Final Report
for Mobile Bay National Estuary Program

Project: West Fowl River Shoreline Survey

Project Manager: Ruth H. Carmichael

Affiliation: Dauphin Island Sea Lab/ University of South Alabama
Reporting period: 1 July – 31 August
(Final report, following 2 month NCE for additional sampling at two sites)

Other key personnel: Ashley Frith (MS student, DISL/USA); CDR Kevin Calci (USFDA), Elizabeth Hieb (Technician, DISL), Ruth Carmichael (DISL/USA)

1. Work accomplished during the period:
Meetings & presentations

- **Team meetings**
  - 07/12/18: Meeting (Carmichael, Frith) for preparation of data for meeting with Mobile County Health Department.
  - 07/12/18: Meeting (Carmichael, Frith, Calci, B. Webb, T. Micher, K. Warren, S. Woods-Crawford) to discuss Portersville Bay water quality and relationships to land use; reviewed septic v. sewer locations and other possible sources of wastewater in the area.
  - 07/13/18: Conference call (Carmichael, Frith, Calci) to plan scope of work for additional sampling and set up in-person meeting (cancelled by NEP).
  - 08/02/18: Meeting (Carmichael, Frith) to review final data presentation for group meeting
- **Stakeholder discussions**
  - 08/02/18: WFR project final presentation (Carmichael, Frith, Calci) "Identifying sources of water quality variation to Portersville Bay"

Research

- **Lab Analyses—**Final microbial, nutrient and stable isotope analyses for additional sites (cow, bird, Jonas Bayou)

Summary of project findings

We evaluated potential sources of water quality variation, including a wastewater treatment plant outfall, river system, and adjacent shoreline sites, in Portersville Bay, AL, an area important for shellfish aquaculture (Fig. 1, attached slide 2). We measured fecal coliforms (fc), male-specific coliphage (MSC), nutrients, and stable isotope ($\delta^{15}N$, $\delta^{13}C$) ratios as indicators of water quality at potential source sites along the West Fowl River shoreline, under different temperature and rainfall conditions. Fc concentrations across all sites ranged from <5 to 5250 CFU/100 mL, with the highest fc concentrations in the river system (West Fowl River) and the lowest concentrations at the wastewater treatment plant outfall (*cf* dataset shared 08/23/18; http://cf.disl.org/datamanagement/metadata_folder/DISL-Carmichael-WFR-ShorelineSurvey2018.xml). We found higher

fc concentrations during the cold/wet period compared to other sampling periods (Kruskal-Wallis, $p < 0.001$), but all sampling periods showed the same overall patterns across sites (Fig. 2, slide 4), with higher fc concentrations associated with residential areas and adjacent agriculture. IN contrast, MSC concentrations were above detection only during warm periods and showed no patterns with land use.

$\delta^{13}C$ values were lower at river sites and decreased upstream, consistent with increasing freshwater influence upstream. $\delta^{15}N$ values were lower and NH_4^+ concentrations were higher during the cold/wet period (Kruskal-Wallis, $\delta^{15}N$: $p < 0.001$; NH_4^+: $p < 0.01$) and at sites adjacent to residential development (Fig. 3, slide 5; Fig. 4, slide 6), suggesting residential areas in the river may be a source of unprocessed sewage to the system.

Similar data collected at nearby bird roosting and cattle grazing sites showed comparable values to those in the river (during warm or dry periods), but rapidly decreased with distance (dilution) from these sources (Fig. 5, slide 7; Fig. 6, slide 8). $\delta^{13}C$ values were consistent with known freshwater influence at these sites (Fig. 7, slide 9). $\delta^{15}N$ values in samples from the bird roosting site were ~3‰ higher than samples from the cattle grazing site, and both of these sample types had higher values than samples in the river during the cold/wet period (Fig. 8, slide 10). Nutrient values at these sites were low (Figs. 9 & 10, slide 11 & 12).

These data indicate that the West Fowl River system is a potential source of contamination to Fowl River Bay where shellfish farms are located downstream. Specific locations in the river may be hotspots for fecal pollution. Overall, microbial and nutrient sources to the system were sufficiently different to provide endpoints for future source-tracing studies that include information on dilution and mixing. These data contribute to our identification and understanding of potential sources of water quality variation, which can inform modeling, further sampling, and enforcement efforts to improve local water quality for recreation and aquaculture.

2. & 3. Problems encountered: N/A

4. Next quarter projected work: N/A

5. & 6. Is the project work on schedule? Yes.

7. What has been spent to date?

Item	Price	Use
Stable Isotope & nutrient Analysis	$835.91	Stable isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) in suspended matter in water samples and dissolved inorganic nutrient concentrations (see list in attached presentation) in water.

8. What is your plan for spending the remaining funds? No change from original proposal

9. Have you submitted an invoice for reimbursement? Attached.

10. Is there a change in project manager? No.

Attachments: Final presentation (2 Aug 2018), dataset and metadata (23 Aug 2018)

