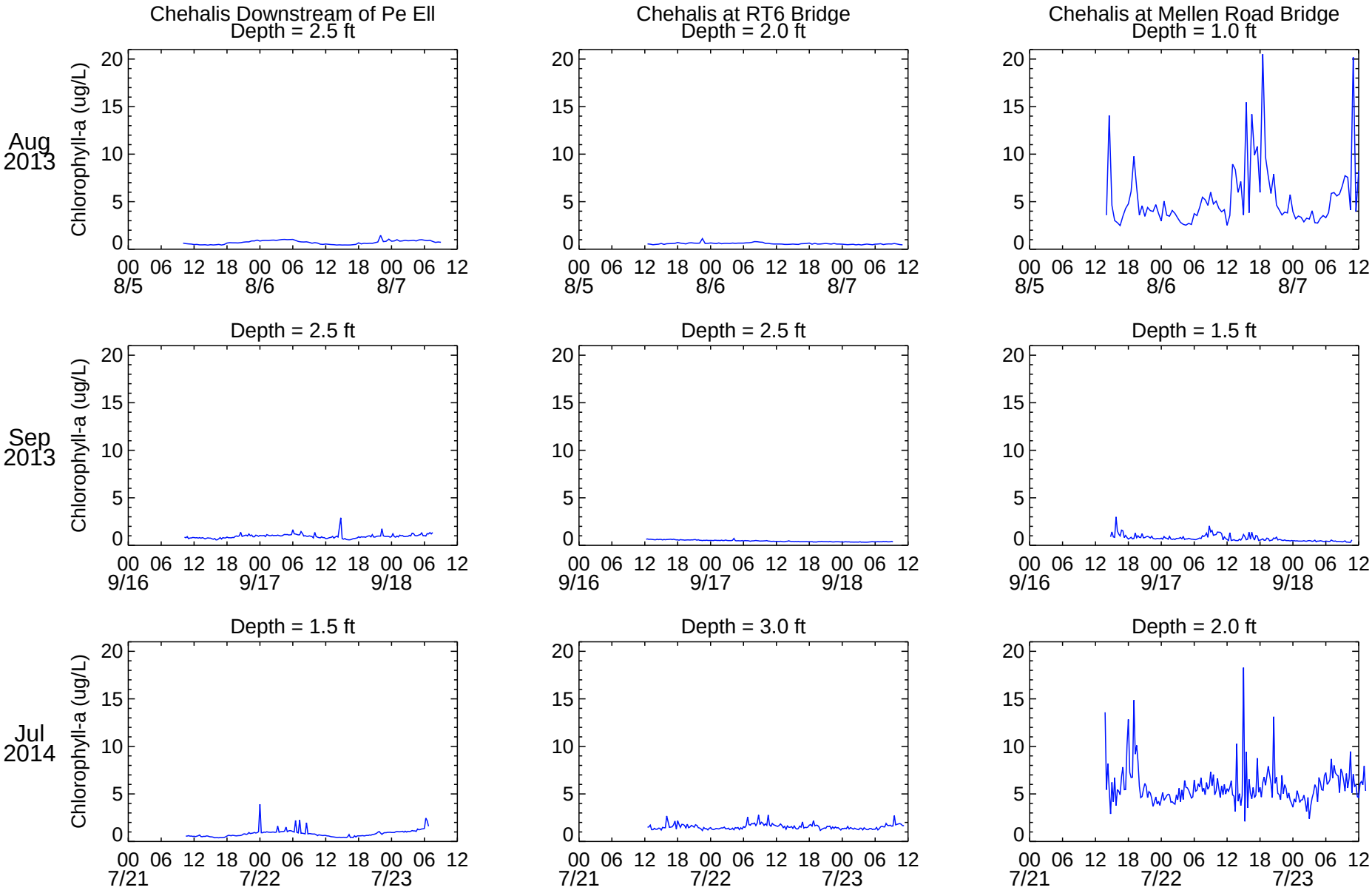


Figure 16

Diurnal Trends in Chlorophyll-a Recorded at Three Locations on the Mainstem Chehalis River

ANCHOR QEA

BG - C:\D_Drive\WORK\Chehalis_Basin\IDL\Chehalis_Data_Plot__HLab_temporal.pro Mon Aug 18 09:50:41 2014

