Temporal and Spatial Patterns of Soil Chemistry and Primary Productivity in a Recently Restored Salt Marsh

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Intertidal Coastal Sediment Transport research unit

Salt Marsh Importance

- Highly productive and lie at interface between land and ocean (Townend et al., 2010; Butler and Weis, 2009)
- Provide unique habitat (Allen, 2000; Townend et al., 2010)
- Protection from storm surges and coastal erosion, carbon sequestration (Townend et al., 2010; Chmura et al., 2003; Butler and Weis, 2009) and limit nutrient exchange between ocean and upland (Kostka et al., 2002)

Hydrology

- Influences physiochemical environment, vegetation and transports sediment and nutrients (Mitsch and Gosselink, 2007)
- Tidal and ground water (Reddy and DeLaune, 2008; Wilson and Morris, 2012)
  - Redox potential, saturation, salinity and nutrient cycling
- Wilson and Morris (2012): at high tide, increase in tidal amplitude will increase the amount of groundwater exchange within the system

Salinity and Sulfide Concentration:
Uptake of Nitrogen for Spartina alterniflora

- Chambers et al. 1998
  - unaffected by extremely high sulfide concentration
  - decreased with an increase in salinity
- Koch and Mendelsshn, 1989; Mendelssohn and Seneca, 1980
  - decreased productivity and uptake with high sulfide concentrations

Salt Marsh Restoration

- Salt marshes, Bay of Fundy (Davidson-Arnott et al., 2002)
  - 395 km^2 prior to European settlement
  - 65 km^2 due to dyking
- Significant loss of species, habitat and productivity (van Proosdij et al., 2010)
- Need for restoration
- BUT
  - Restoration of tidal flow = changes to biogeochemisty = effects vegetation, nekton and other wildlife (Anisfeld, 2012)

Research Questions

- How does the hydrologic network of a newly restored salt marsh relate to spatial and temporal variability of salinity, sulfide concentration and redox potential?
- How do these variables influence above ground biomass across the marsh surface?

Objectives

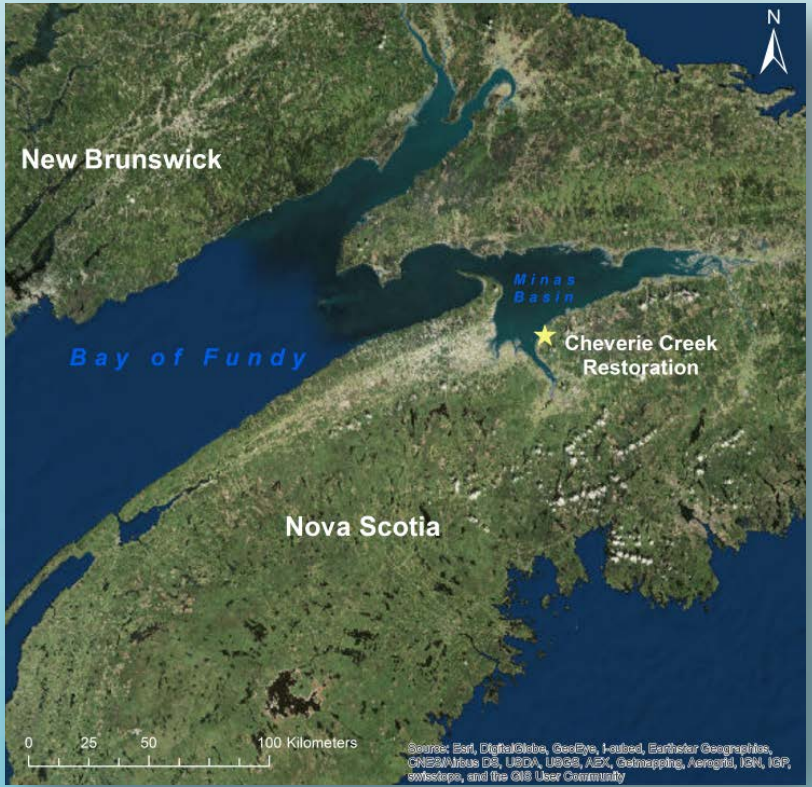
- Determine appropriate depth for redox potential and salinity levels
- Determine temporal variation of sulfide concentration, salinity and redox potential and how this relates to hydrology and above ground biomass
- Determine spatial variation of sulfide concentration, salinity and redox potential and how this relates to hydrology and above ground biomass
- Determine the influence of meteorological conditions, specifically rainfall and temperature, on sulfide concentration, salinity and redox potential