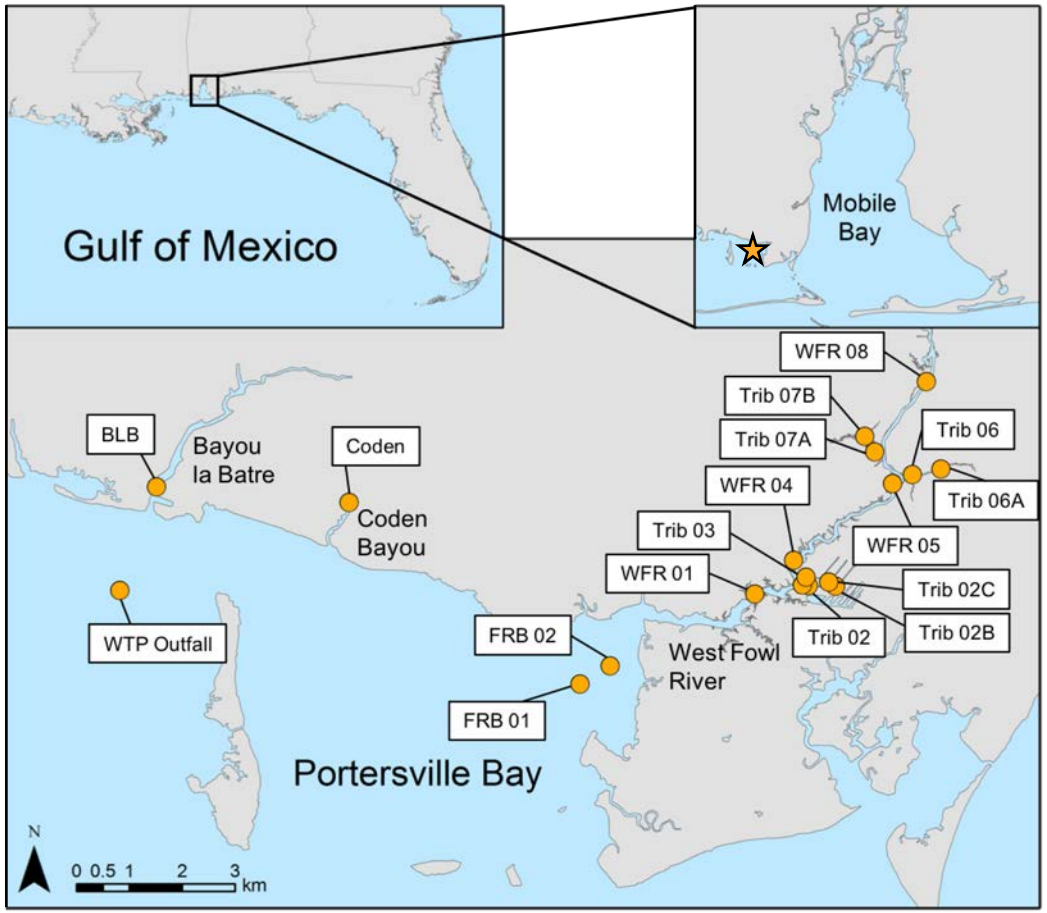
Identifying Sources of Water Quality Variation to Portersville Bay

Ashley Frith[1], Ruth H. Carmichael[1], Kevin Calci[2]

[1]University of South Alabama, Dauphin Island Sea Lab

[2]U.S. Food and Drug Administration

Sampling Sites



Shoreline Survey:

Warm & Dry (7/31, 8/21 2017)
Warm & Wet (11/6 2017)
Cold & Dry (1/16 2018)
Cold & Wet (2/12 2018)

Other Sources:

Birds, Cows, Jonas Bayou
Warm & Dry (5/17 2018)

Analyses

Indicator microbes:

Fecal coliforms (bacterial)

Male-specific coliphage (viral)

Stable Isotopes:

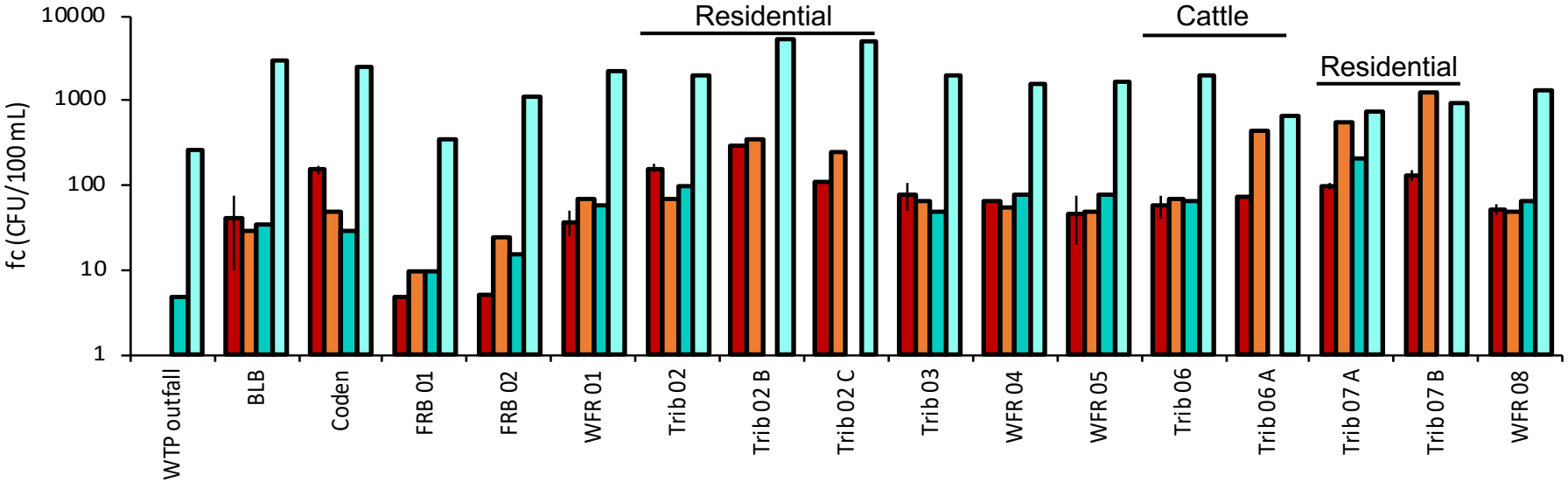
$\delta^{13}C$ (freshwater)

$\delta^{15}N$ (wastewater)