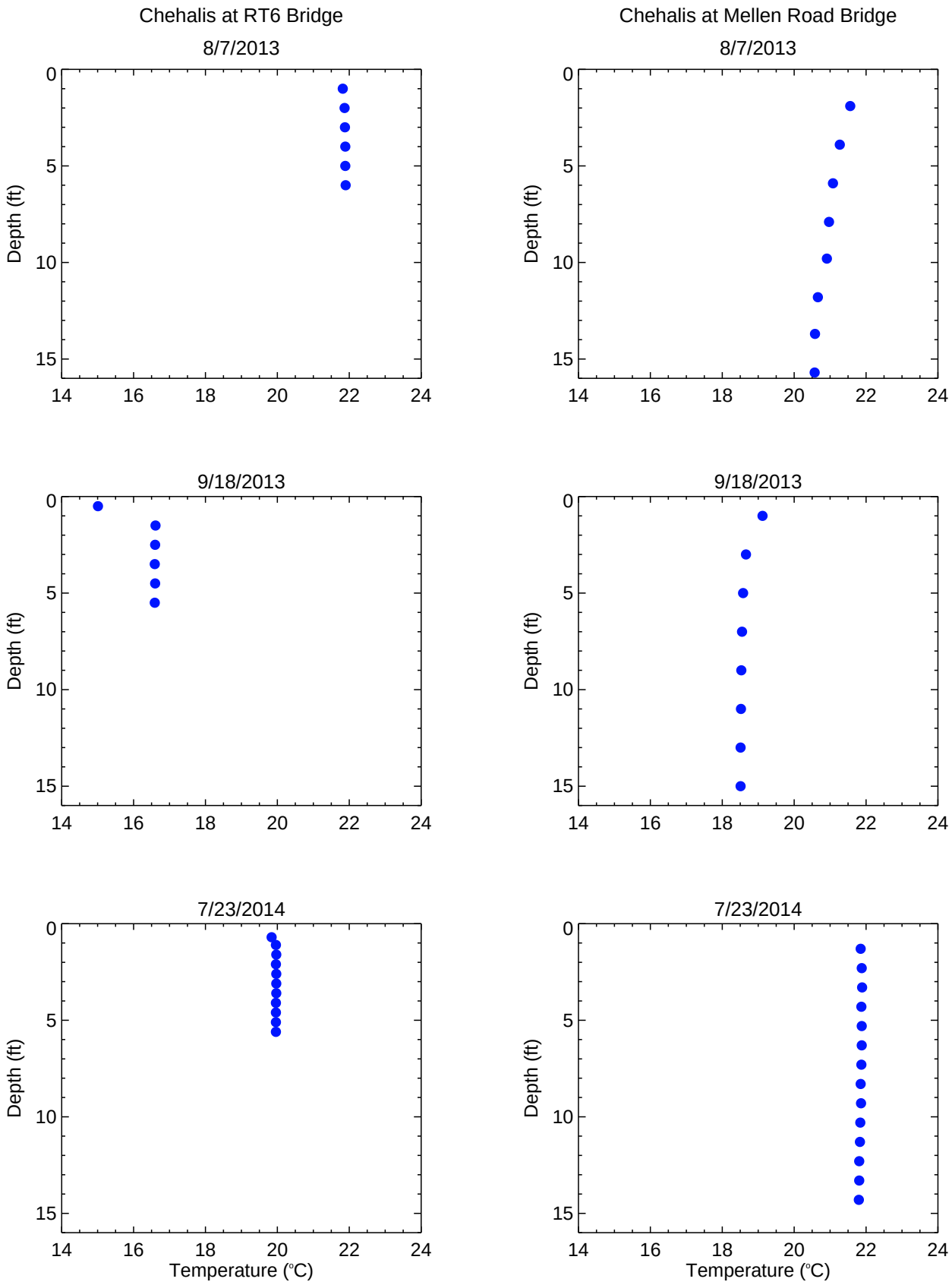


Figure 17

Temperature Depth Profiles at Two Locations on the Mainstem Chehalis River

ANCHOR QEA

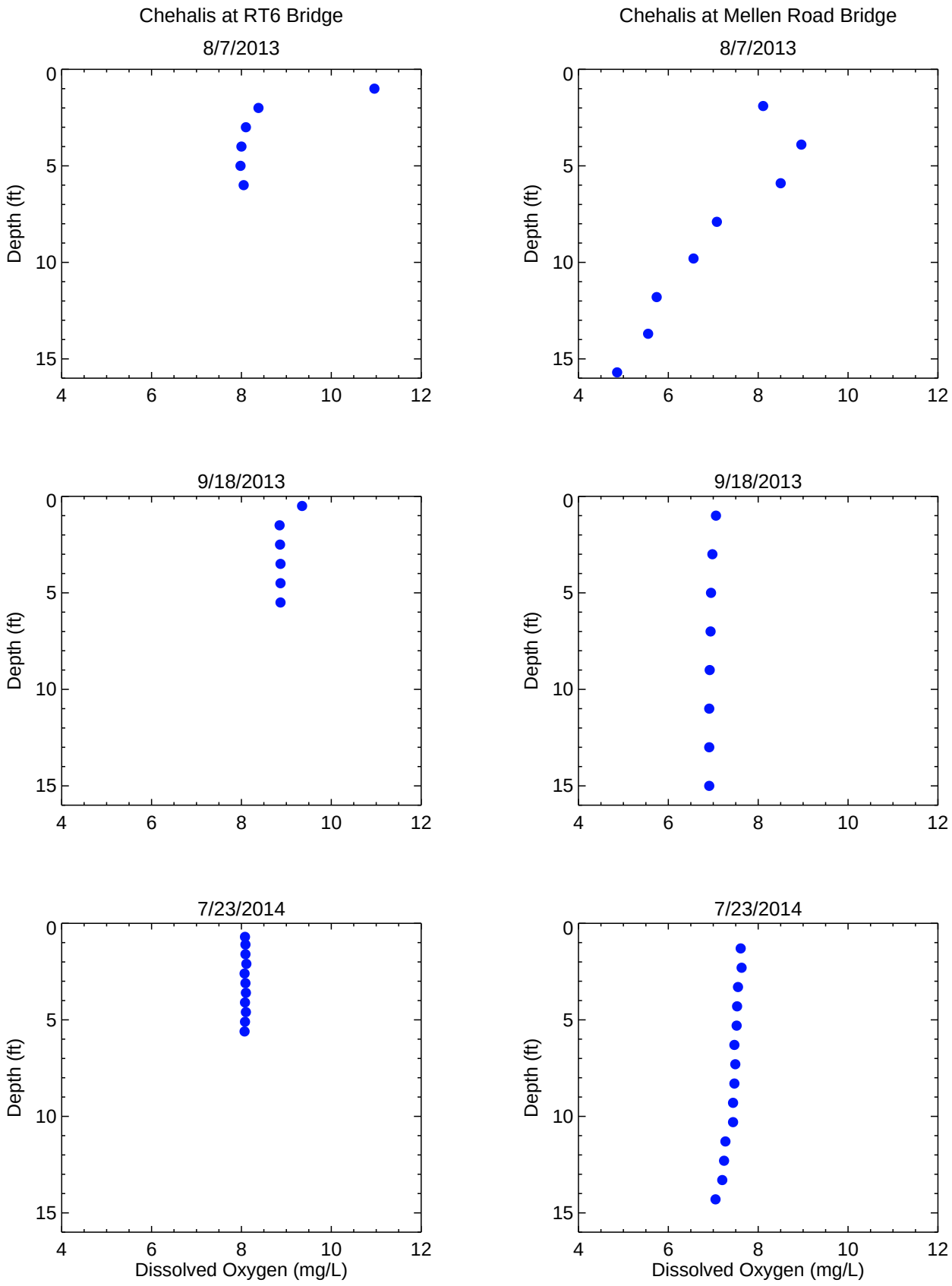


Figure 18

Dissolved Oxygen Depth Profiles at Two Locations on the Mainstem Chehalis River

ANCHOR QEA

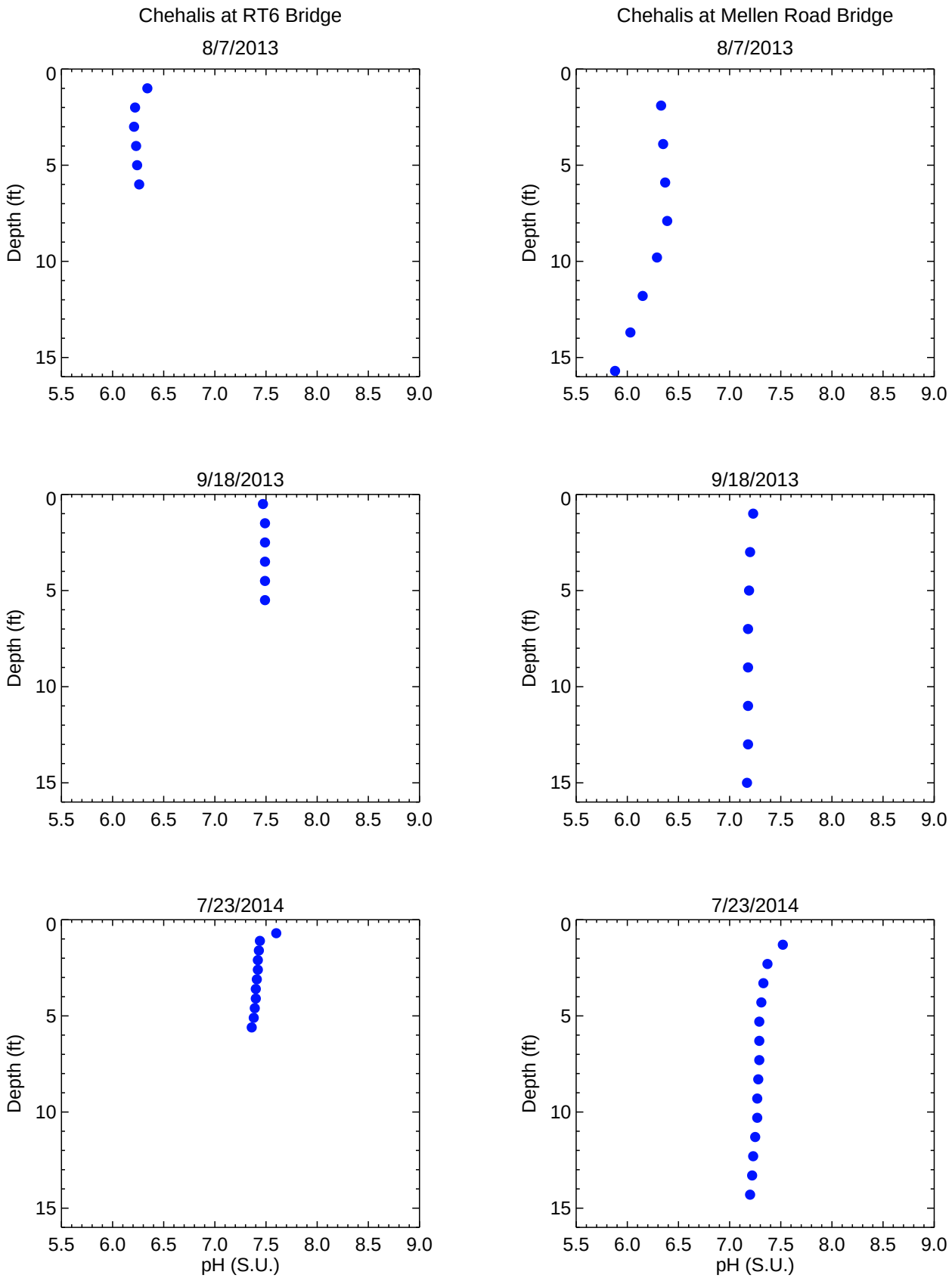


Figure 19

pH Depth Profiles at Two Locations on the Mainstem Chehalis River

ANCHOR QEA

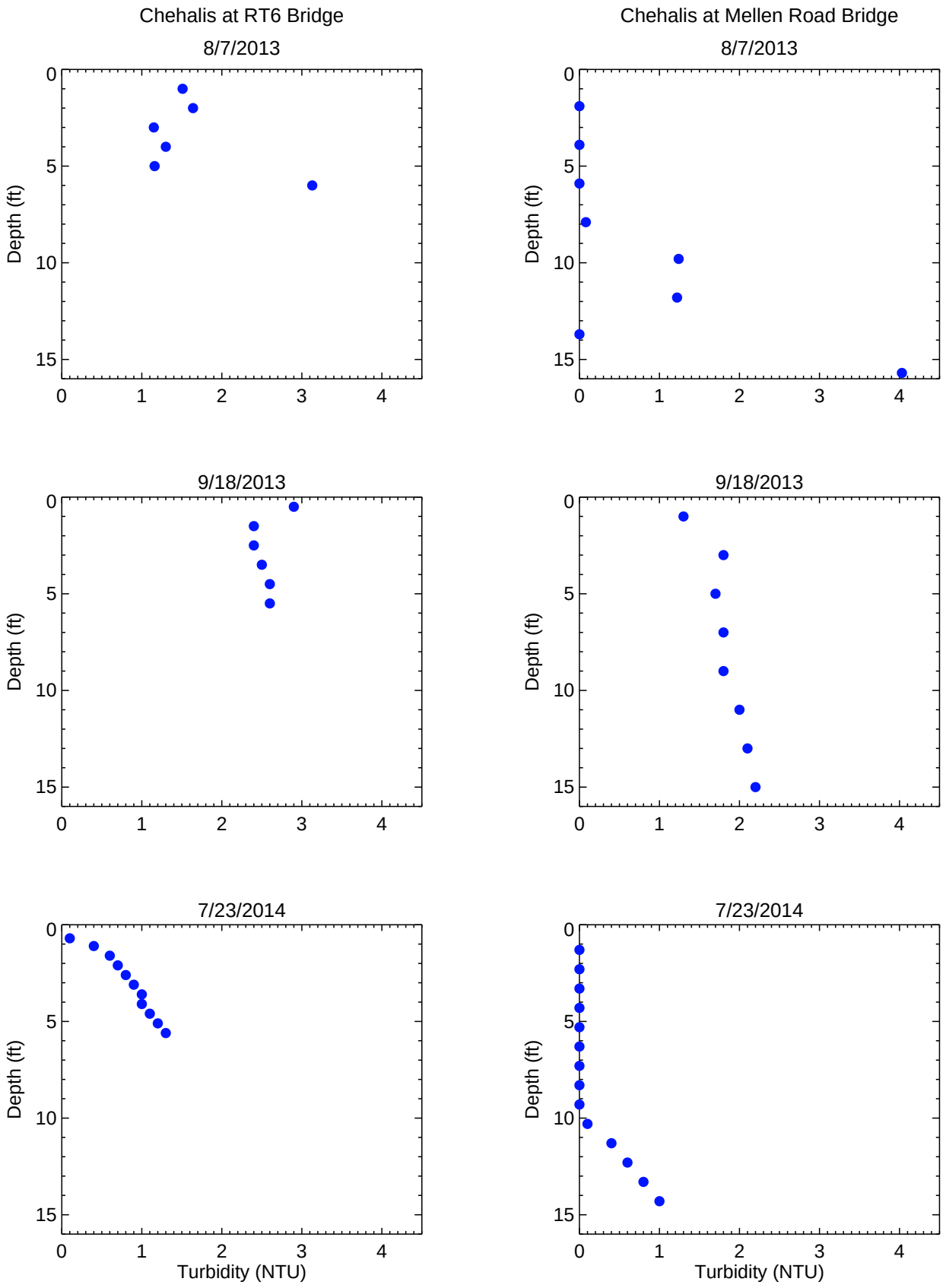


Figure 20

Turbidity Depth Profiles at Two Locations on the Mainstem Chehalis River

ANCHOR QEA

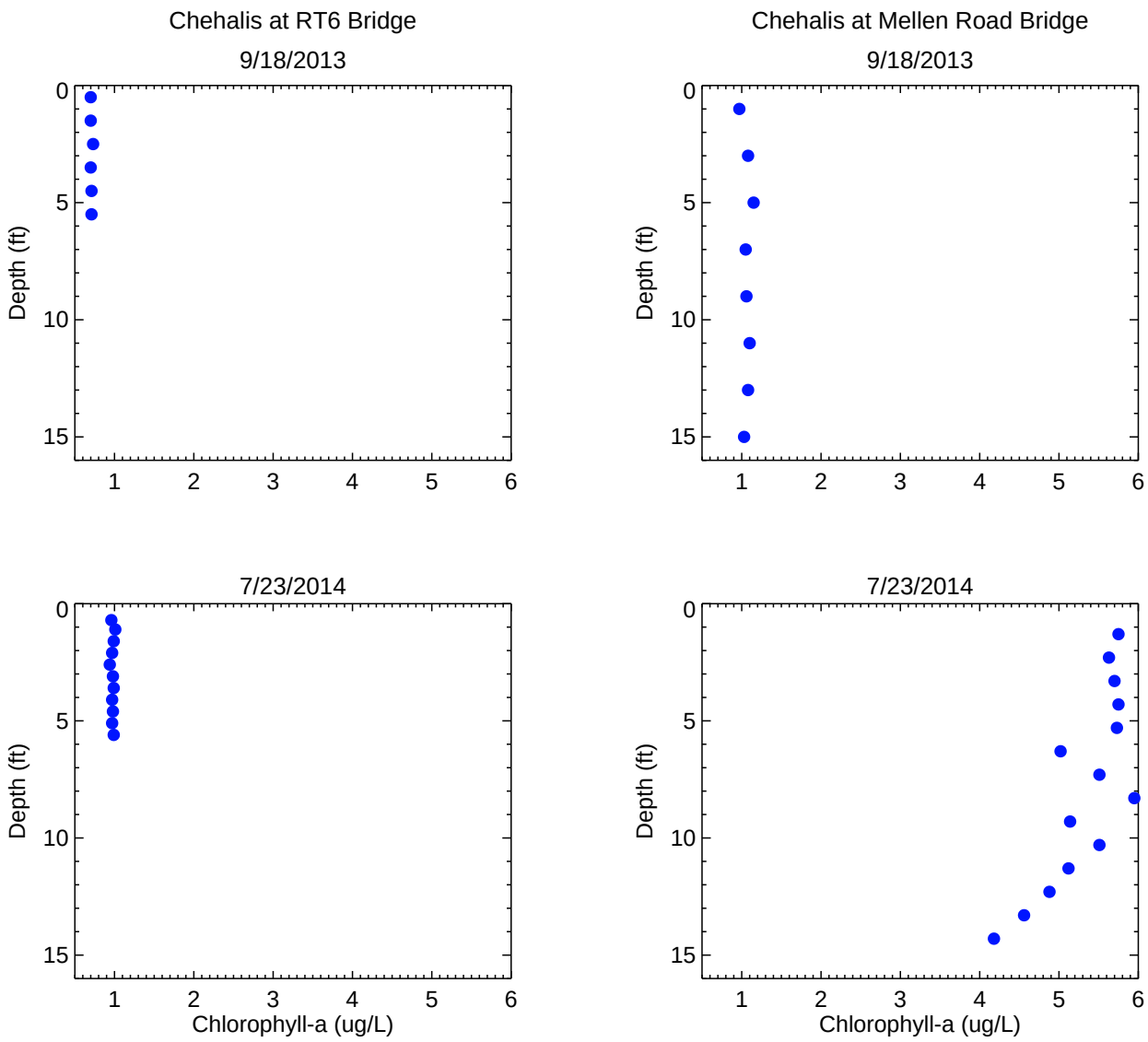


Figure 21

Chlorophyll-a Depth Profiles at Two Locations on the Mainstem Chehalis River

ANCHOR QEA

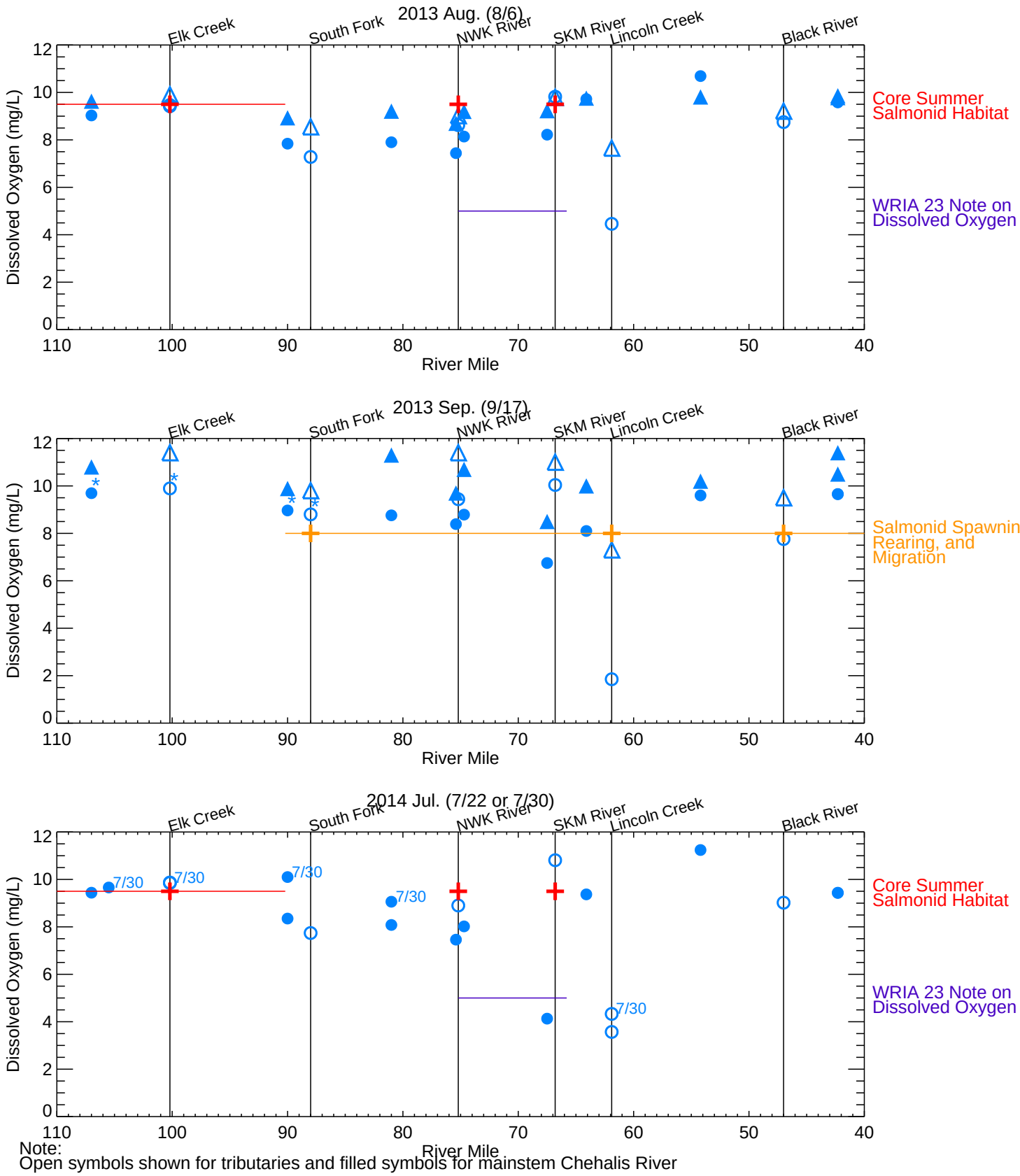


