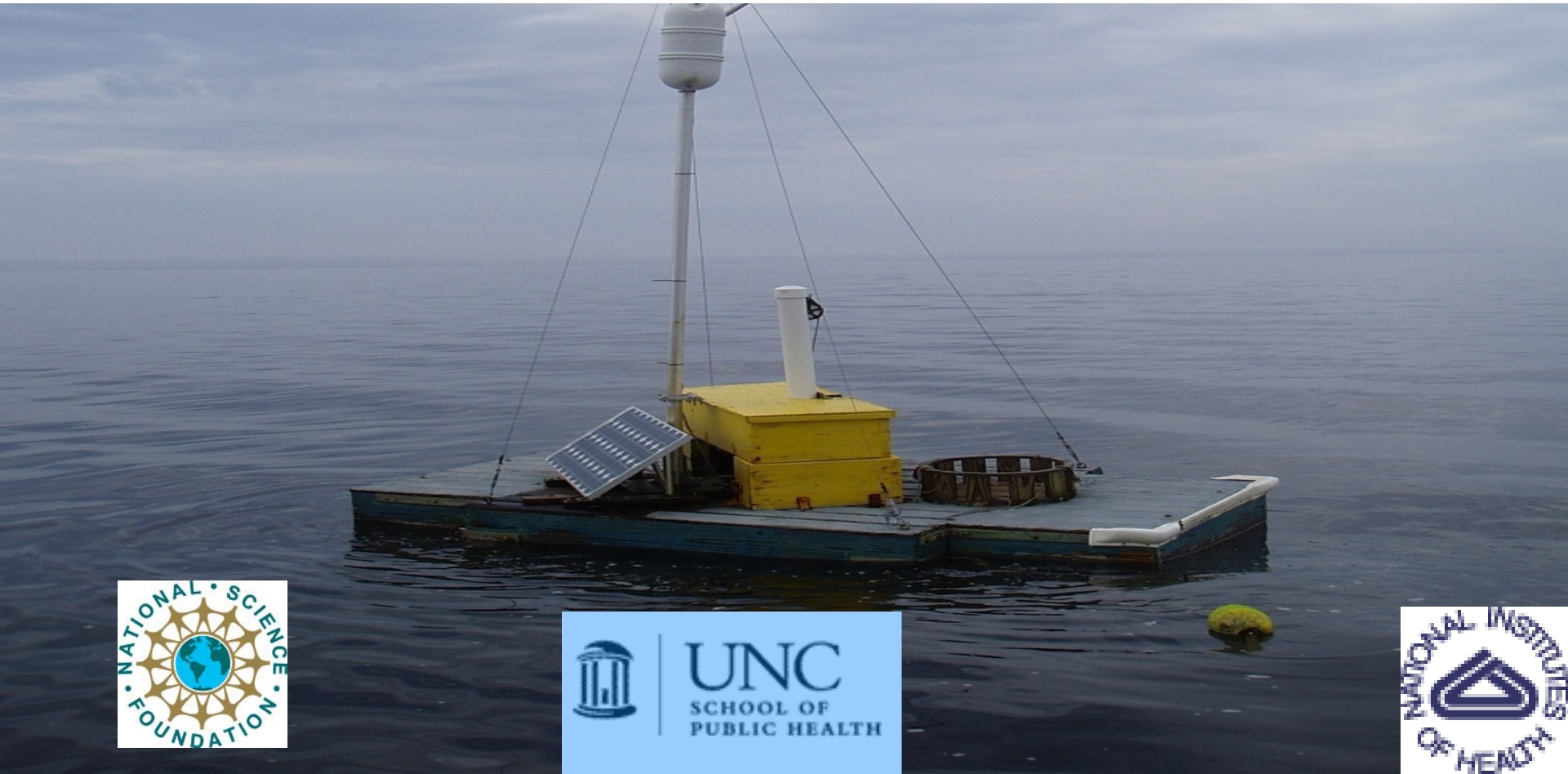
INVESTIGATING PATHOGENS IN THE FACE OF CLIMATE CHANGE

NSF/NIH Ecology of Infectious Disease Program

OCE 0812913

Rachel T. Noble



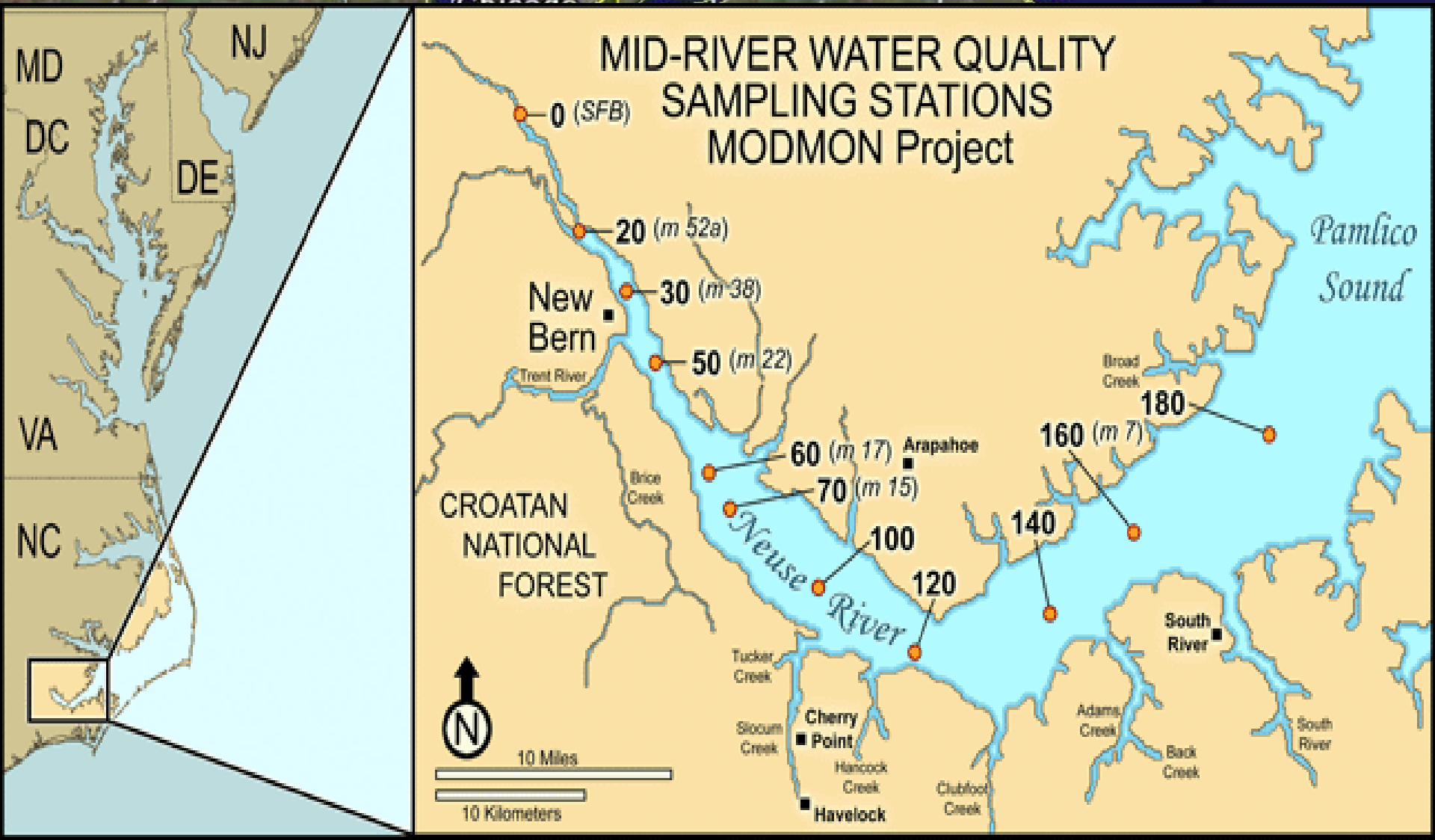
UNC Chapel Hill EID Program

- Understand the impact of excessive nutrient inputs and extreme storm events on estuarine health, including humans as stressors and ecosystem components
- Interdisciplinary research team from epidemiology, marine & environmental sciences, risk assessment, microbial ecology, biogeochemistry, modeling, and public health (current team of 7 PIs)
- Develop computational models to predict the effects on microbial ecology and human health