Study Area: Bay of Fundy

- Largest tides in the world
  - 4m at the entrance of the Bay (Davidson-Arnott et al., 2002)
  - 13 to 16 m in the upper reaches of the Minas Basin (Hinch, 2004)
- Substantial suspended sediment concentration and deposition (van Proosdij et al., 2010)
  - 150 mgl^{-1} on the marsh surface
  - 4000 mgl^{-1} in the upper reaches of the Minas Basin

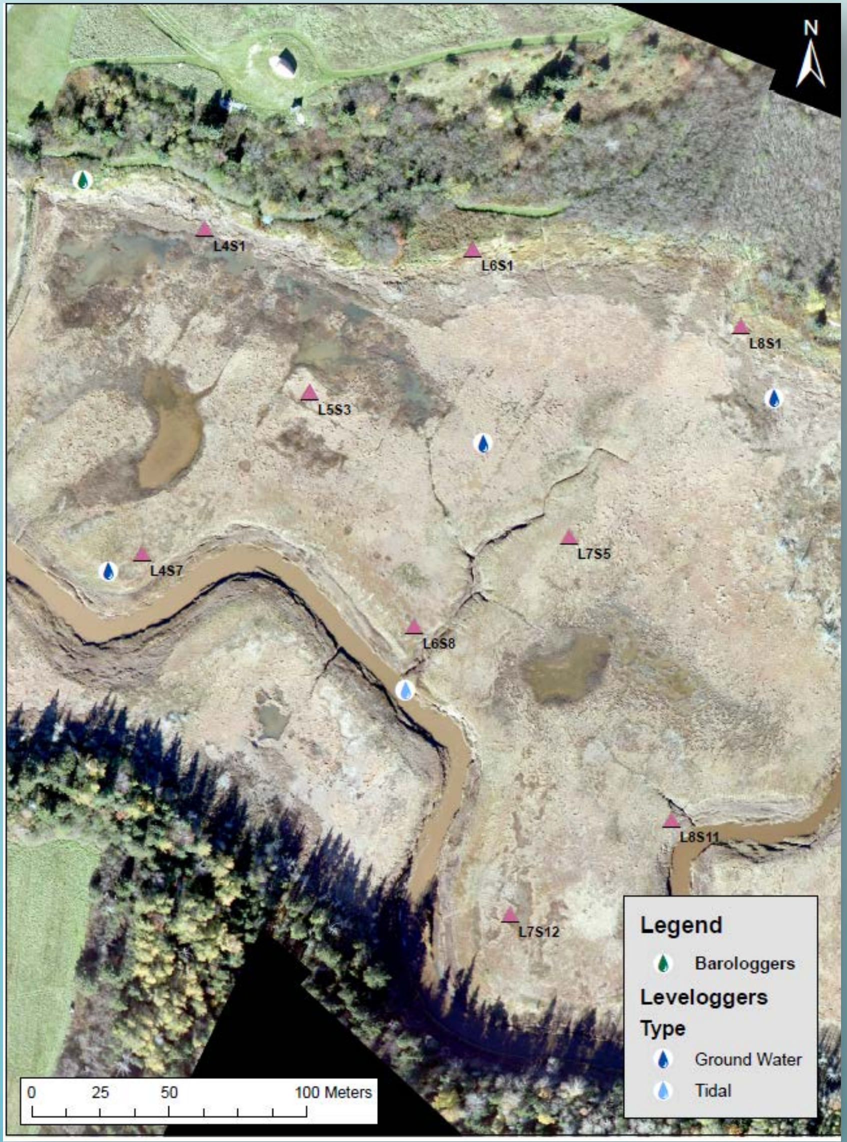
Top: http://de.wikipedia.org/wiki/Bay_of_Fundy Bottom: http://husky1.smu.ca/~dvanproo/Research_main.html