Figure 22

Spatial Patterns in Dissolved Oxygen in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

ANCHOR QEA

● Field
▲ Lab - Dragon

Ecology criteria shown and labeled. Crosses shown when the criteria apply to tributaries
*Sept. measurements flagged with * signs were calibrated from raw measurements at 637 mmHg to values shown at 750 mmHg*

BG - C:\D_Drive\WORK\Chehalis_Basin\IDL\Chehalis_Data_Plot__WQ_spatial.pro Mon Aug 18 12:30:44 2014

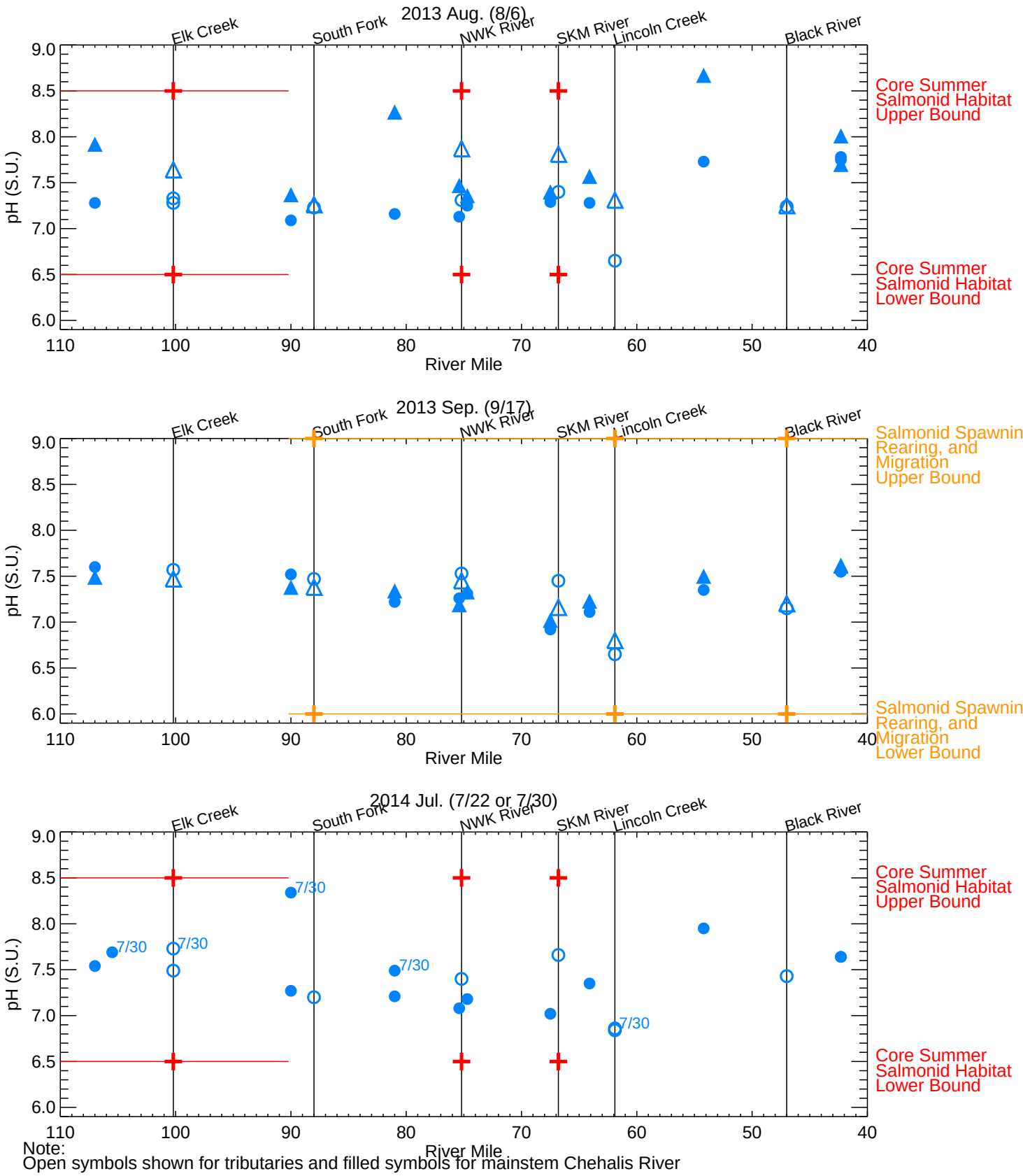


Figure 23

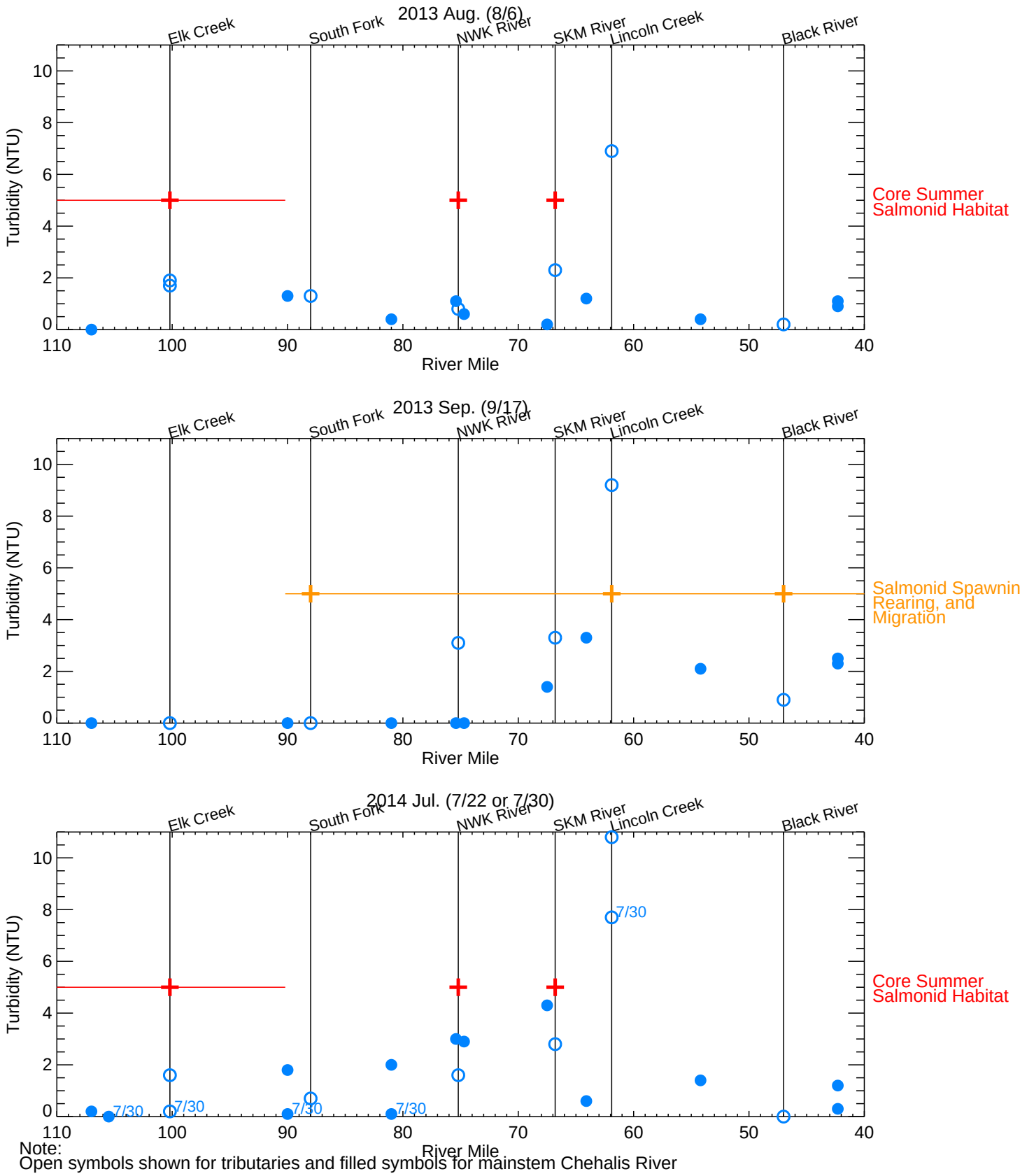
Spatial Patterns in pH in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Ecology criteria shown and labeled. Crosses shown when the criteria apply to tributaries