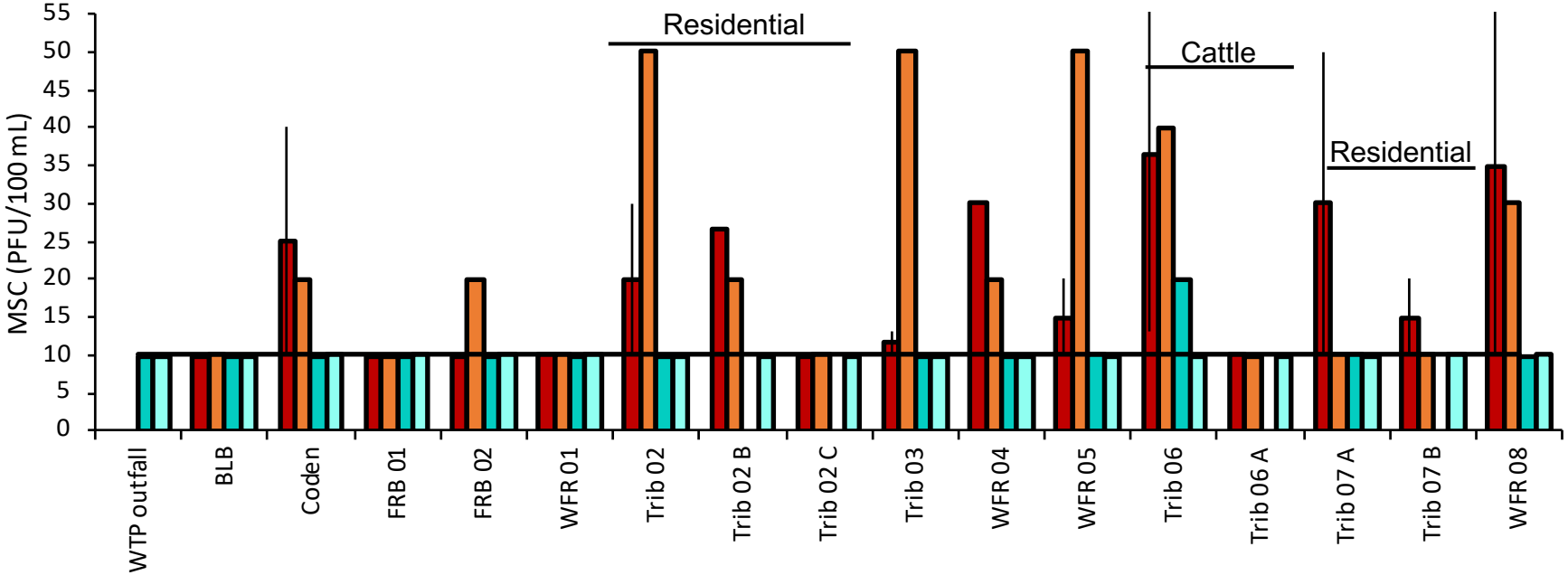
Nutrients:

NO_2^-	DON
NO_3^-	TDN
NH_4^+	PO_4^{3-}

Shoreline Survey Results: Indicator microbes

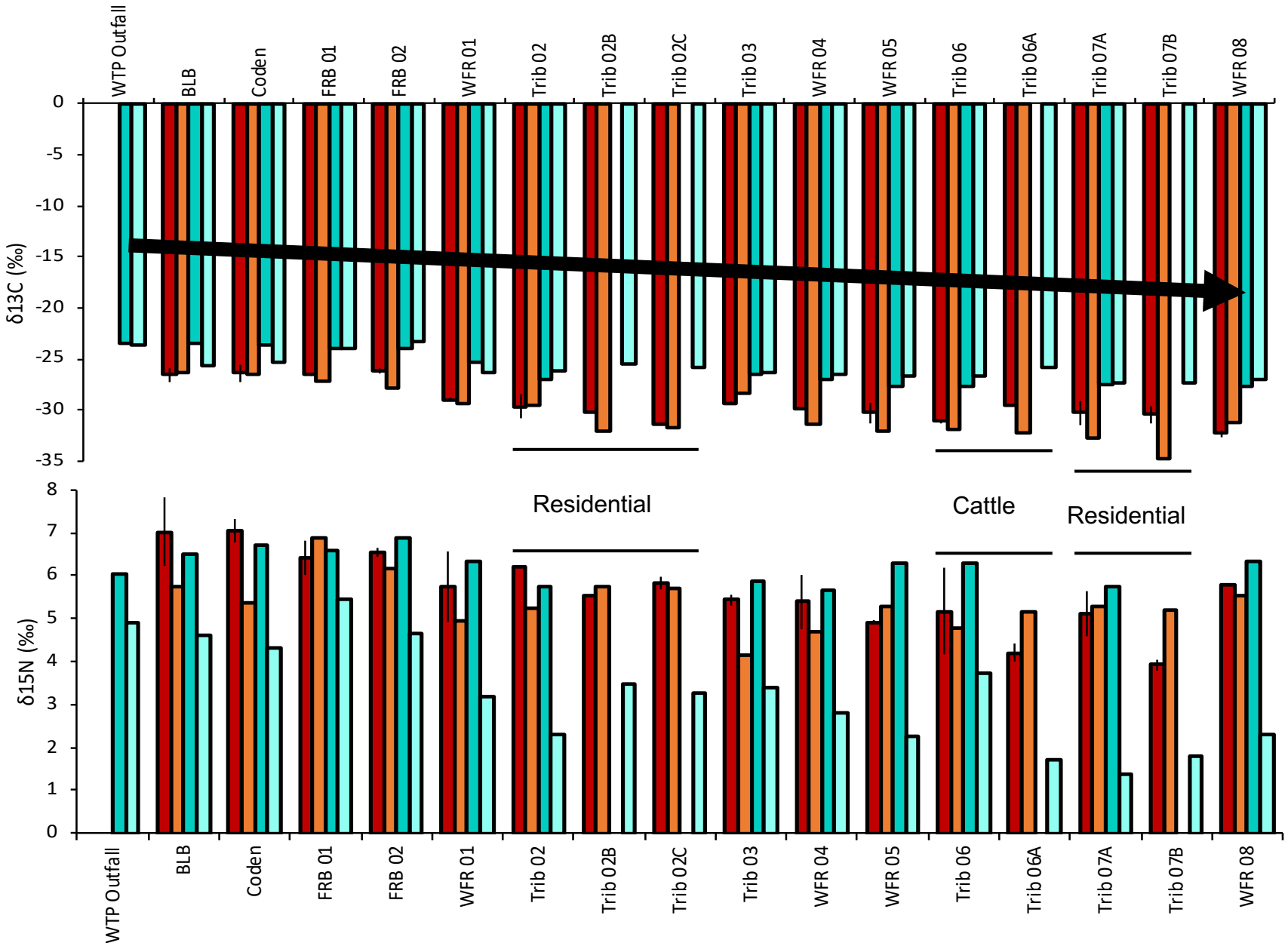


- Higher fc in cold, wet (Kruskal-Wallis, $p<0.001$)
- Patterns with land use



- Above detection in warm periods
- No patterns with land use

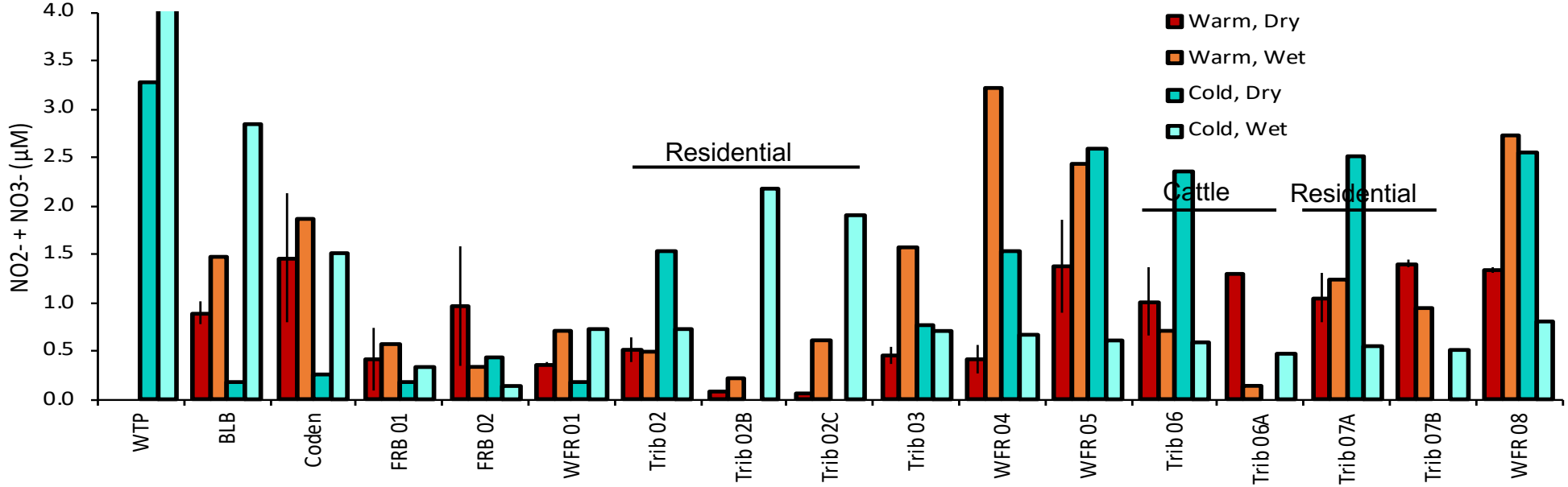
Shoreline survey results: Stable Isotopes

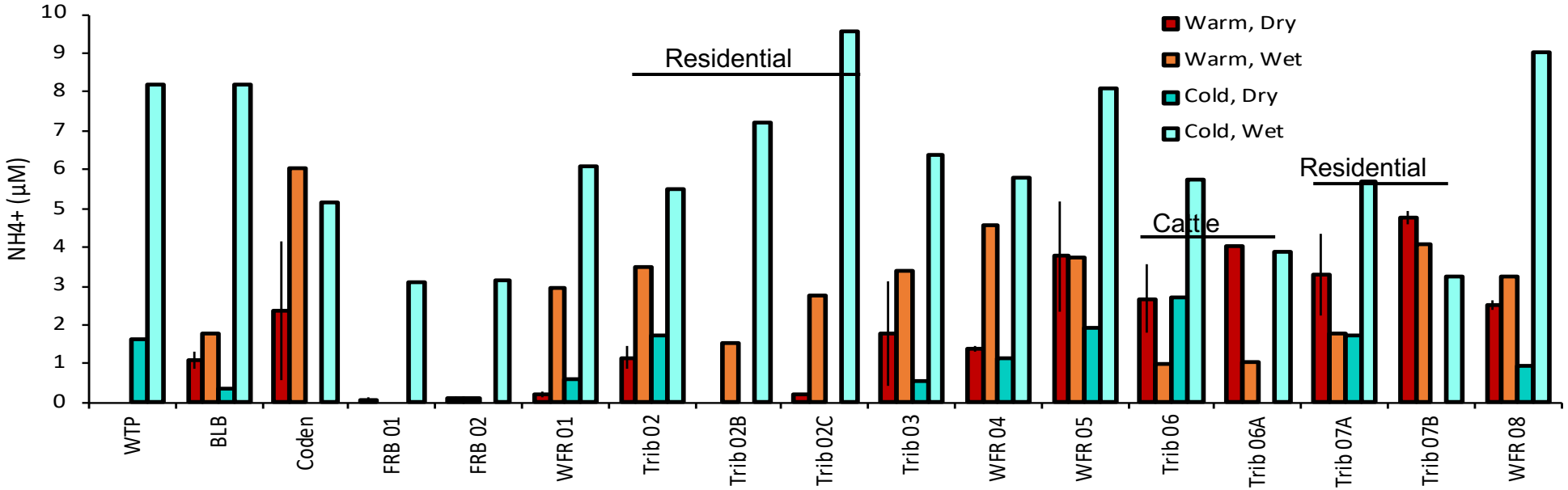


- Values decrease upstream
- Lighter in warm periods (Kruskal-Wallis, $p<0.01$)

- Lighter in cold, wet conditions (Kruskal-Wallis, $p<0.001$)
- Patterns with land use (& upstream)
- Unprocessed WW?