Study Area:
Cheverie Creek Salt Marsh Restoration Site

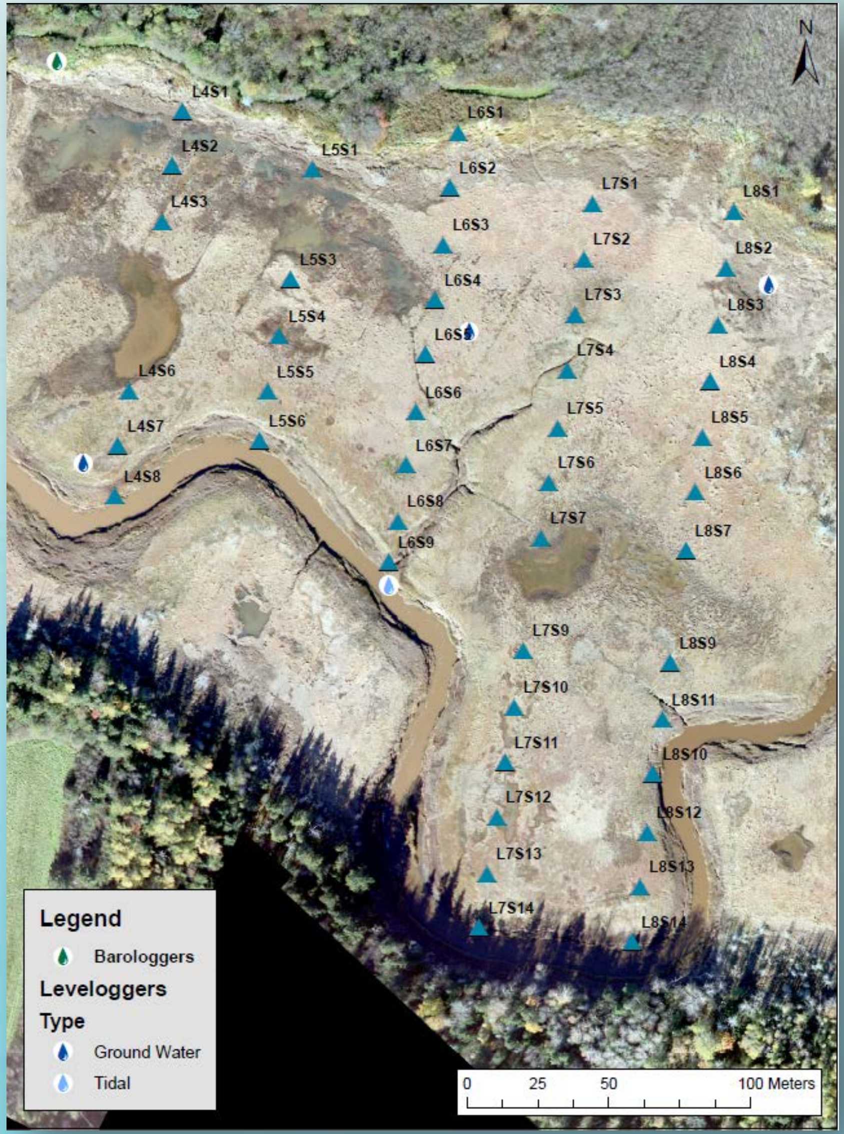


Site Set Up

Pilot Study



Study



Methodology: Pilot Study

Methodology

Methodology: Study

What was Different?

- Used 42 sample plots instead of 9
- Root depth processing identified bulk root depth between 0 – 10 cm therefore 5 cm chosen for redox and salinity
- 3 measurements for salinity & redox