ANCHOR QEA

● Field
▲ Lab - Dragon

BG - C:\D_Drive\WORK\Chehalis_Basin\IDL\Chehalis_Data_Plot__WQ_spatial.pro Mon Aug 18 12:30:44 2014



Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River

Figure 24

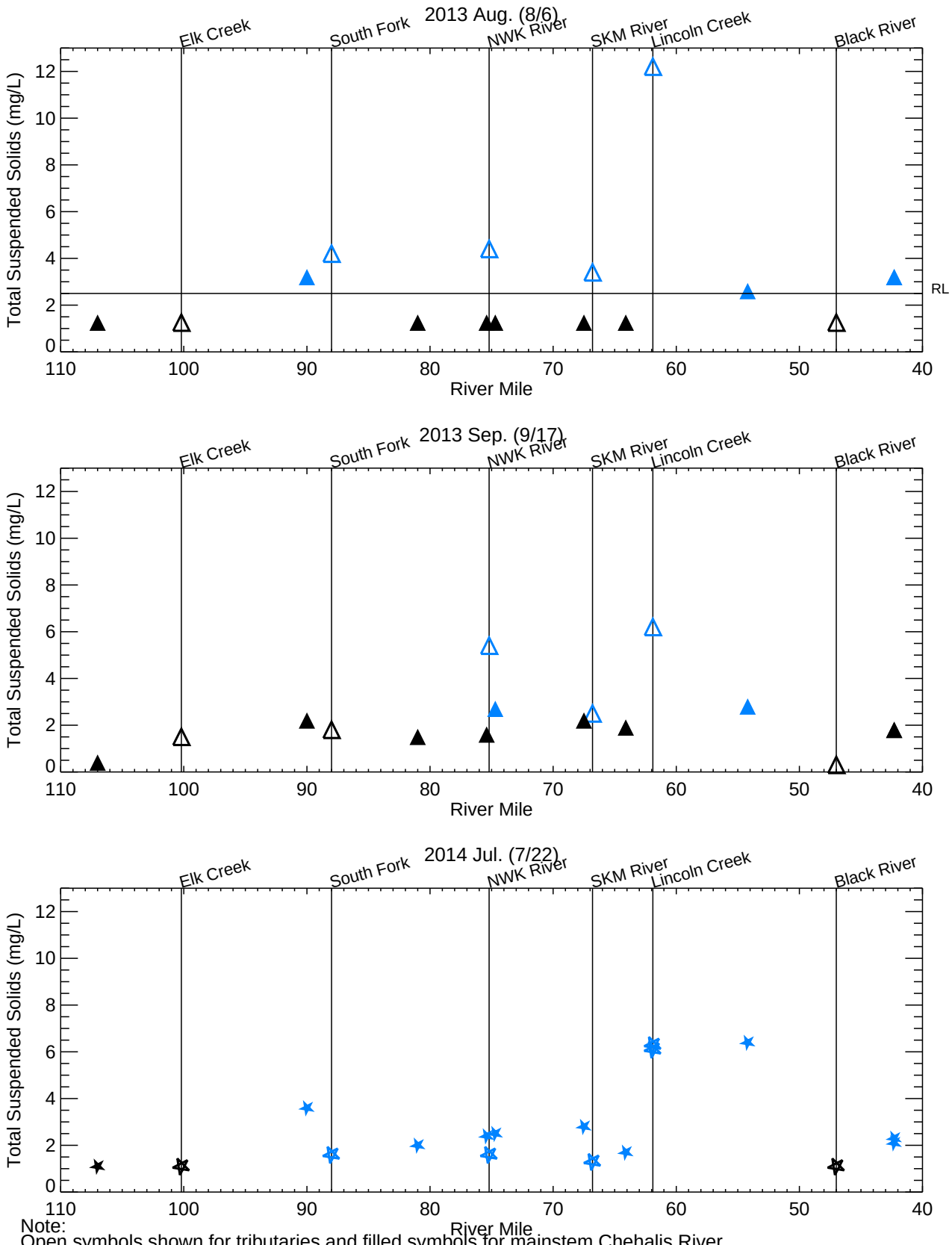
Spatial Patterns in Turbidity in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Ecology criteria shown and labeled. Crosses shown when the criteria apply to tributaries

ANCHOR QEA

● Field

BG - C:\D_Drive\WORK\Chehalis_Basin\IDL\Chehalis_Data_Plot__WQ_spatial.pro Mon Aug 18 12:30:44 2014



Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River
Non-detected or J-flagged results shown in black

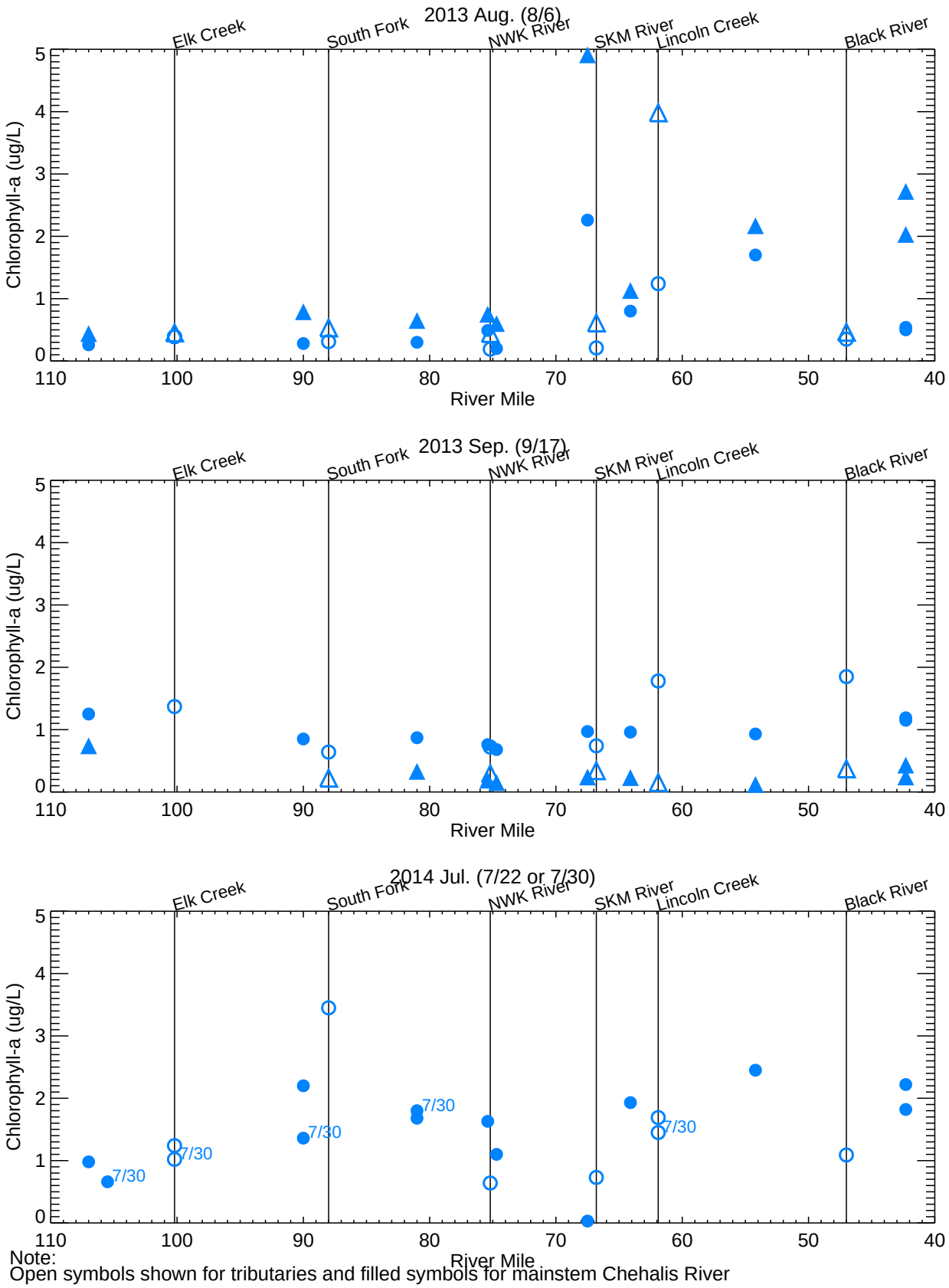
Figure 25

Spatial Patterns in Total Suspended Solids in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Non-detects set to half of reporting limits

ANCHOR QEA

Lab - ARI
Lab - Dragon



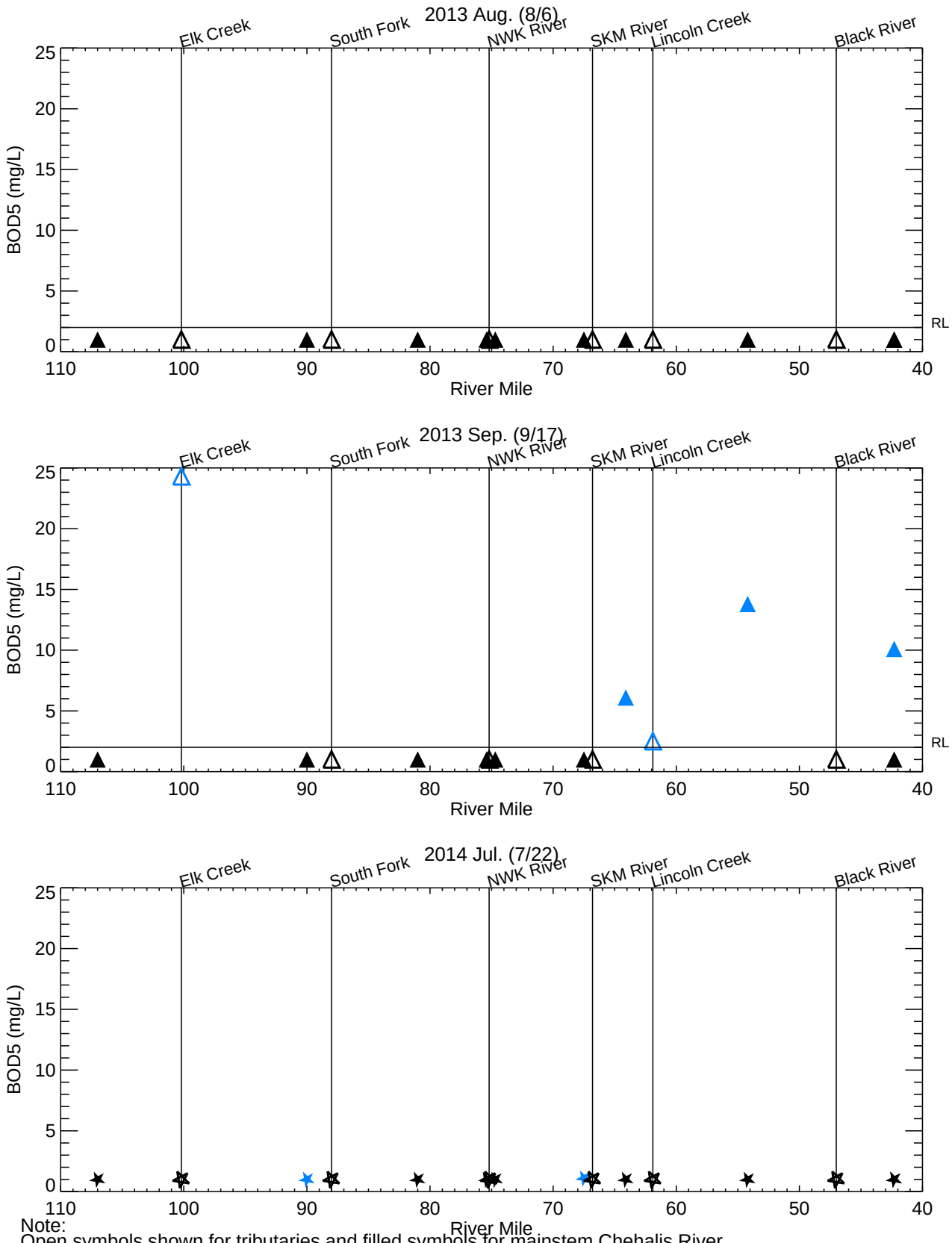
Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River