- Improve student training in state-of-the-art scientific disciplines and foster undergraduate and graduate training

Why study EID in theNeuse River Estuary?

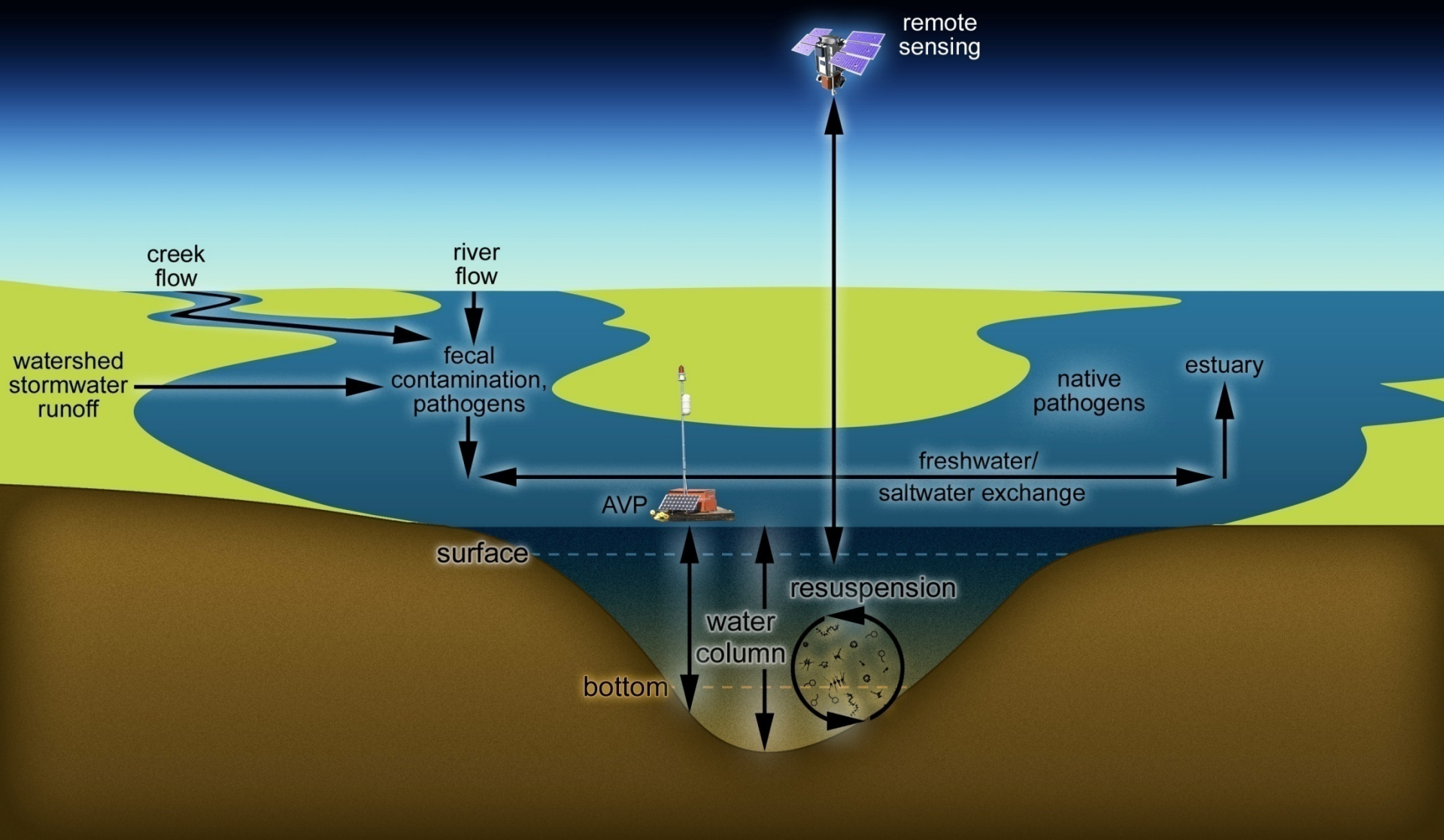
- Rapid urbanization and agricultural development
- Expanding swine and poultry industry=nutrient loading and eutrophication
- Increasing hurricanes and floods
- Representative of shallow Atlantic and Gulf coastal plain estuarine ecosystems (2nd largest in USA)
- Subject of intense hydrological and water quality modeling efforts (25 yrs of data, ModMon, FerryMon)
- Important episodic events (HABs, fish kills, sewage spills, intense stormwater inputs, hurricanes. Nor'easters)