Shoreline survey results: Nutrients





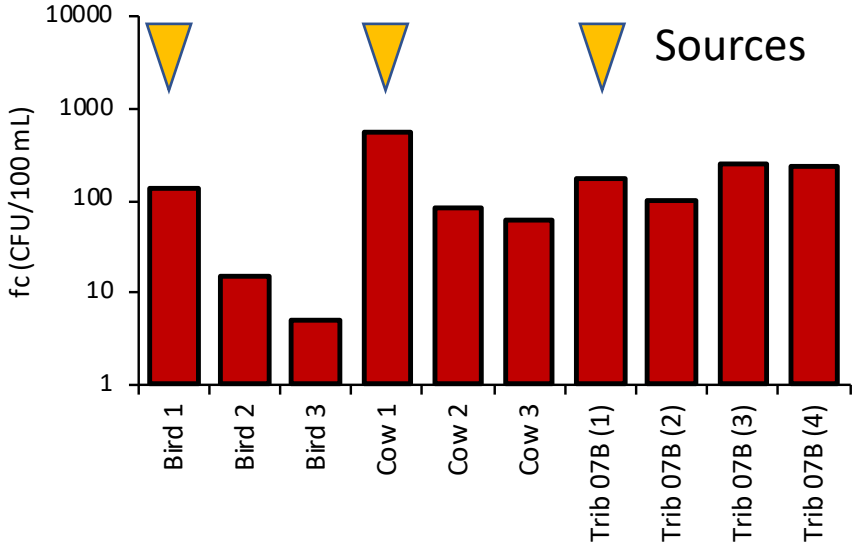
- No significant differences
- Higher in cold, wet periods (Kruskal-Wallis, $p<0.01$)
- Consistent with unprocessed WW

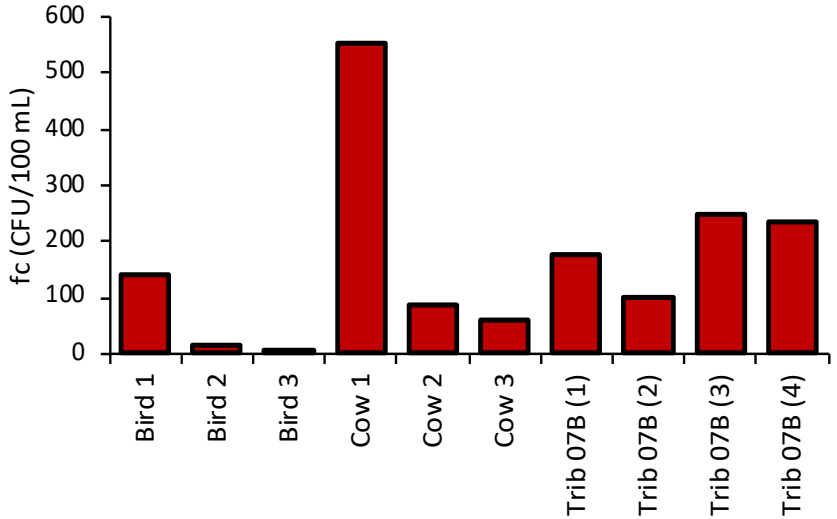
Other Sources Results: Indicator Microbes