Figure 26

Spatial Patterns in Chlorophyll-a in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

ANCHOR QEA

● Field
▲ Lab - Dragon



Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River
Non-detected or J-flagged results shown in black

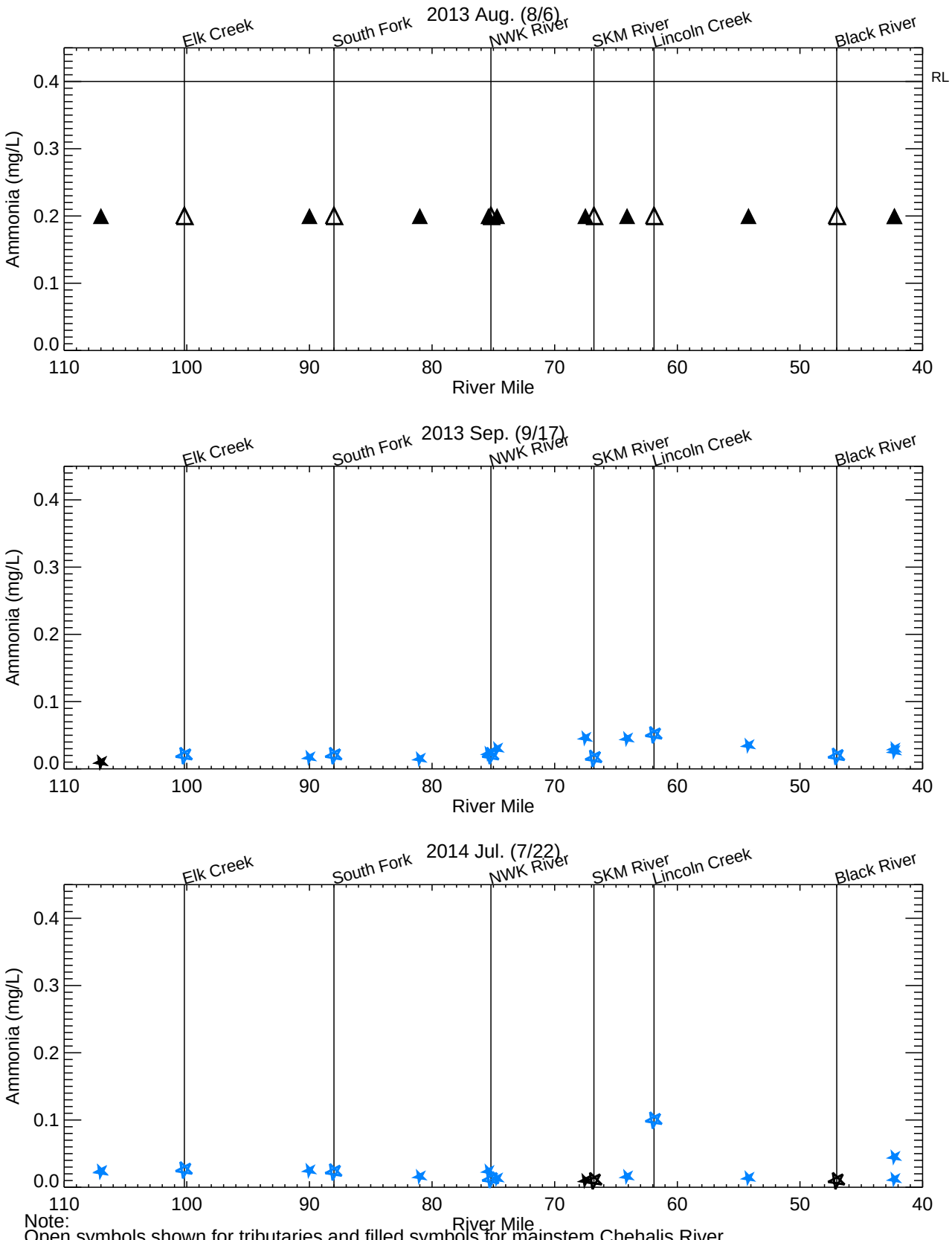
Figure 27

Spatial Patterns in 5-Day Biochemical Oxygen Demand in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Non-detects set to half of reporting limits

ANCHOR QEA

Lab - ARI
Lab - Dragon



Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River
Non-detected or J-flagged results shown in black

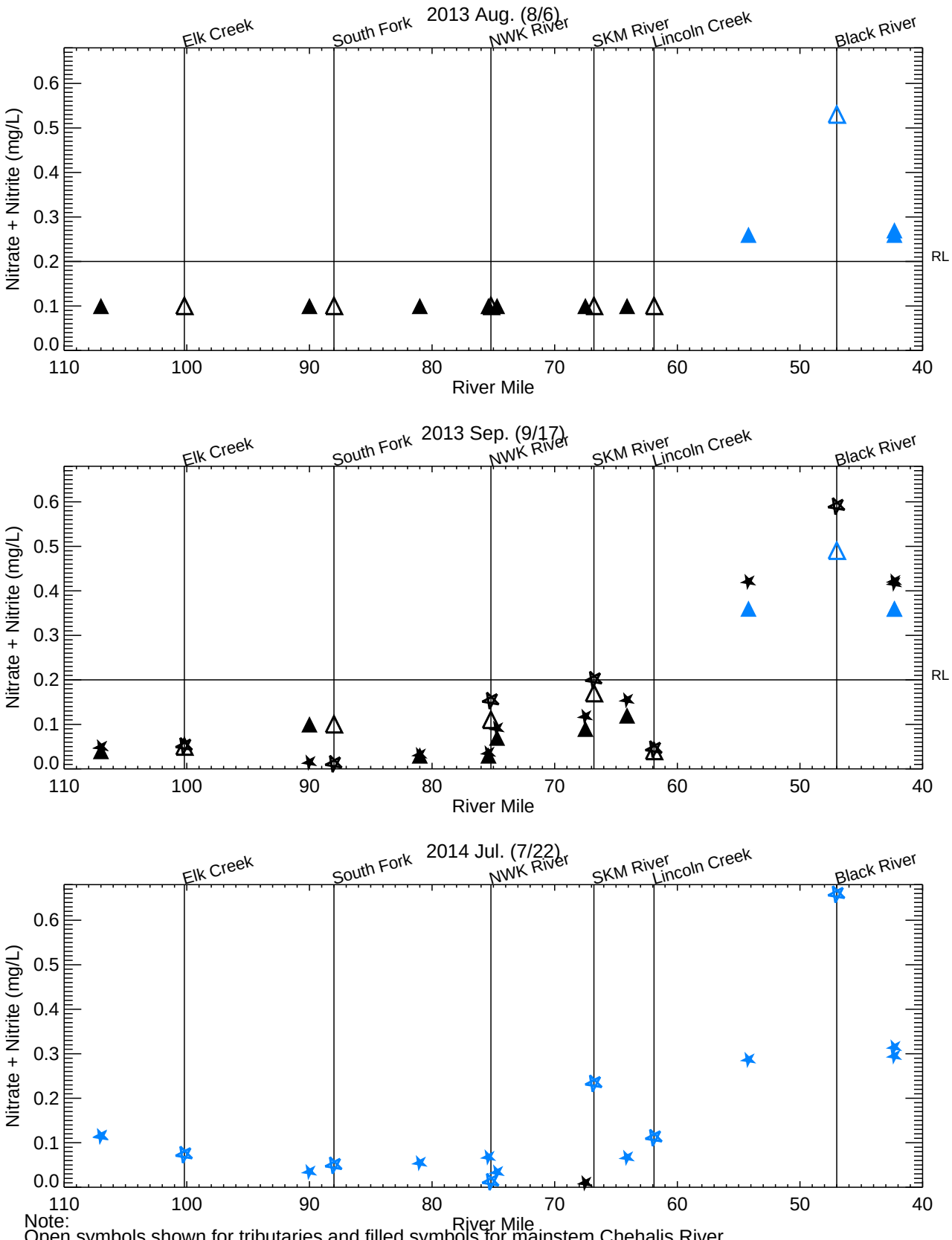
Figure 28

Spatial Patterns in Ammonia in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Non-detects set to half of reporting limits

ANCHOR QEA

Lab - ARI
Lab - Dragon



Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River
Non-detected or J-flagged results shown in black