Methodology: Throughout study

Ground Water & Tide Level

Meteorological

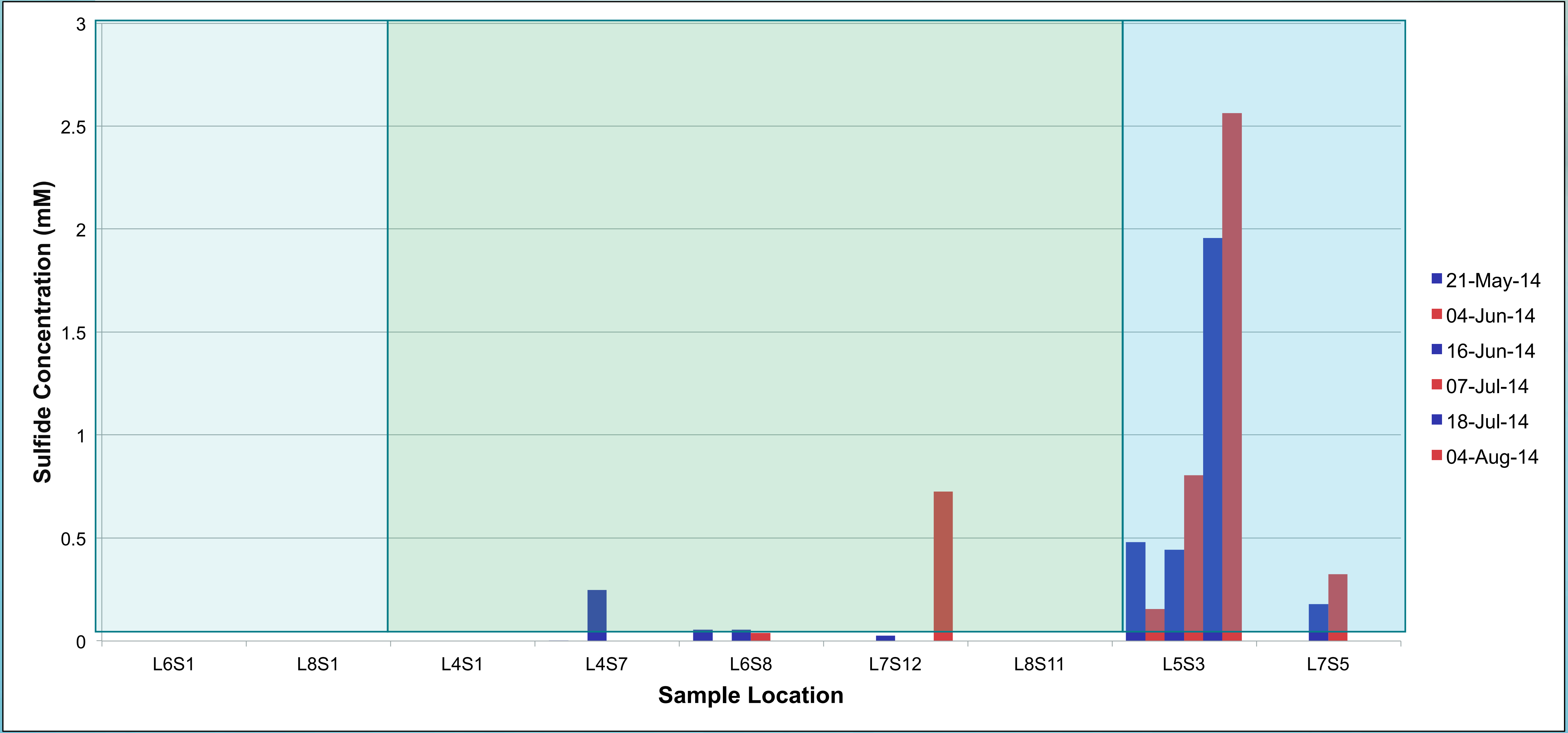
Results: Pilot Study

Redox Potential

- Majority of stations were experiencing: Oxygen, Nitrate; Manganese (IV) and Iron (III) reduction at the time of sampling
- Oddities:
  - May 21, 2014 at L7S12 (5 cm depth) Sulfate
  - June 4, 2014 at L8S11 (20 cm depth) Carbon Dioxide
  - June 16, 2014 at L7S5 (15 cm depth) Carbon Dioxide

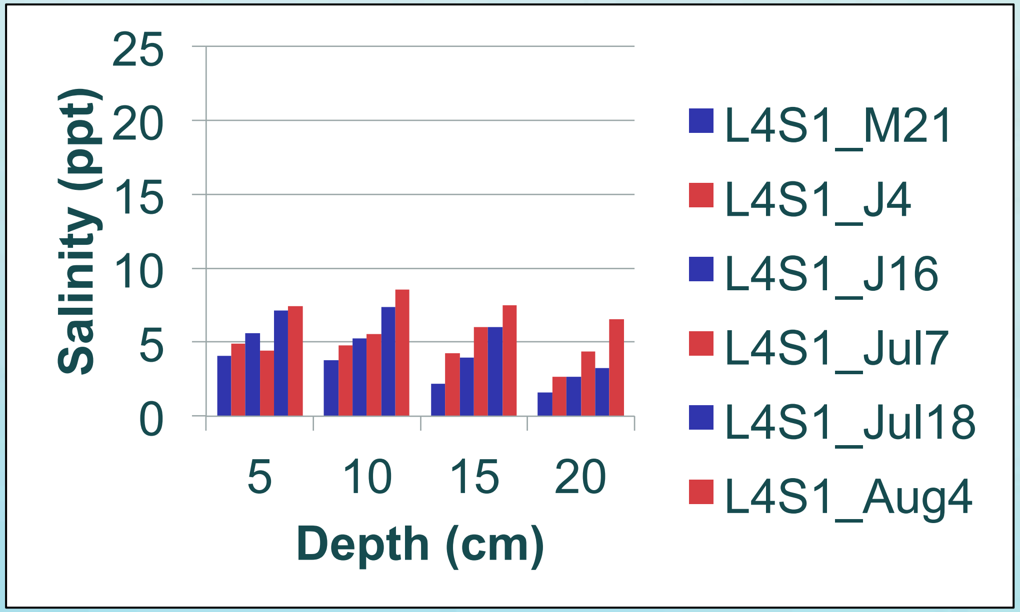
Electron Acceptor	Reduced To	Redox Potential (mV)
Oxygen (O_2)	H_2O	> +300
Nitrate (NO_3^-)	N_2, NH_4^+	+300 to +100
Manganese (Mn^{4+})	Mn^{2+}	+300 to +100
Iron (Fe^{3+})	Fe^{2+}	+100 to -100
Sulfate (SO_4^{2-})	S^{2-}	-100 to -200
Carbon dioxide (CO_2)	CH_4	-200 to -300