Decreasing from source

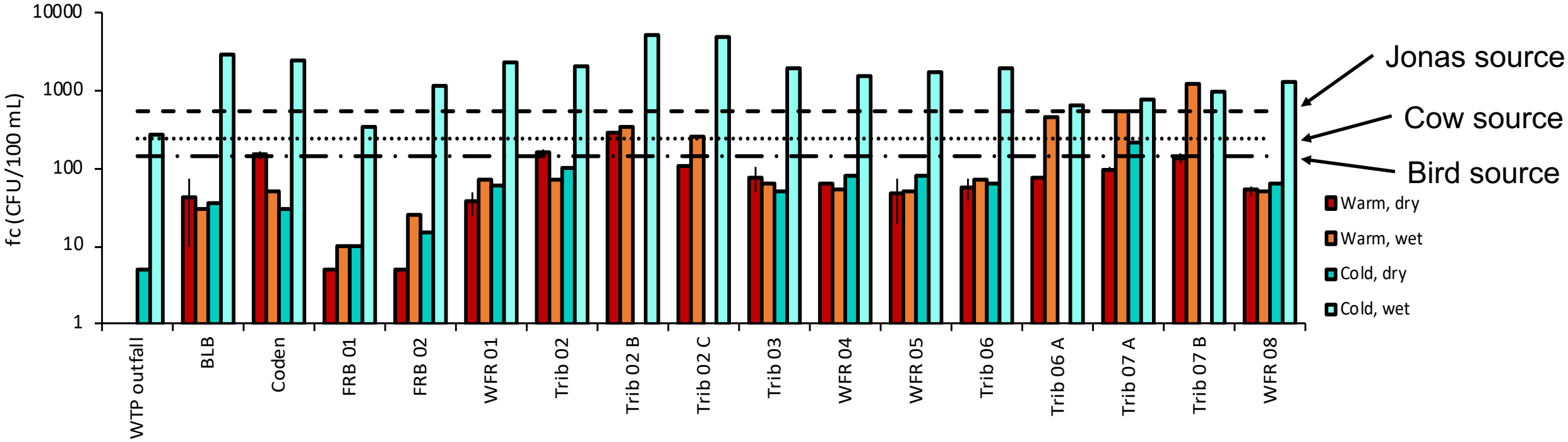
Decreasing from source

No change

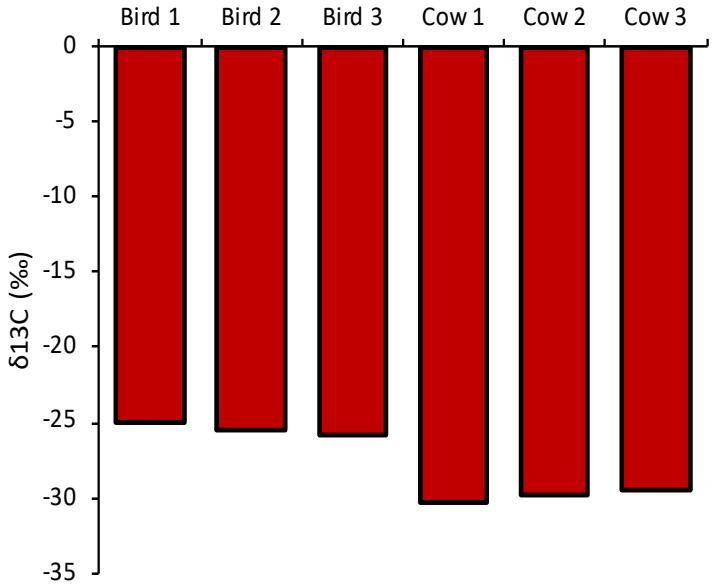


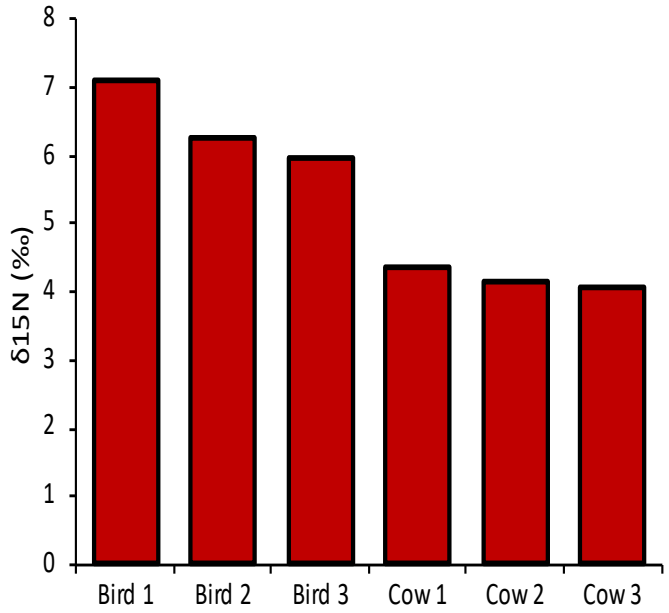


Other Sources Results compared to WFR

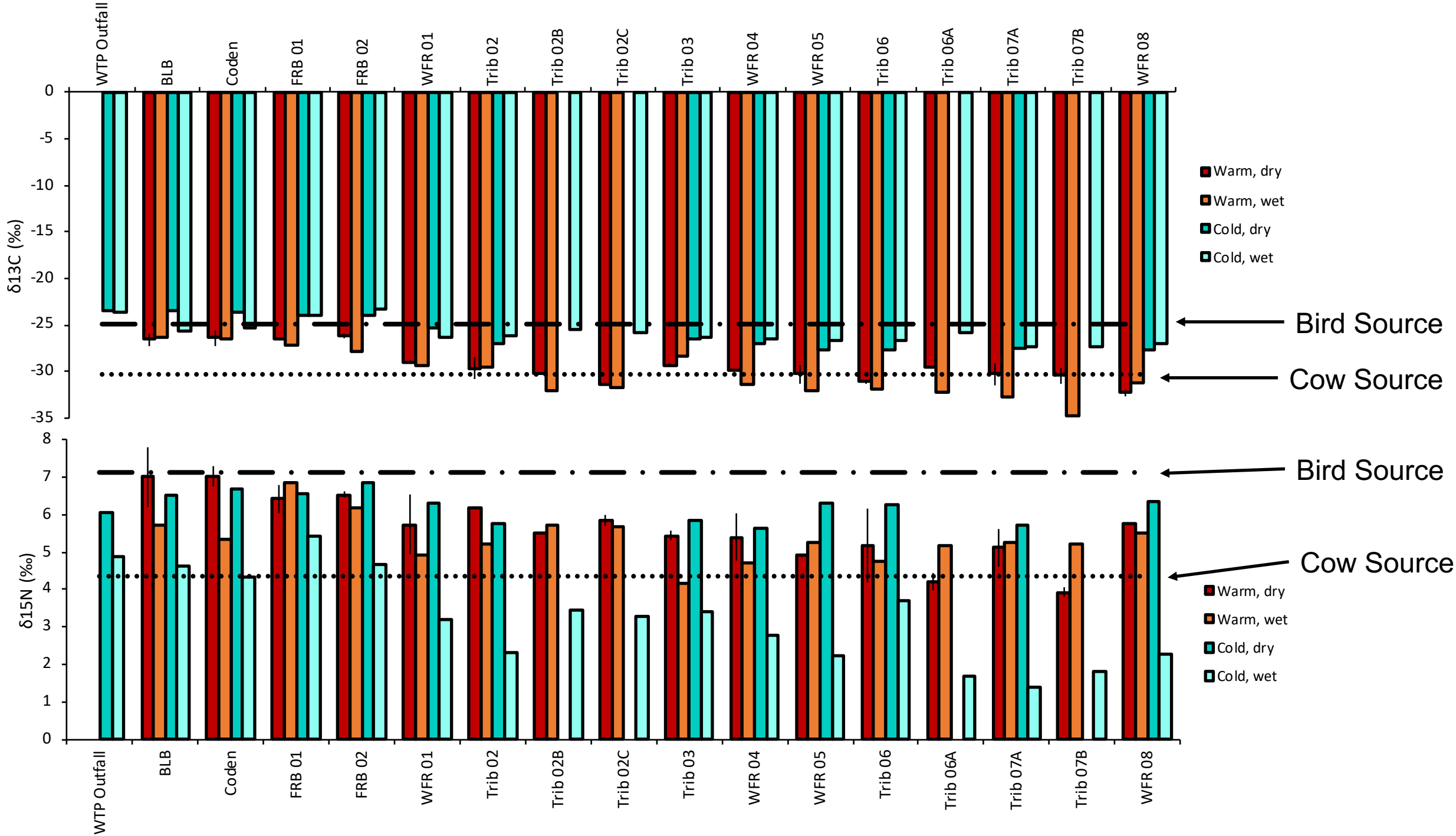


Other Sources Results: Stable Isotopes

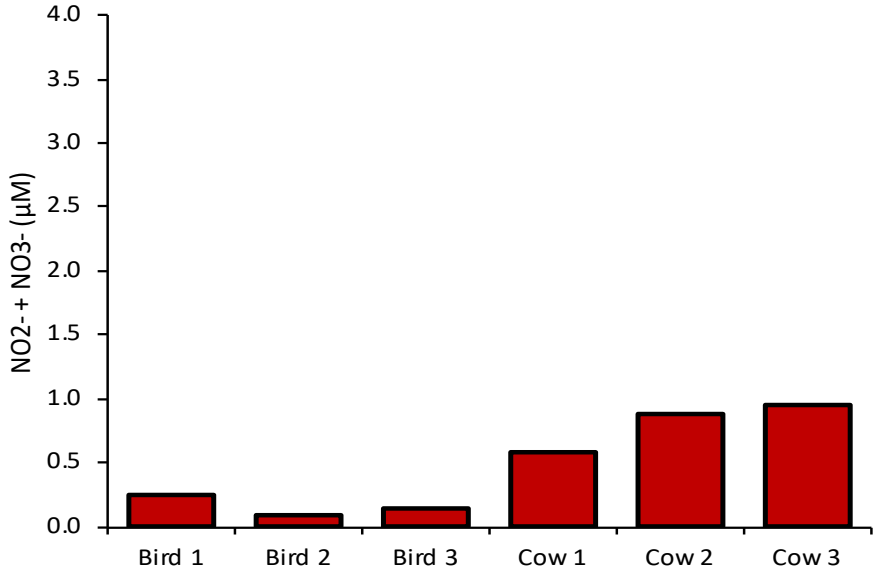


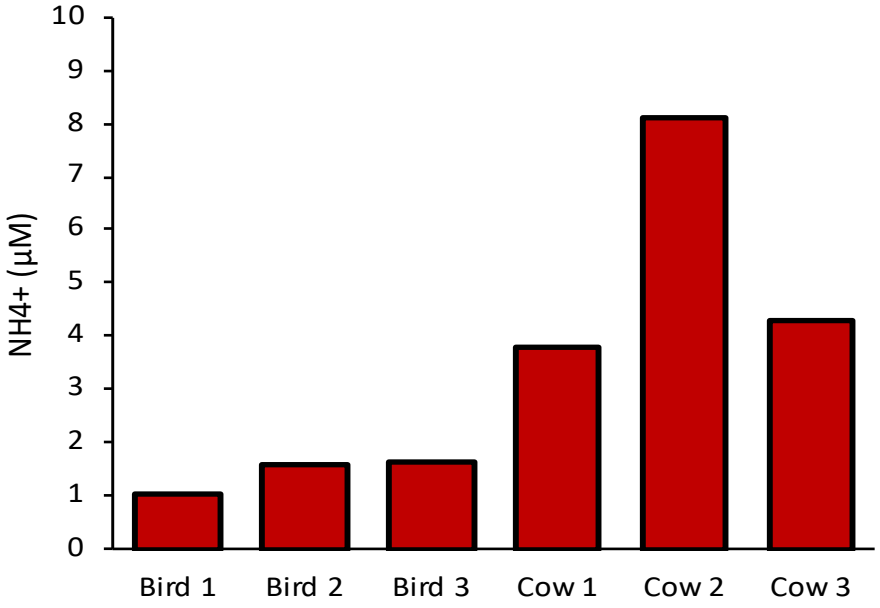


- Cows lighter than birds for C & N (more terrestrial)