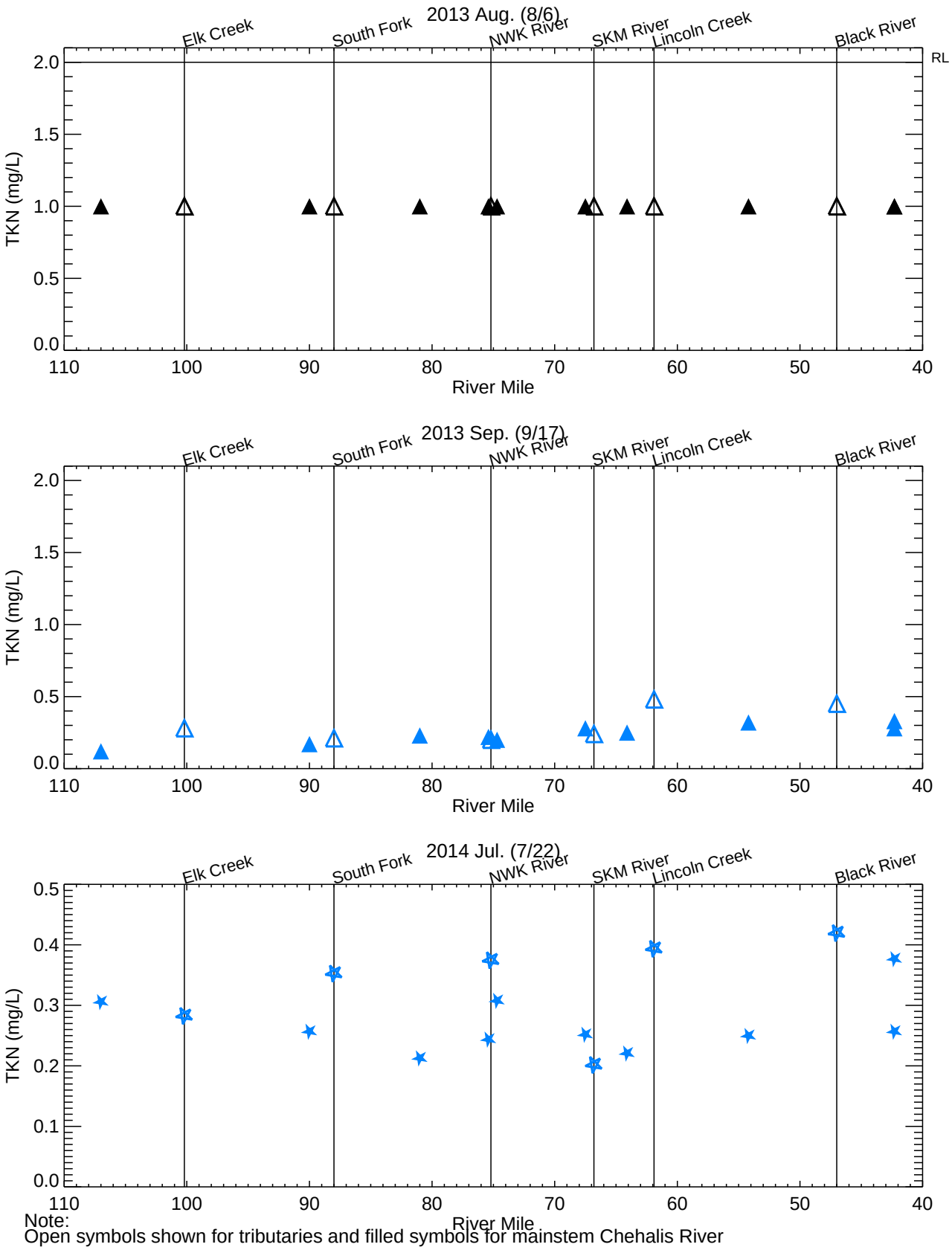
Figure 29

Spatial Patterns in Nitrite plus Nitrate in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Non-detects set to half of reporting limits

ANCHOR QEA

Lab - ARI
Lab - Dragon



Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River

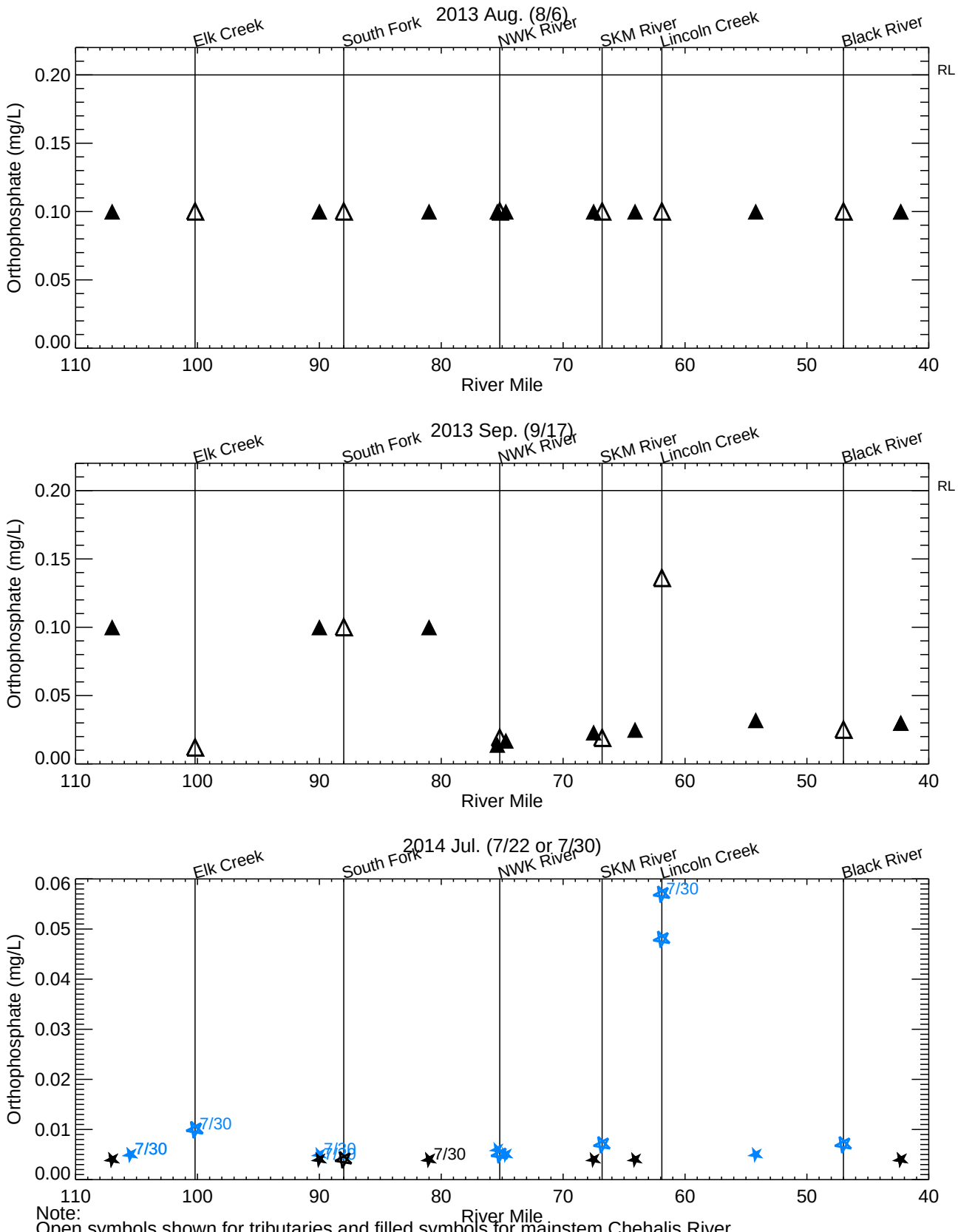
Figure 30

Spatial Patterns in Total Kjeldahl Nitrogen in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Non-detects set to half of reporting limits

ANCHOR QEA

Lab - ARI
Lab - Dragon



Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River
Non-detected or J-flagged results shown in black

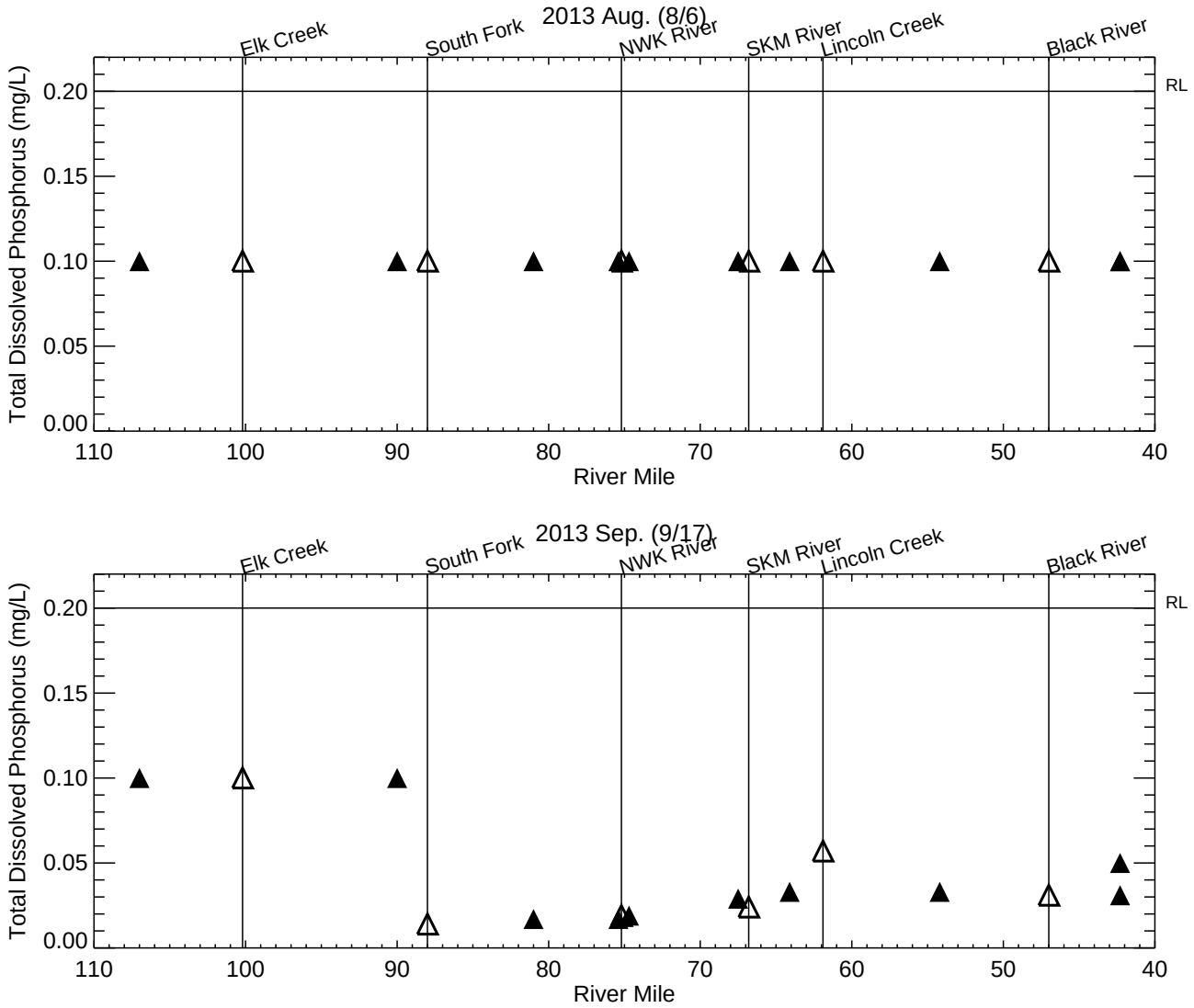
Figure 31

Spatial Patterns in Orthophosphate in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Non-detects set to half of reporting limits