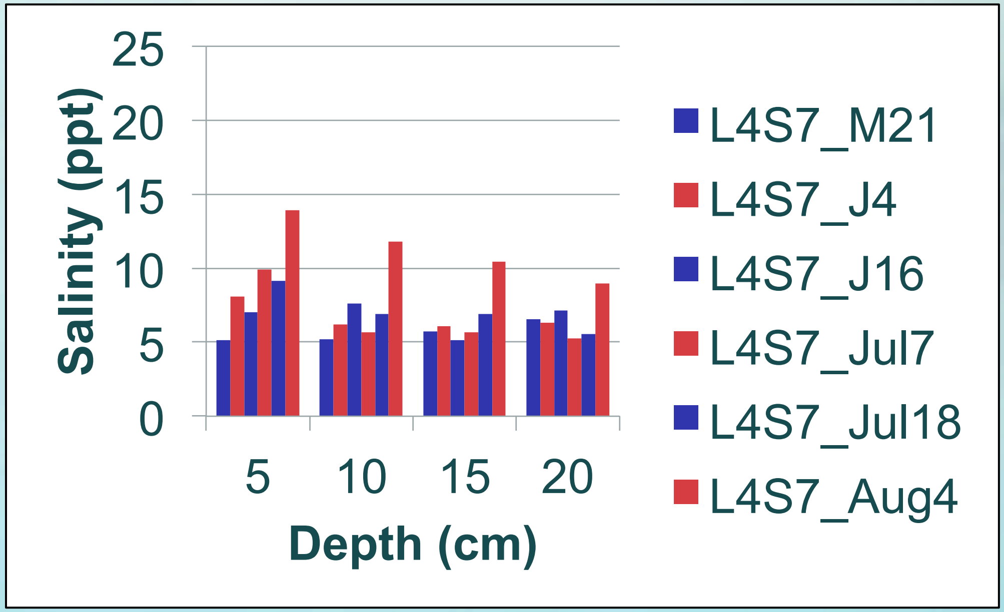
Sulfide

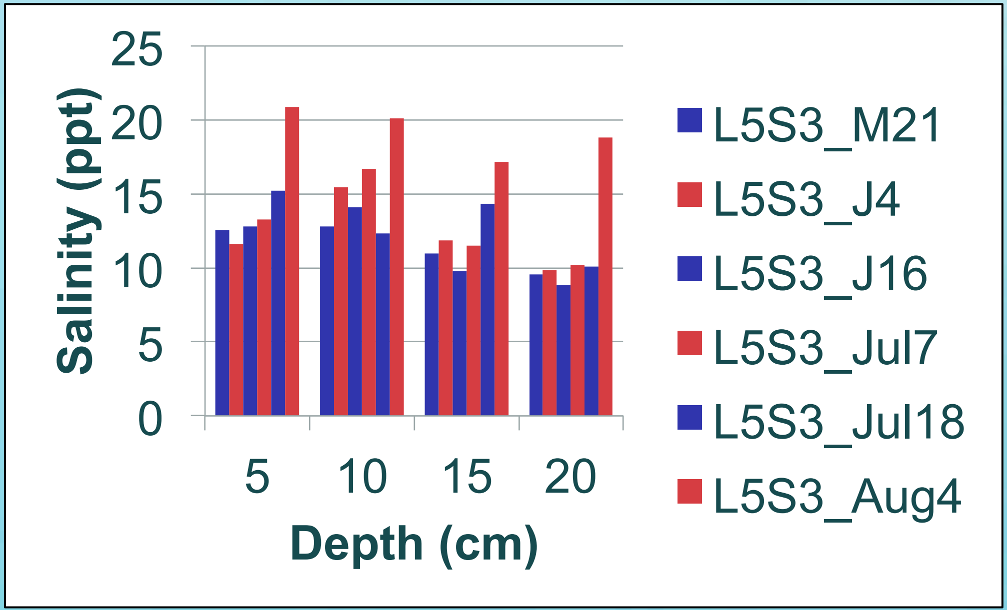


Sulfide Concentration (mM)
3
2.5
2
1.5
1
0.5
0
L6S1
L8S1
L4S1
L4S7
L6S8
L7S12
L8S11
L5S3
L7S5
Sample Location
21-May-14
04-Jun-14
16-Jun-14
07-Jul-14
18-Jul-14
04-Aug-14