Neuse River Estuary, Eastern North Carolina

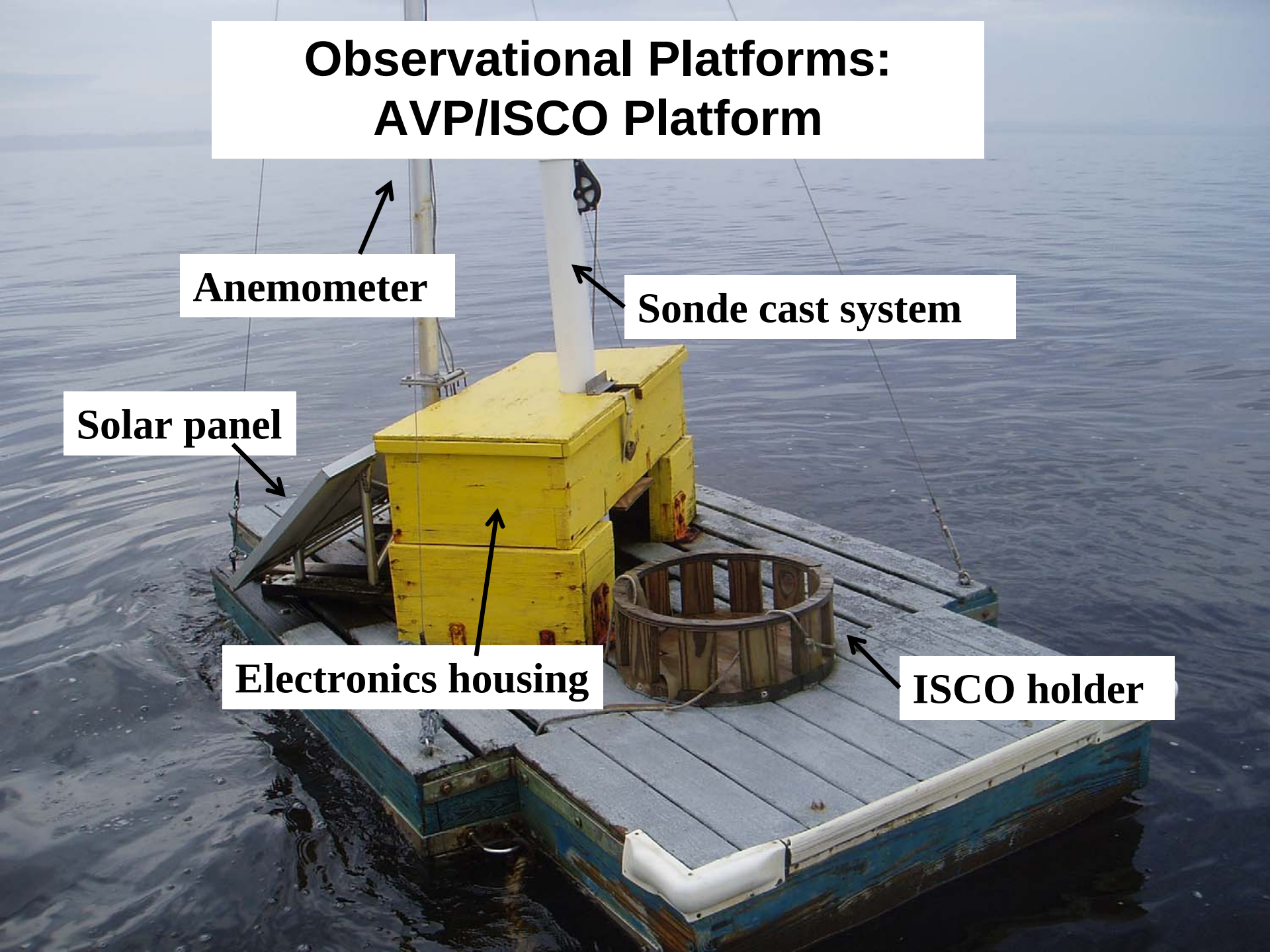


Linking Scales

a major marine science research need is the ability to link across multiple scales



Observational Platforms: AVP/ISCO Platform



Conceptual Framework

- Estuaries function through a balance b/w freshwater input and oceanic influence
- Stratification versus well mixed systems dictate the success of microbial communities
- Hurricanes can result in strong winds and freshwater inputs, pulses of nutrients, and stormwater runoff (well mixed systems)
- Droughts result in heightened stratification, stagnation of water
- Drought periods favor stratification and HABs, certain types of virulent Vibrios

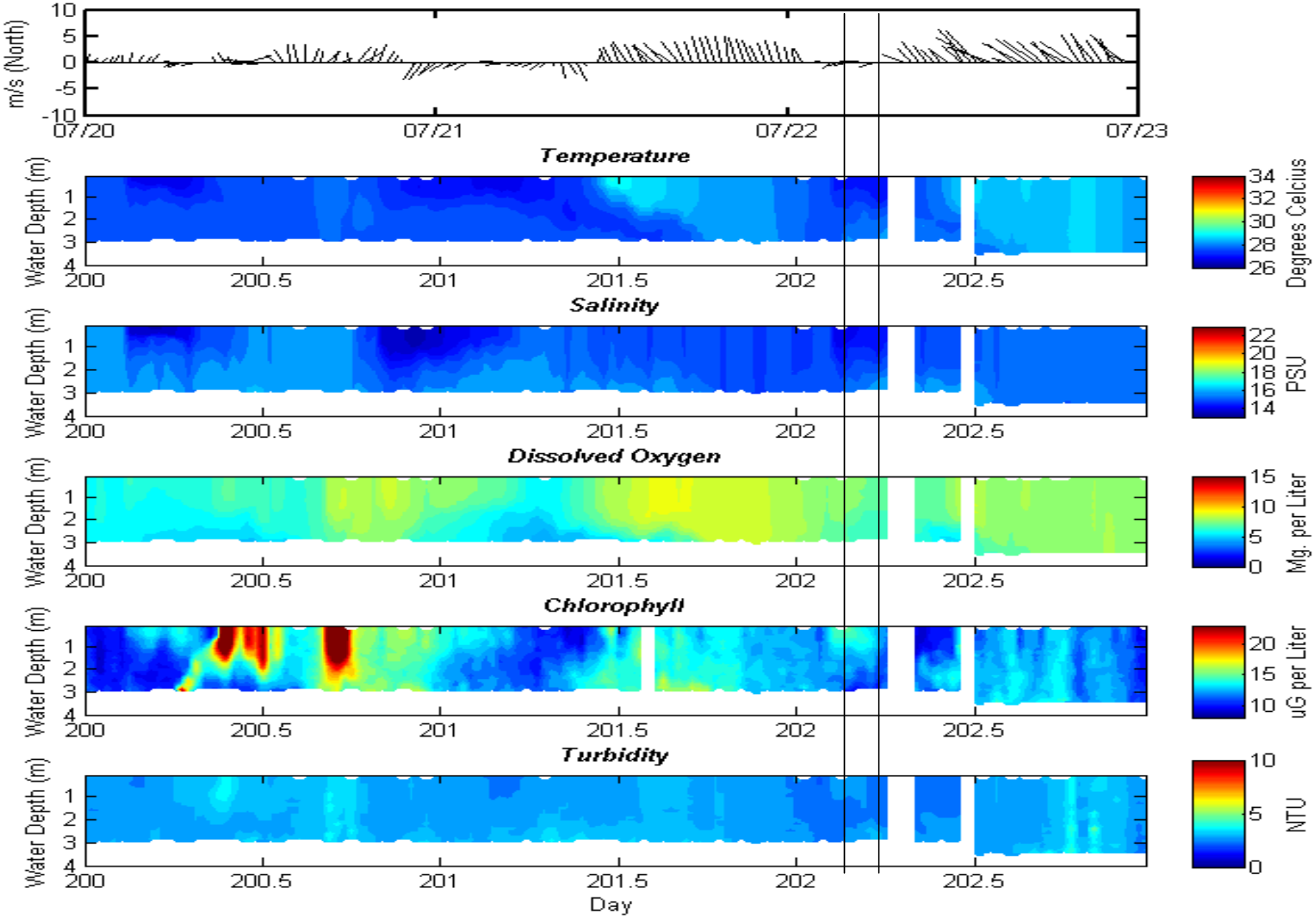
Microbial ecology

- **Studies of both native and “contaminant” bacterial species**
- **All studied are relevant to public health outcomes**
- **Poor reporting and categorization of health outcomes confounds assessment**
- **Vibrio sp., including *V. vulnificus*, *V. parahaemolyticus*, all ecotypes**
- **Fecal indicator bacteria, molecular markers**
- **Bdellovibrio “predatory” bacteria**
- **Interactions between phytoplankton and Vibrios**
- **Effects of particle attachment and resuspension**