- N decreased away from source (dilution)

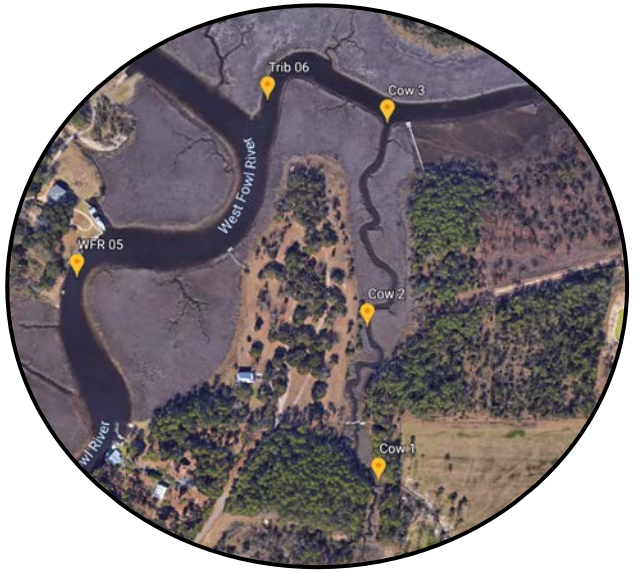

WTP Outfall
BLB
Coden
FRB 01
FRB 02
WFR 01
Trib 02
Trib 02B
Trib 02C
Trib 03
WFR 04
WFR 05
Trib 06
Trib 06A
Trib 07A
Trib 07B
WFR 08
δ13C (‰)
0
-5
-10
-15
-20
-25
-30
-35
Warm, dry
Warm, wet
Cold, dry
Cold, wet
Bird Source
Cow Source
δ15N (‰)
8
7
6
5
4
3
2
1
0
Bird Source
Cow Source
Warm, dry
Warm, wet
Cold, dry
Cold, wet