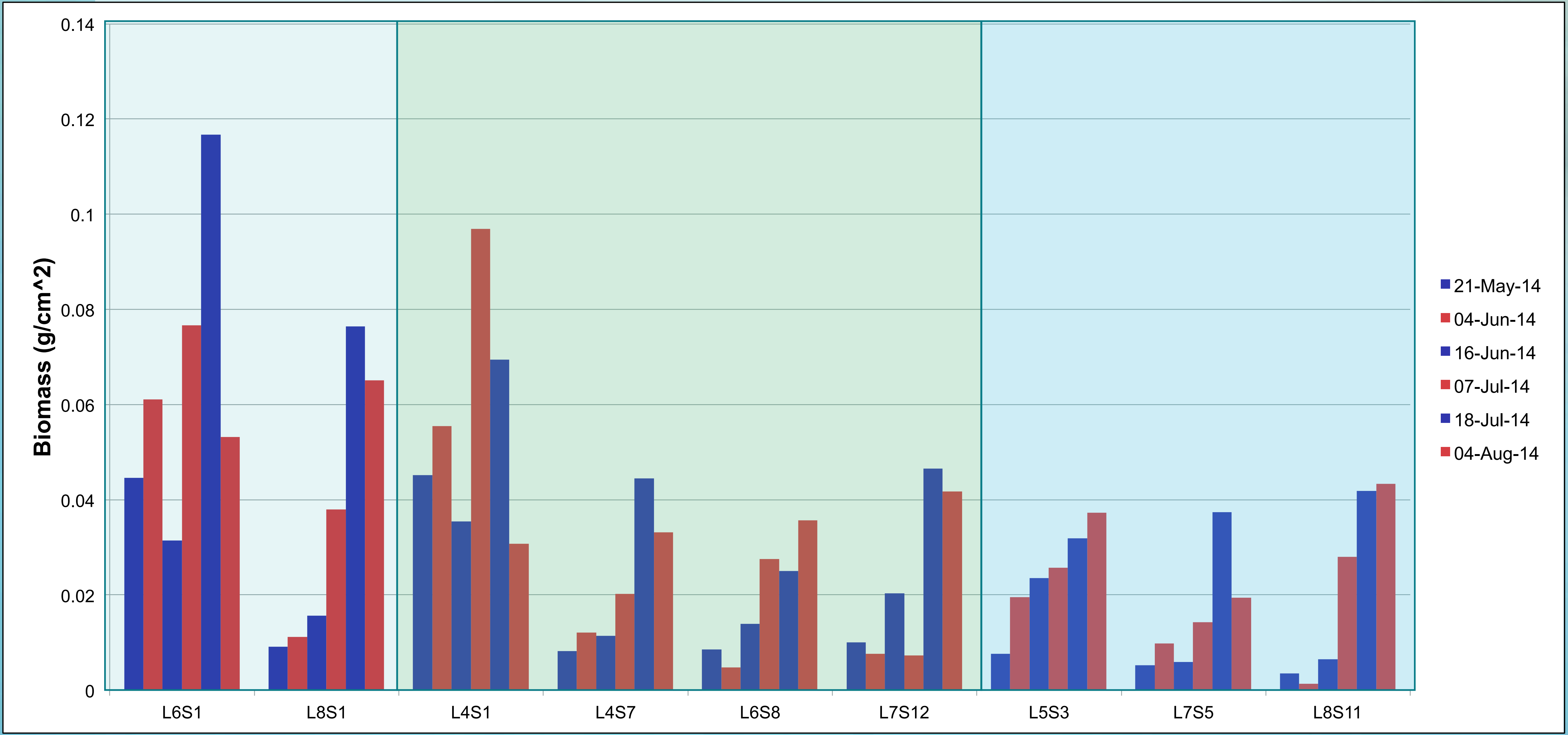
Salinity


Salinity (ppt)
25
20
15
10
5
0
5
10
15
20
Depth (cm)
L4S1_M21
L4S1_J4
L4S1_J16
L4S1_Jul7
L4S1_Jul18
L4S1_Aug4


Salinity (ppt)
25
20
15
10
5
0
5
10
15
20
Depth (cm)
L4S7_M21
L4S7_J4
L4S7_J16
L4S7_Jul7
L4S7_Jul18
L4S7_Aug4


Salinity (ppt)
25
20
15
10
5
0
5
10
15
20
Depth (cm)
L5S3_M21
L5S3_J4
L5S3_J16
L5S3_Jul7
L5S3_Jul18
L5S3_Aug4