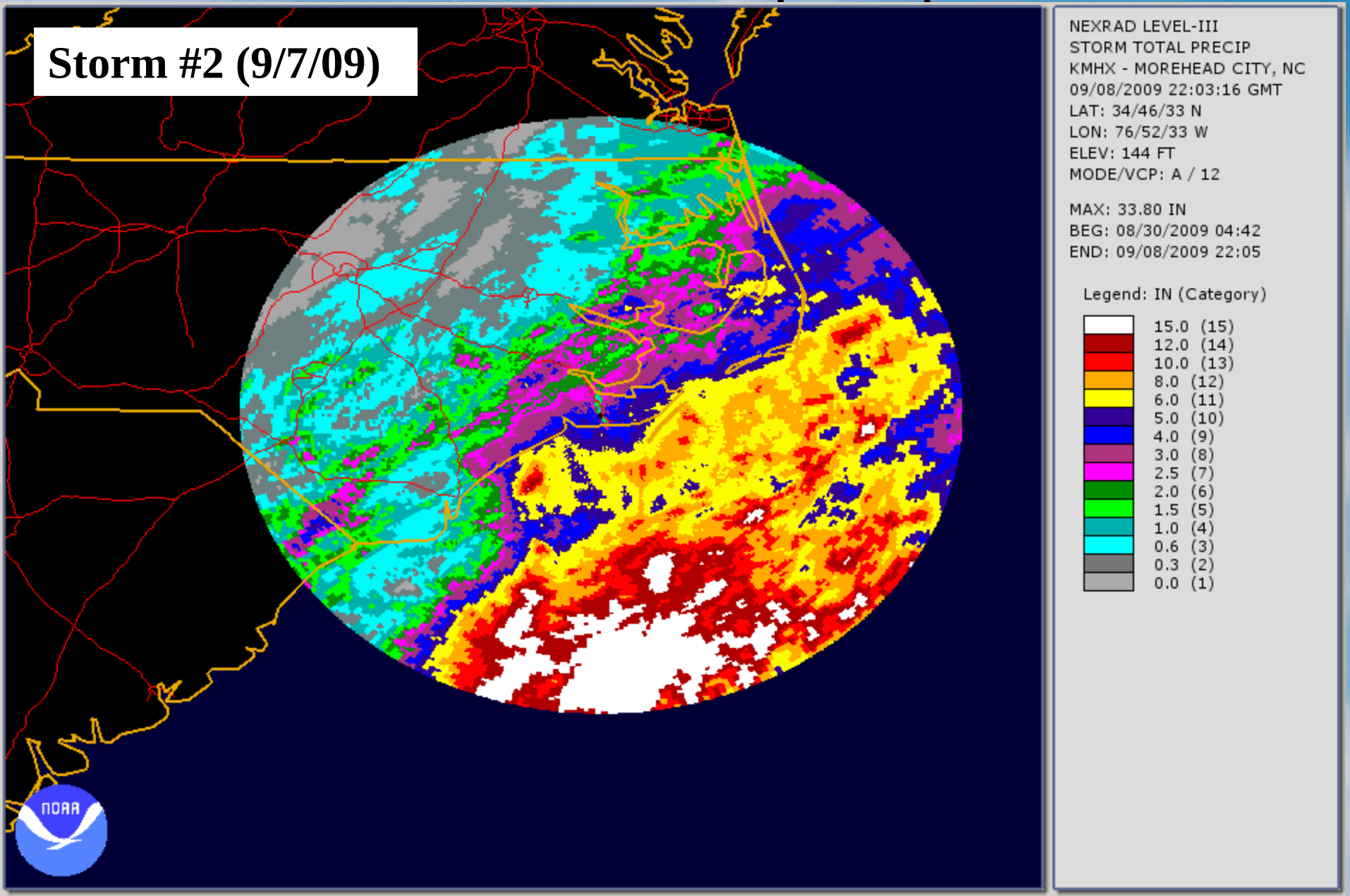
Storm Events

- Baseline “Normal” Sampling
- Storm #1 (August 13-14, 2009)
  - ~14 cm rain in Havelock on 8/12, additional precipitation over next 48 hours, low wind
- Storm #2 (September 7, 2009)
  - 15 to 30 cm rain along the coast over ~24 hours preceding and during sampling event
  - Short hard rain; wind in the evening
- Storm #3 (September 26-Oct 1, 2010)
  - Major NC flood, 30-38+ cm rain along the coast over ~24 hours preceding and during sampling events