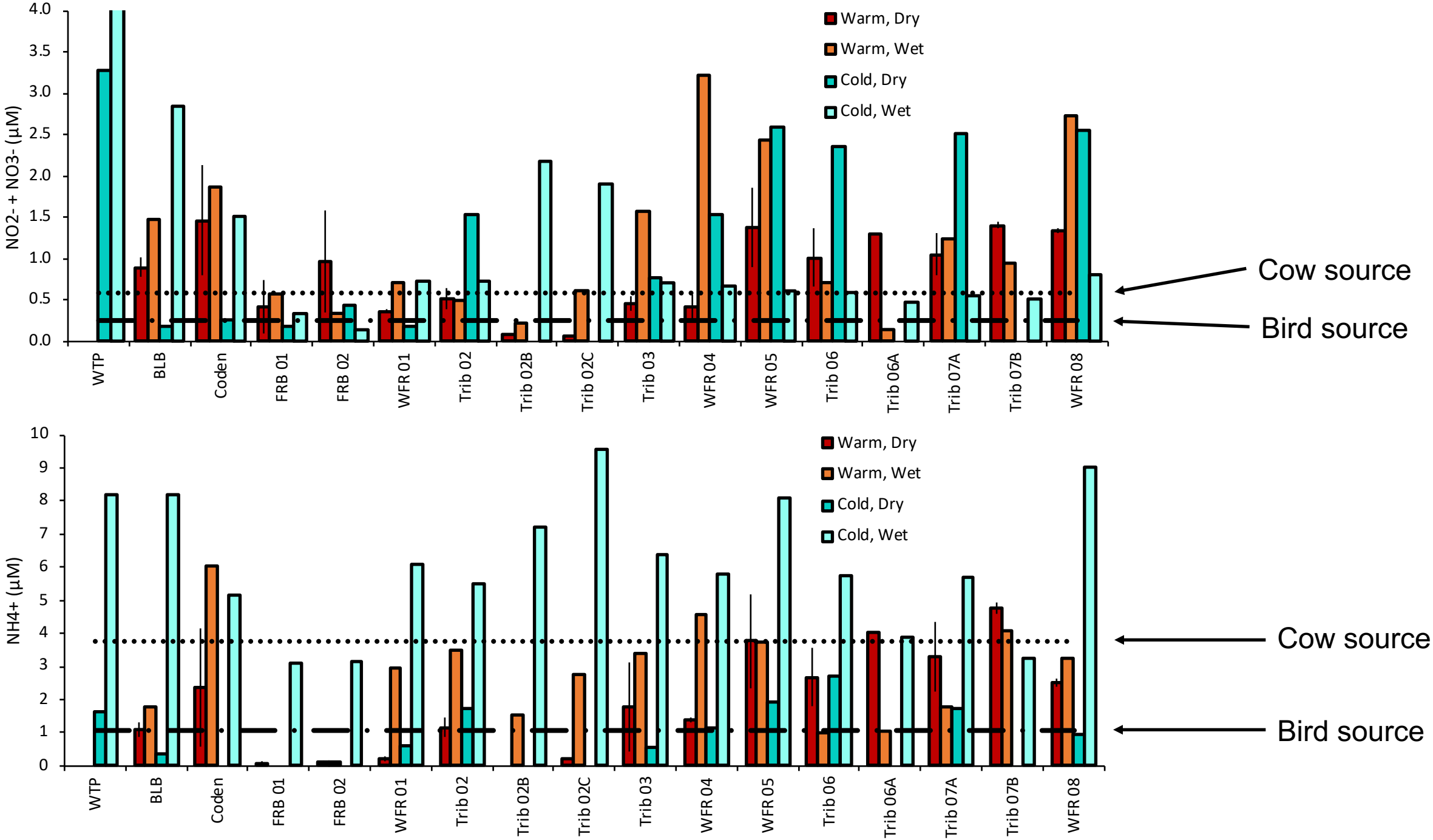
Other Sources Results: Nutrients





- Values overall low
- Dilution happens




NO2- + NO3- (µM)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Warm, Dry
Warm, Wet
Cold, Dry
Cold, Wet
Cow source
Bird source
WTP
BLB
Coden
FRB 01
FRB 02
WFR 01
Trib 02
Trib 02B
Trib 02C
Trib 03
WFR 04
WFR 05
Trib 06
Trib 06A
Trib 07A
Trib 07B
WFR 08
NH4+ (µM)
10
9
8
7
6
5
4
3
2
1
0
Warm, Dry
Warm, Wet
Cold, Dry
Cold, Wet
Cow source
Bird source
WTP
BLB
Coden
FRB 01
FRB 02
WFR 01
Trib 02
Trib 02B
Trib 02C
Trib 03
WFR 04
WFR 05
Trib 06
Trib 06A
Trib 07A
Trib 07B
WFR 08

Conclusions

- Unprocessed WW is likely entering WFR from sources upstream, particularly associated with residential land use
- Microbial & nutrient sources (residential areas, agriculture, wildlife) to the Fowl River Bay area are sufficiently different to allow endpoints for tracing, if dilution & mixing can be defined.

Acknowledgements

- Mobile Bay National Estuary Program
- Field and lab assistance: E. Hieb, H. Nicholson, C. Williams, G. Forster, S. Bulls, P. Stott, D. Hill, J. Kudulis