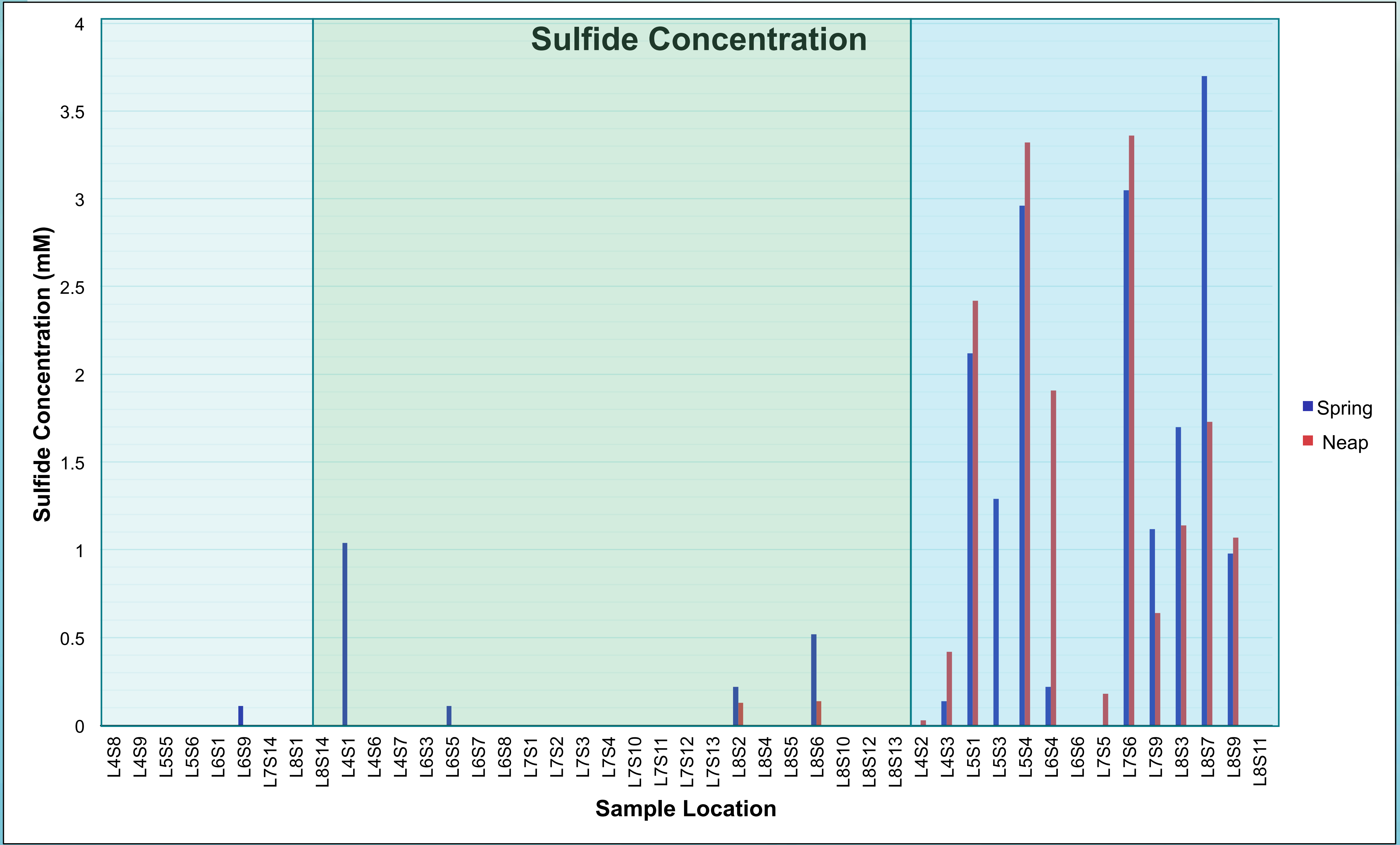
Above Ground Biomass



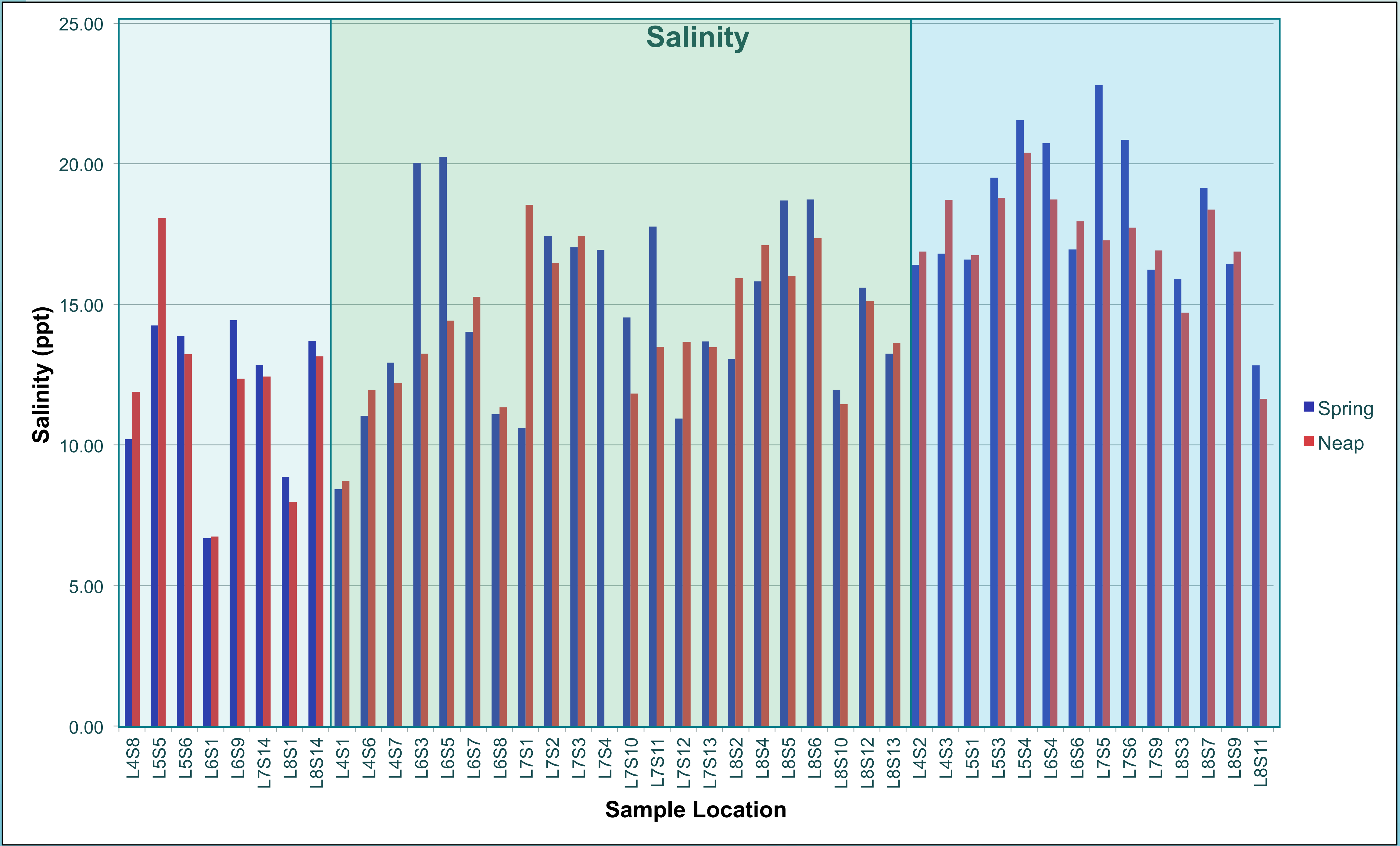
Results: Study

Redox Potential

- All of the stations were experiencing Nitrate; Manganese (IV) and Iron (III) reduction
- Sites experiencing Oxygen reduction:
  - L6S1 August 14, 2014 & August 21, 2014
  - L8S1 August 21, 2014



Sulfide Concentration
Sulfide Concentration (mM)
Sample Location
0
0.5
1
1.5
2
2.5
3
3.5
4
L4S8
L4S9
L5S5
L5S6
L6S1
L6S9
L7S14
L8S1
L8S14
L4S1
L4S6
L4S7
L6S3
L6S5
L6S7
L6S8
L7S1
L7S2
L7S3
L7S4
L7S10
L7S11
L7S12
L7S13
L8S2
L8S4
L8S5
L8S6
L8S10
L8S12
L8S13
L4S2
L4S3
L5S1
L5S3
L5S4
L6S4
L6S6
L7S5
L7S6
L7S9
L8S3
L8S7
L8S9
L8S11
Spring
Neap


Salinity
Salinity (ppt)
25.00
20.00
15.00
10.00
5.00
0.00
L4S8
L5S5
L5S6
L6S1
L6S9
L7S14
L8S1
L8S14
L4S1
L4S6
L4S7
L6S3
L6S5
L6S7
L6S8
L7S1
L7S2
L7S3
L7S4
L7S10
L7S11
L7S12
L7S13
L8S2
L8S4
L8S5
L8S6
L8S10
L8S12
L8S13
L4S2
L4S3
L5S1
L5S3
L5S4
L6S4
L6S6
L7S5
L7S6
L7S9
L8S3
L8S7
L8S9
L8S11
Sample Location
Spring
Neap

Preliminary Conclusions

- Differences emerging between "well", "moderate" and "poorly" drained sites
- Processing to be completed:
  - Hydrology
  - Biomass
  - Meterological
  - Sediment characteristics

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Questions?

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