ANCHOR QEA

Lab - ARI
Lab - Dragon



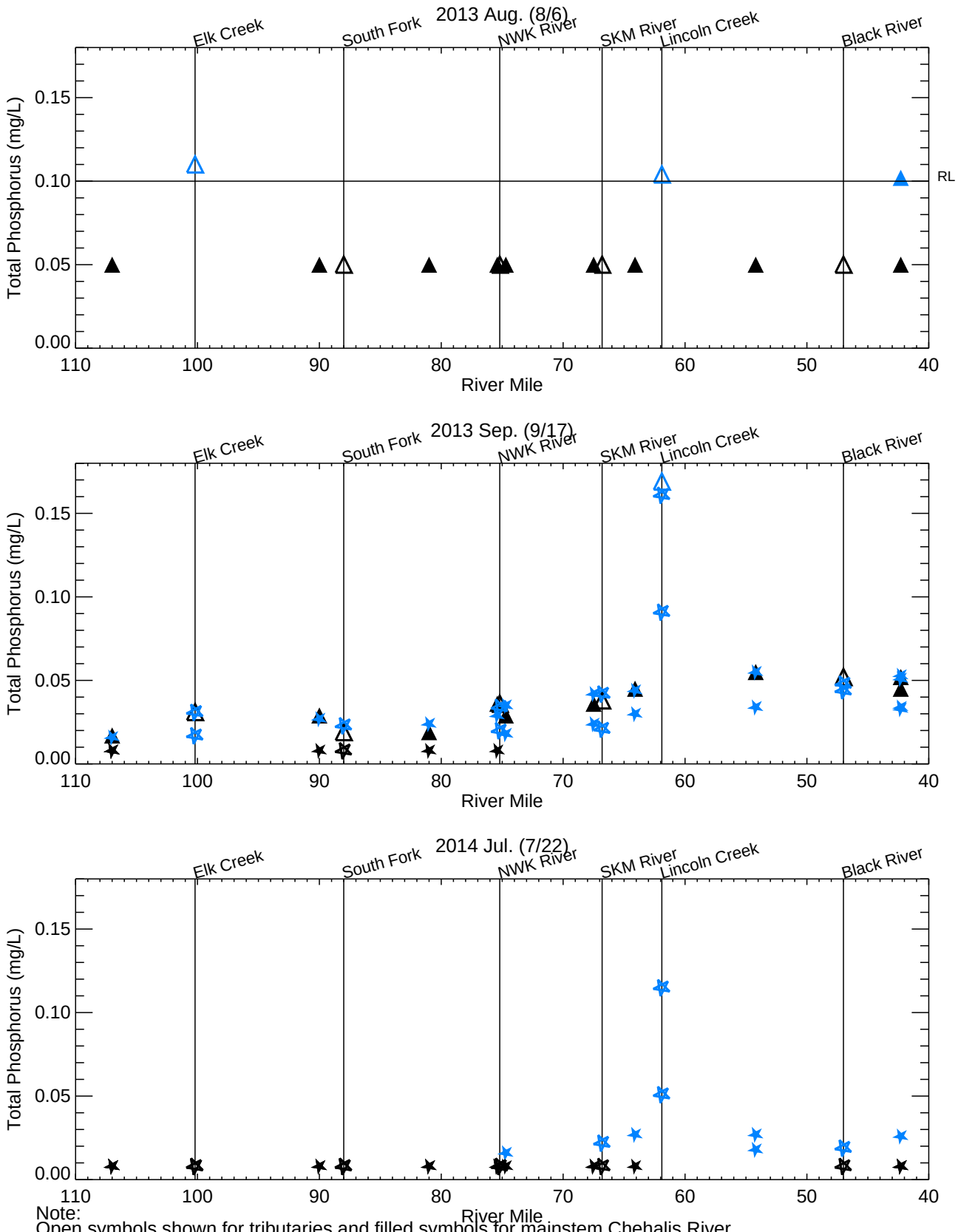
Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River
Non-detected or J-flagged results shown in black

Figure 32

Spatial Patterns in Total Dissolved Phosphorus in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Non-detects set to half of reporting limits

▲ Lab - Dragon



Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River
Non-detected or J-flagged results shown in black

Figure 33

Spatial Patterns in Total Phosphorus in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Non-detects set to half of reporting limits

ANCHOR QEA

Lab - ARI
Lab - Dragon

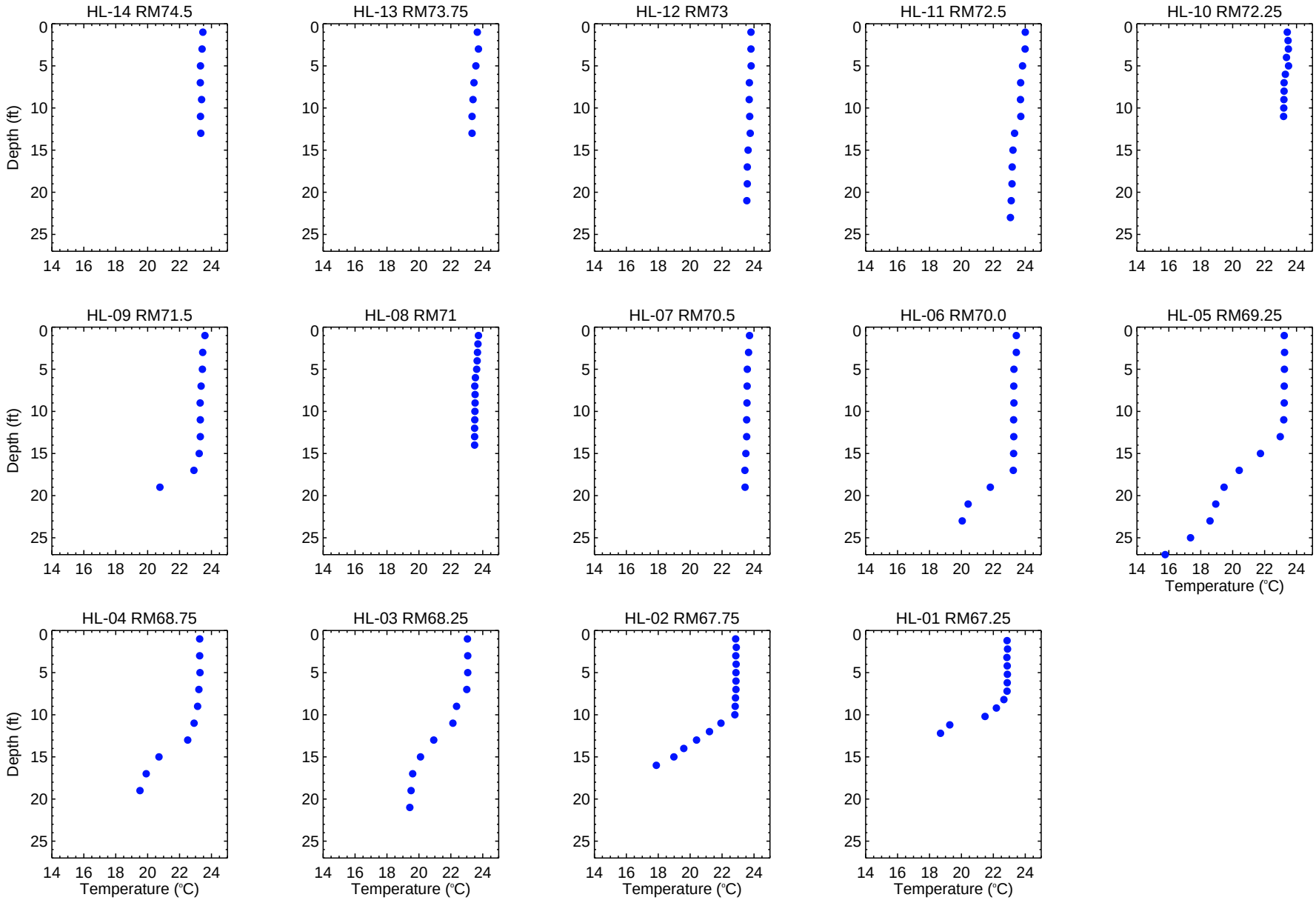


Figure 34

Depth Profiles of Temperature in the Centralia Reach

Depth profiles were collected on 7/31/2014

ANCHOR QEA

BG - C:\D_Drive\WORK\Chehalis_Basin\IDL\Chehalis_Data_Plot__WQ_depth_profile.pro Fri Aug 15 12:56:51 2014

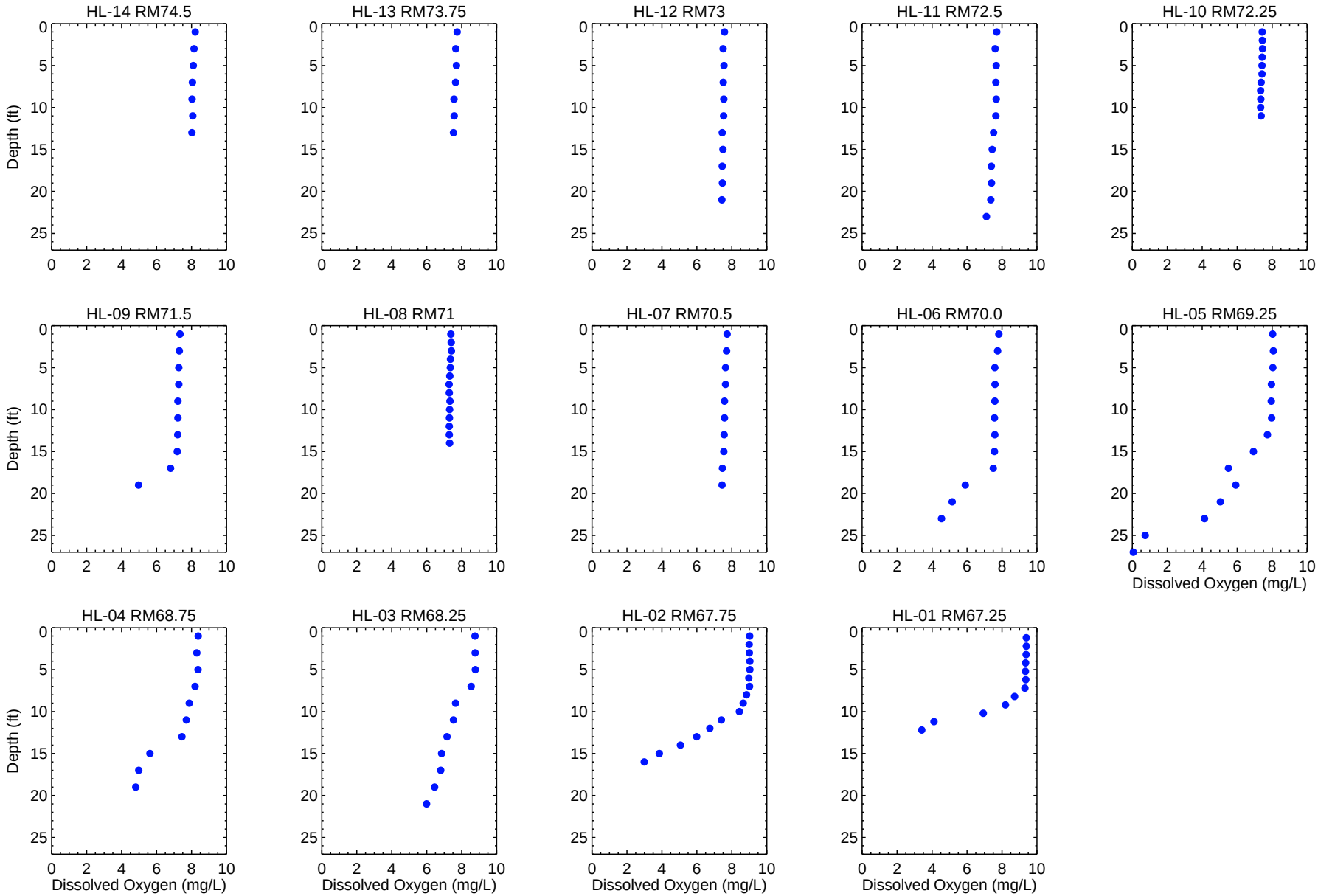


Figure 35

Depth Profiles of Dissolved Oxygen in the Centralia Reach

Depth profiles were collected on 7/31/2014

ANCHOR QEA

BG - C:\D_Drive\WORK\Chehalis_Basin\IDL\Chehalis_Data_Plot__WQ_depth_profile.pro Fri Aug 15 12:56:51 2014