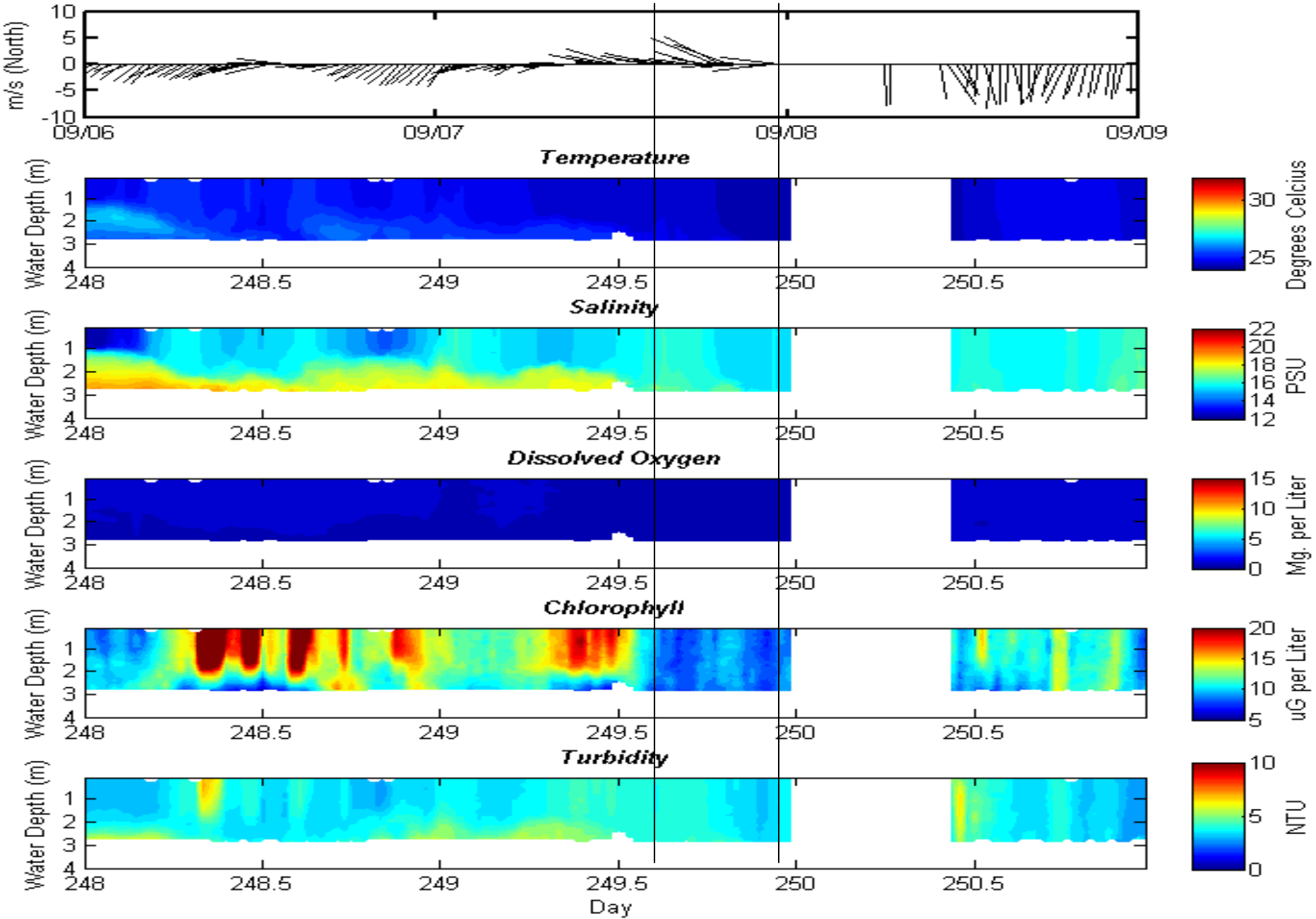
Sonde data - Baseline



Radar-based total precipitation

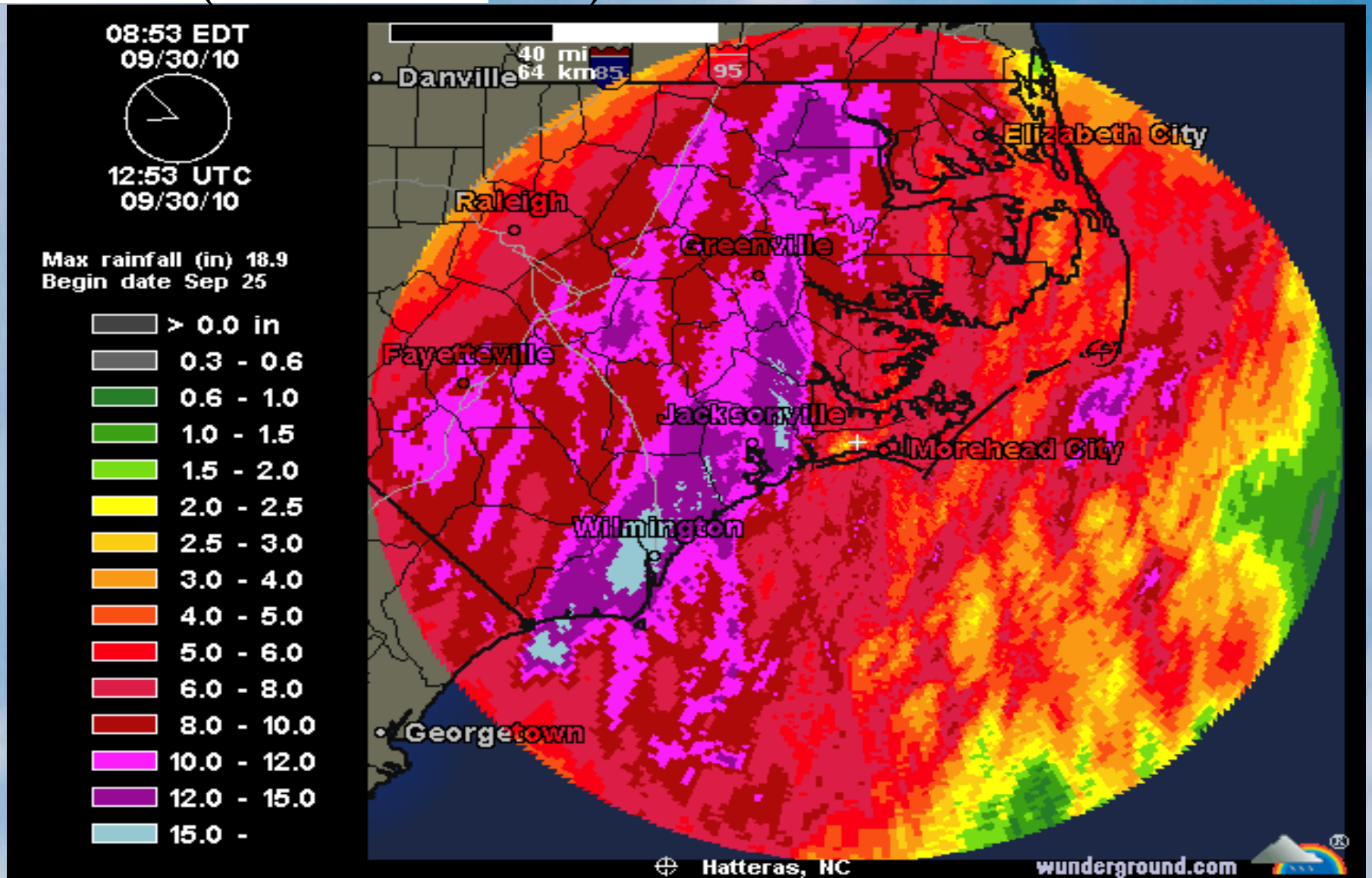


Sonde data – Storm #2

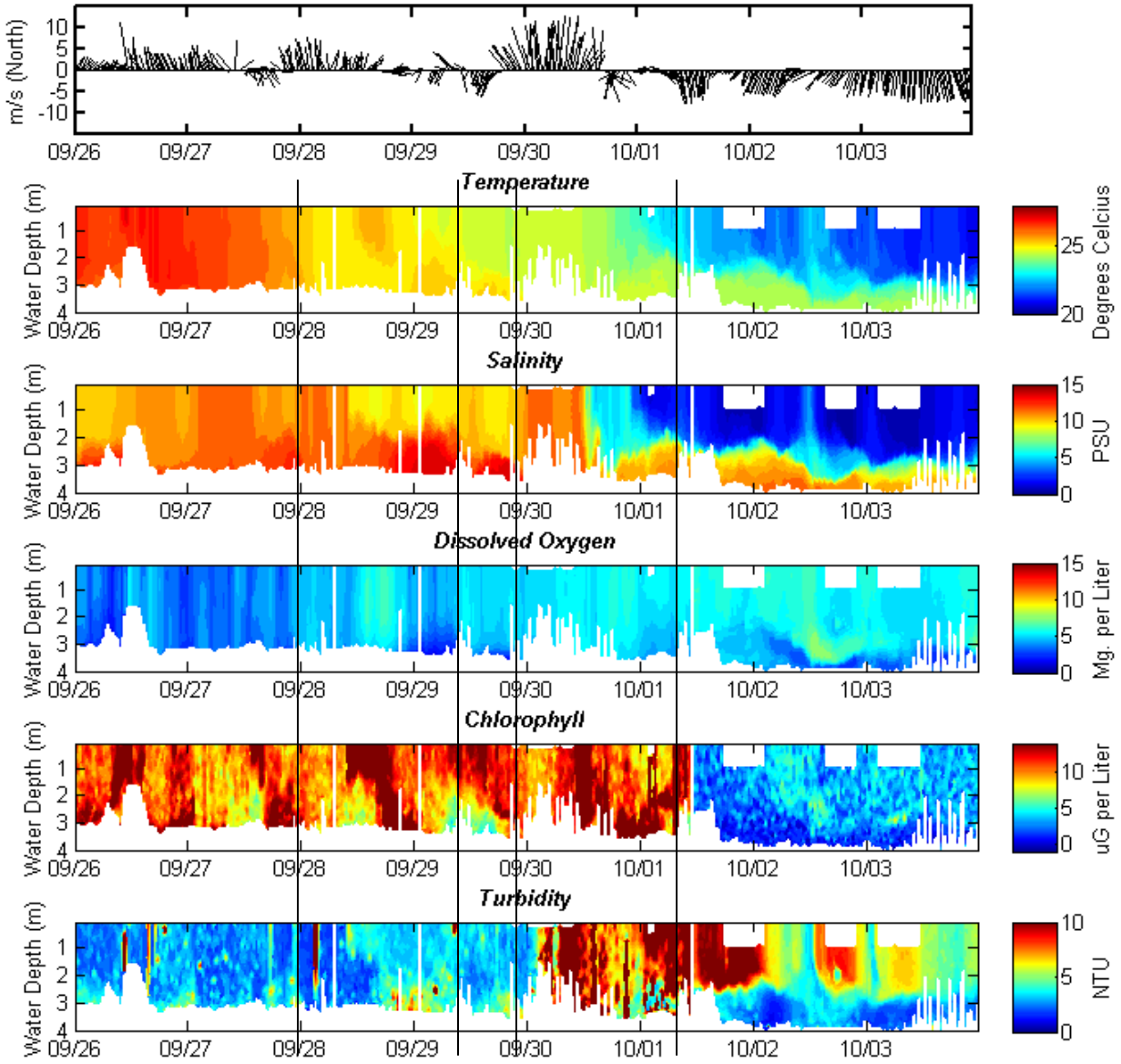


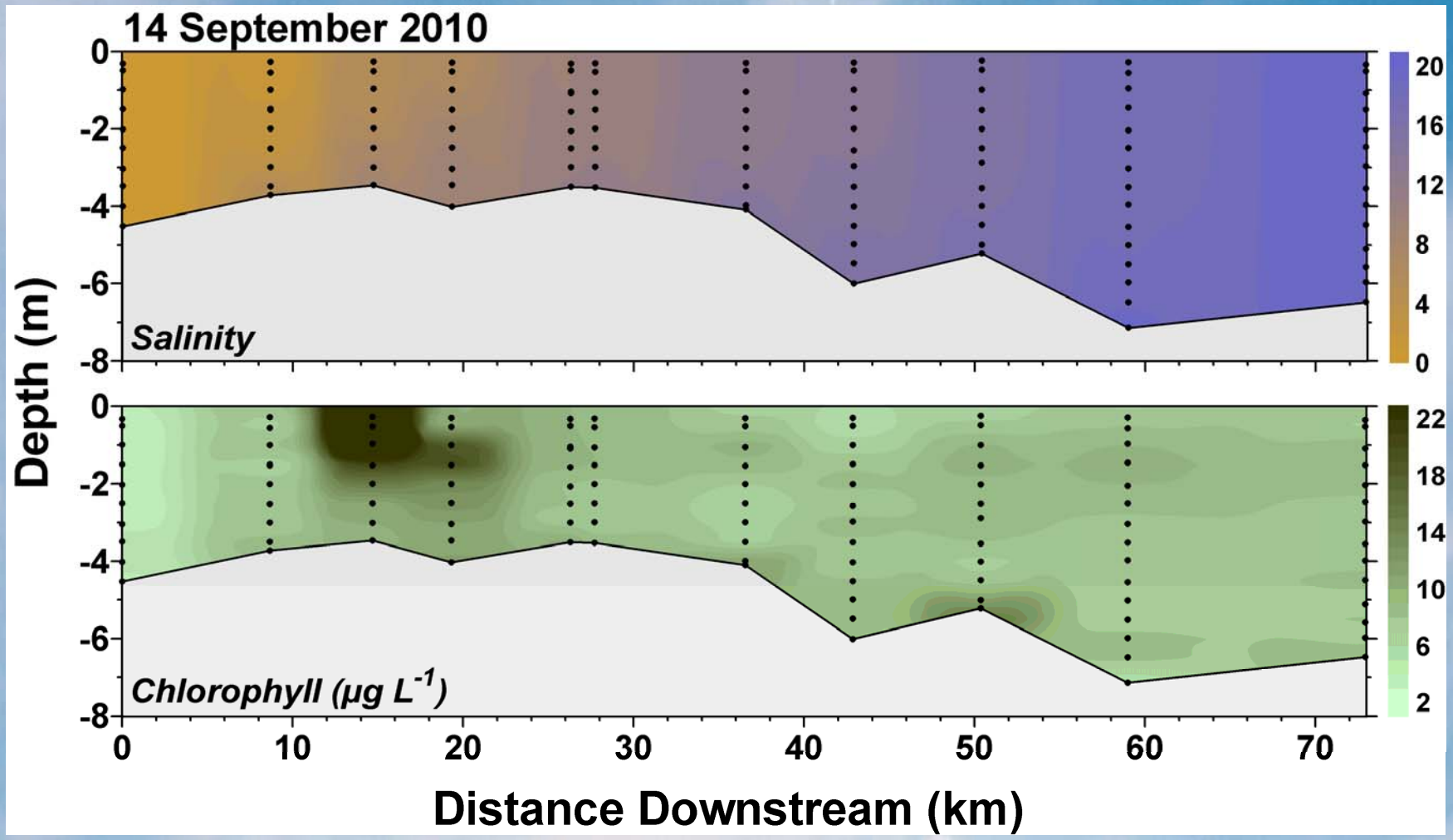