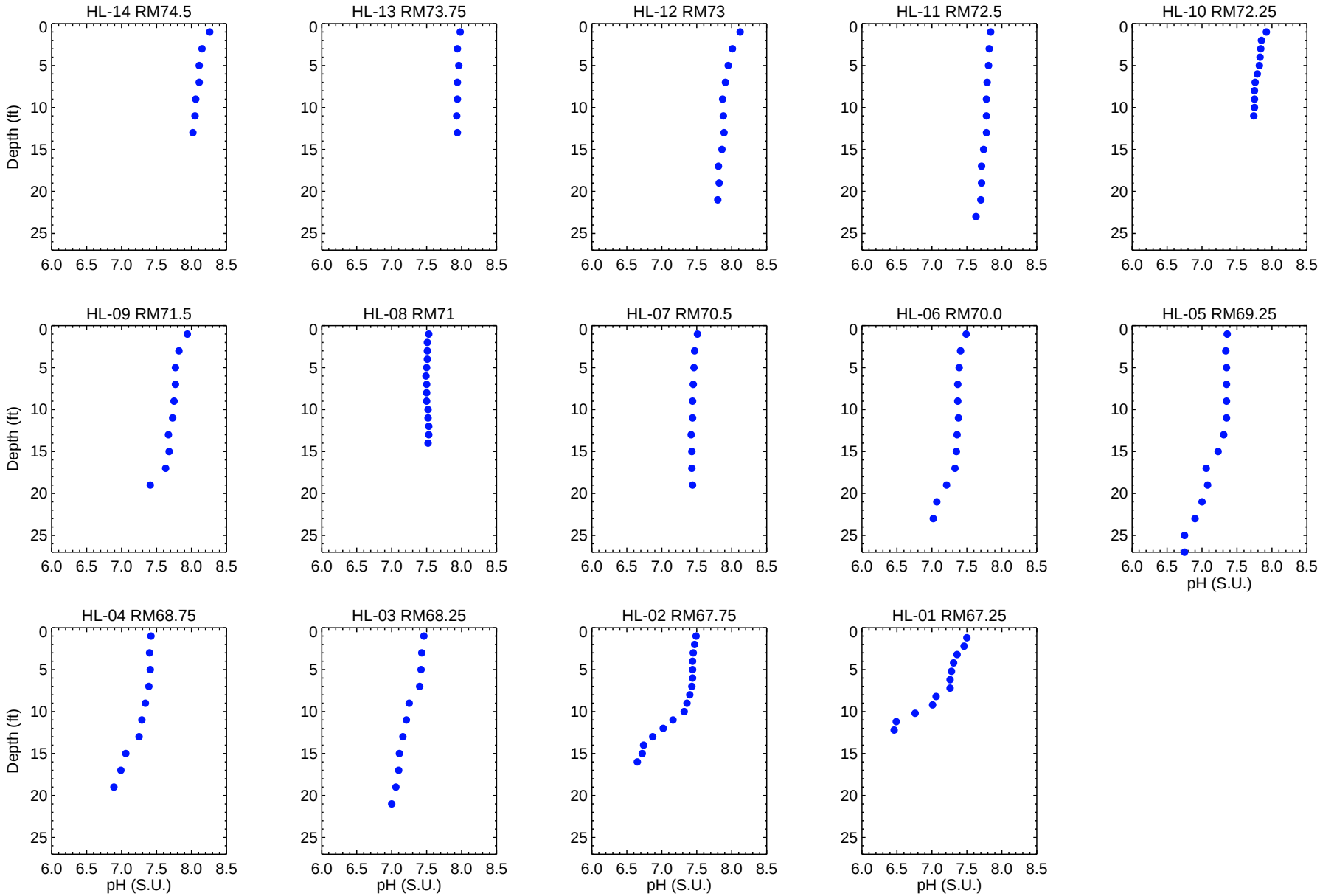


Figure 36

Depth Profiles of pH in the Centralia Reach

Depth profiles were collected on 7/31/2014

ANCHOR QEA

BG - C:\D_Drive\WORK\Chehalis_Basin\IDL\Chehalis_Data_Plot__WQ_depth_profile.pro Fri Aug 15 12:56:51 2014

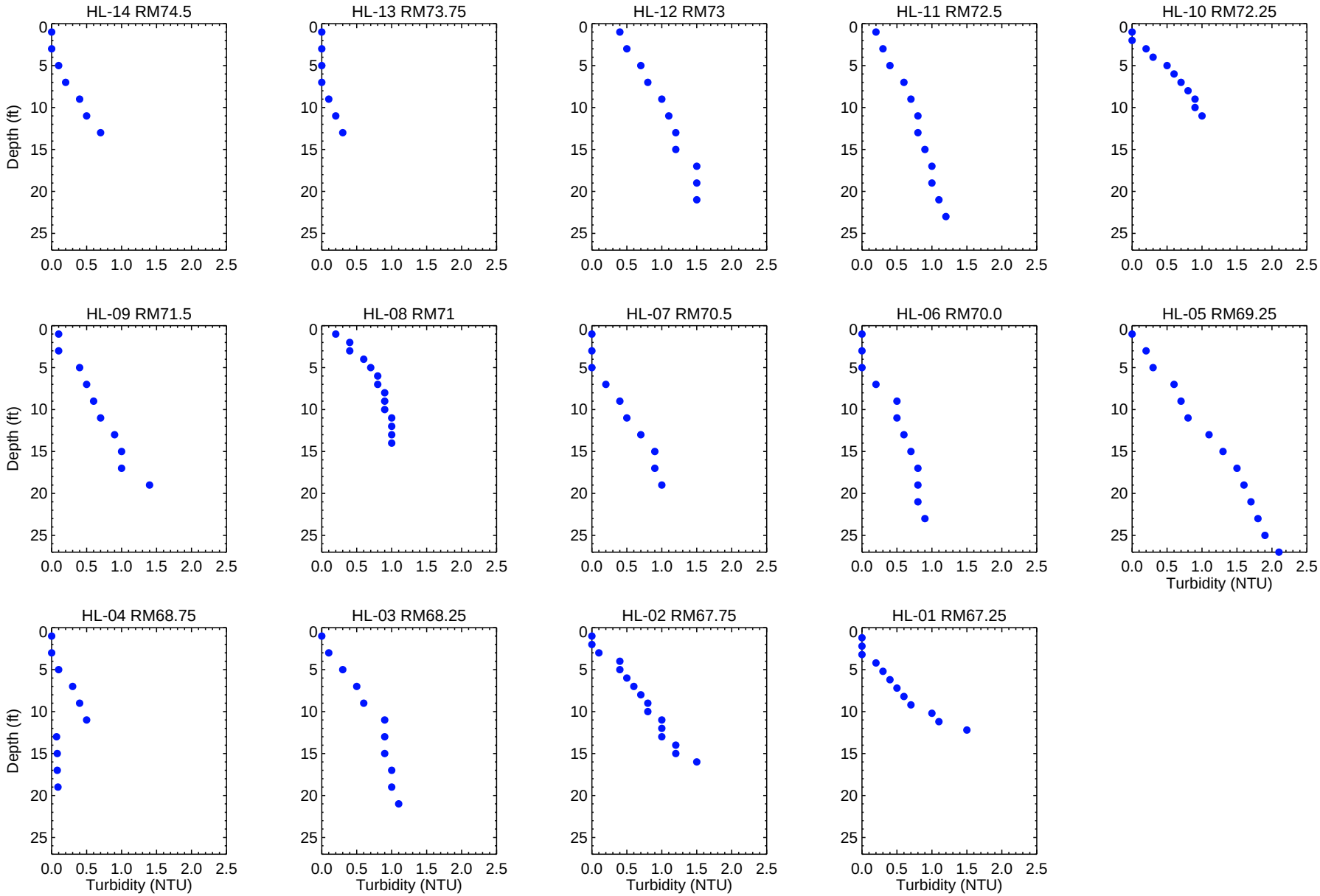


Figure 37

Depth Profiles of Turbidity in the Centralia Reach

Depth profiles were collected on 7/31/2014

ANCHOR QEA

BG - C:\D_Drive\WORK\Chehalis_Basin\IDL\Chehalis_Data_Plot__WQ_depth_profile.pro Fri Aug 15 12:56:51 2014

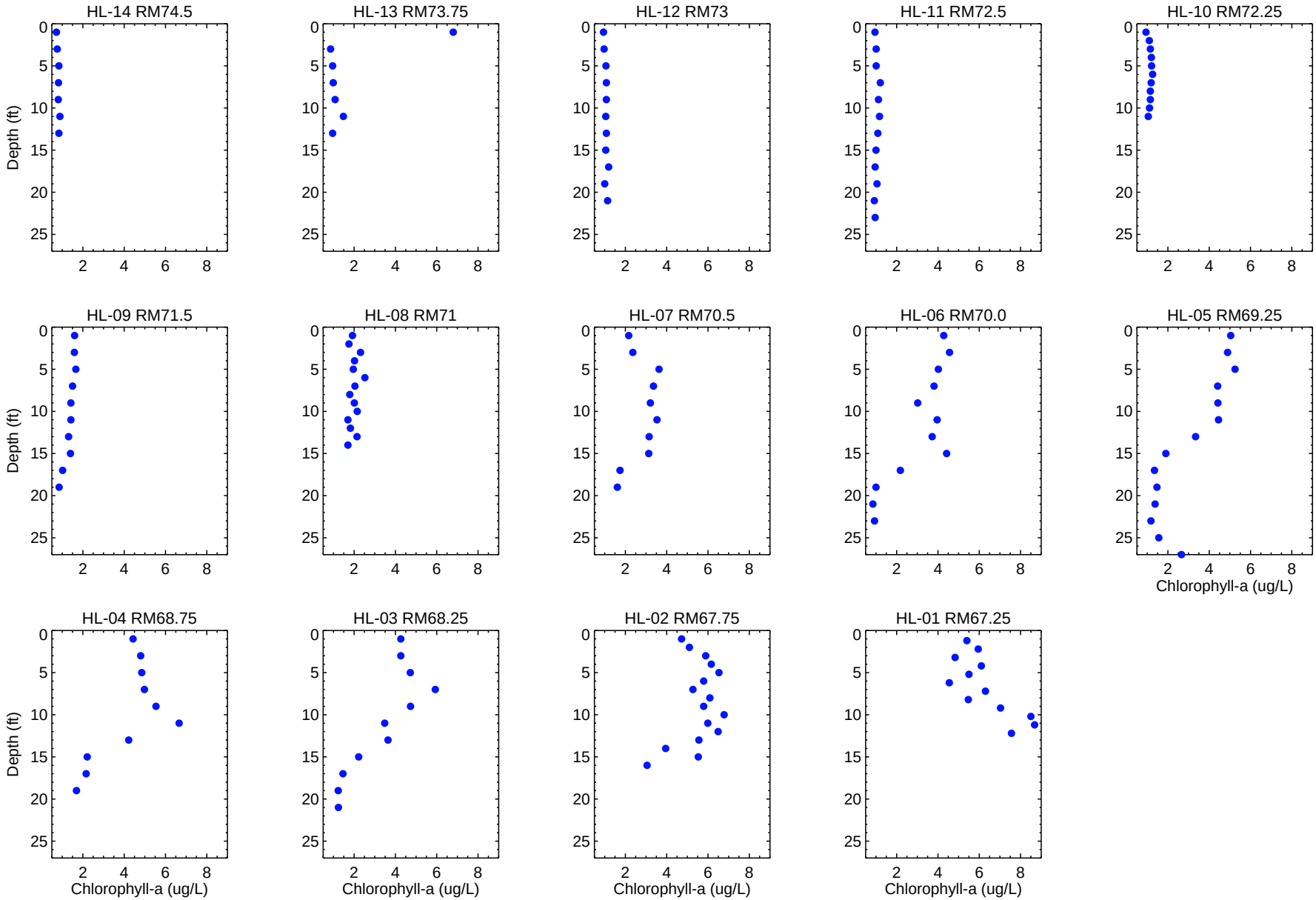


Figure 38

Depth Profiles of Chlorophyll-a in the Centralia Reach

Depth profiles were collected on 7/31/2014

ANCHOR QEA

BG - C:\D_Drive\WORK\Chehalis_Basin\IDL\Chehalis_Data_Plot__WQ_depth_profile.pro Fri Aug 15 12:56:51 2014