Radar-based total precipitation

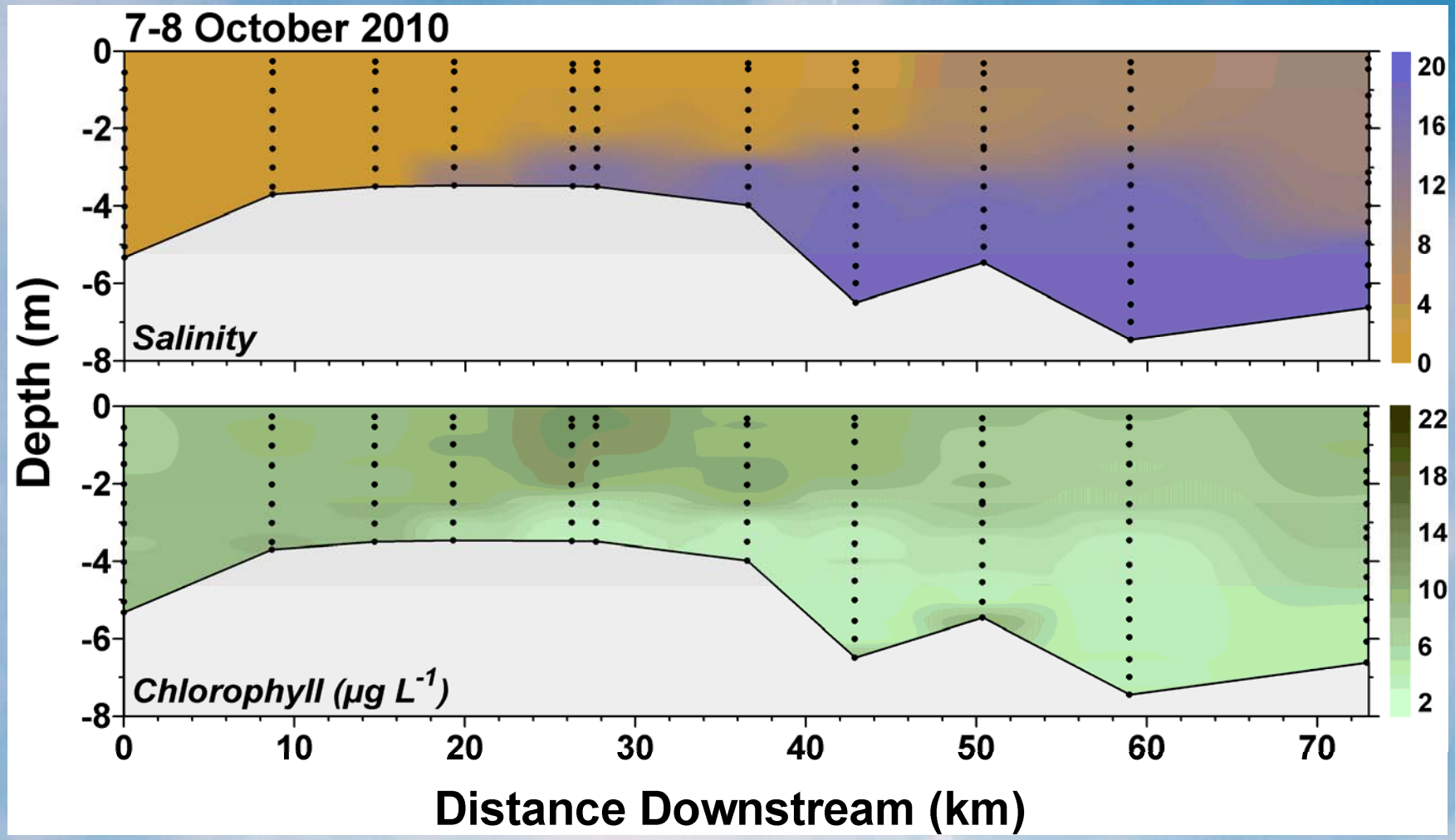
Storm #3 (9/26/10 – 10/03/10)

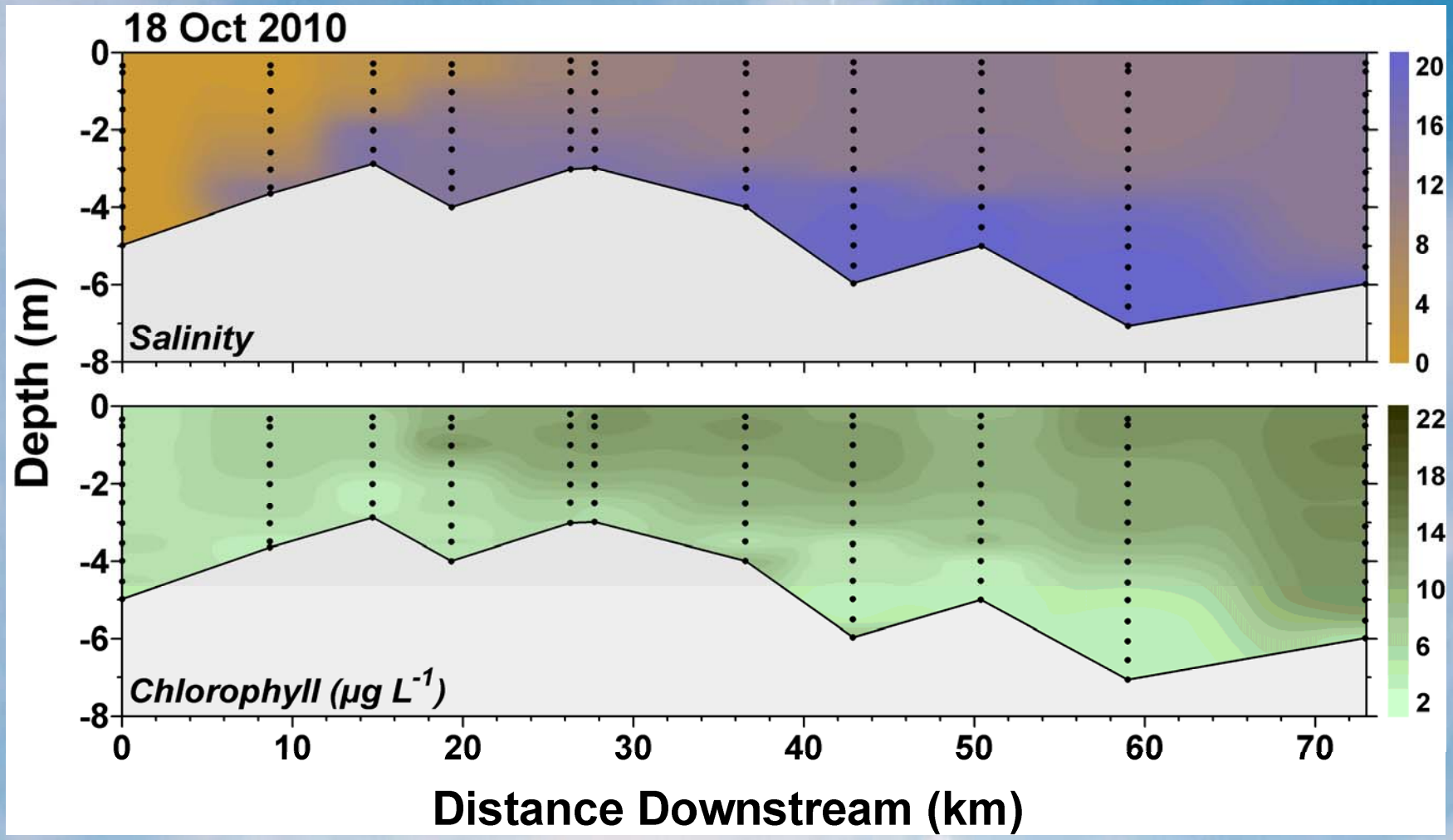


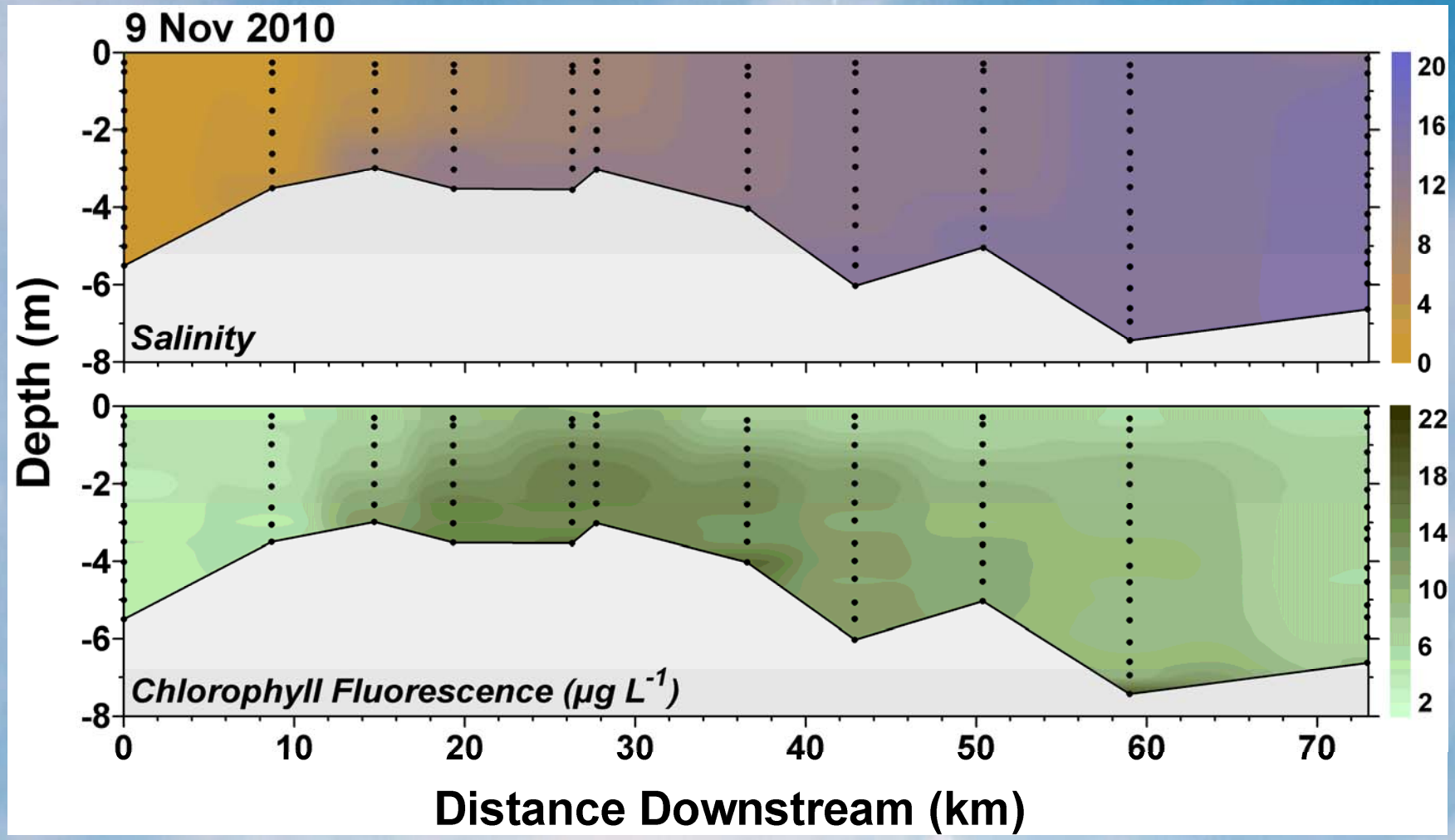
Sonde data – Storm #3



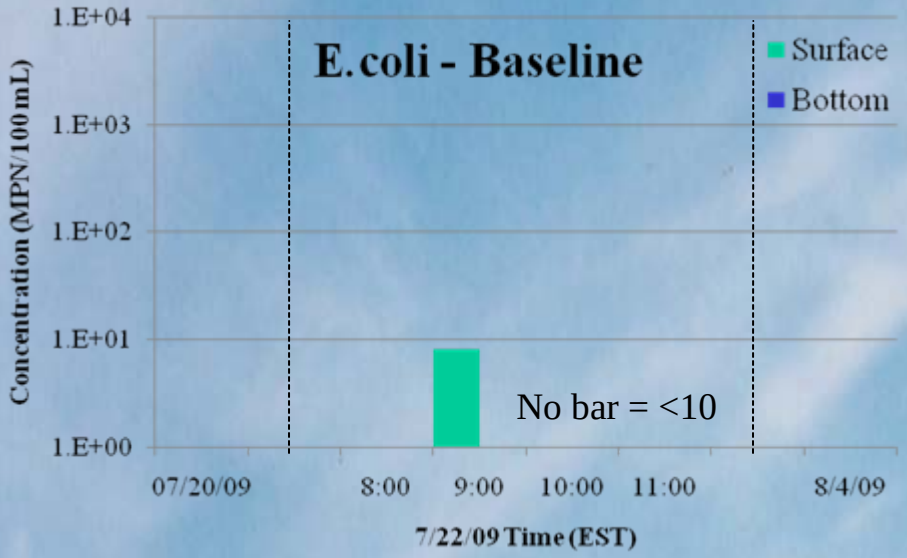

14 September 2010
Depth (m)
Salinity
Chlorophyll (µg L-1)
Distance Downstream (km)
0
-2
-4
-6
-8
0
10
20
30
40
50
60
70
20
16
12
8
4
0
22
18
14
10
6
2


7-8 October 2010
Depth (m)
Salinity
Chlorophyll (µg L-1)
Distance Downstream (km)
0
-2
-4
-6
-8
0
10
20
30
40
50
60
70
20
16
12
8
4
0
22
18
14
10
6
2

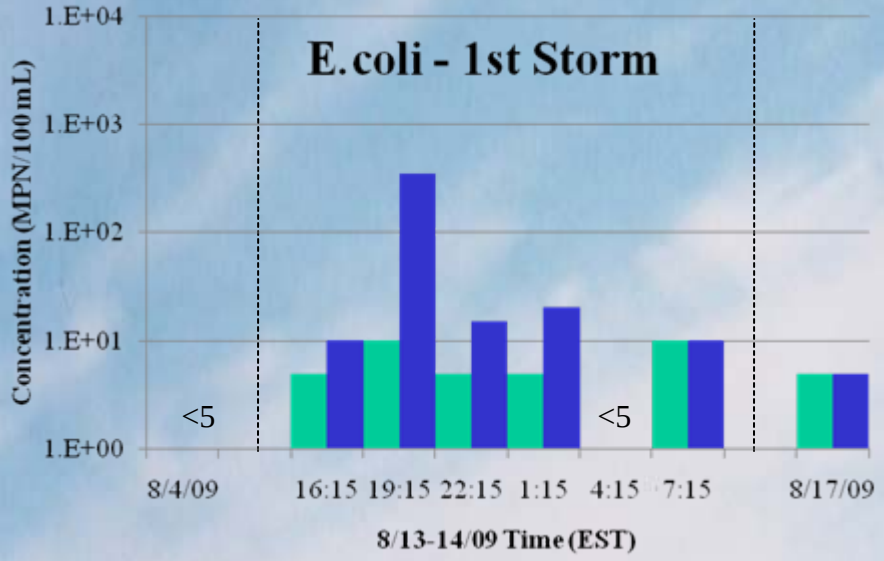

18 Oct 2010
Depth (m)
Salinity
Chlorophyll (µg L-1)
Distance Downstream (km)
0
-2
-4
-6
-8
0
10
20
30
40
50
60
70
20
16
12
8
4
0
22
18
14
10
6
2

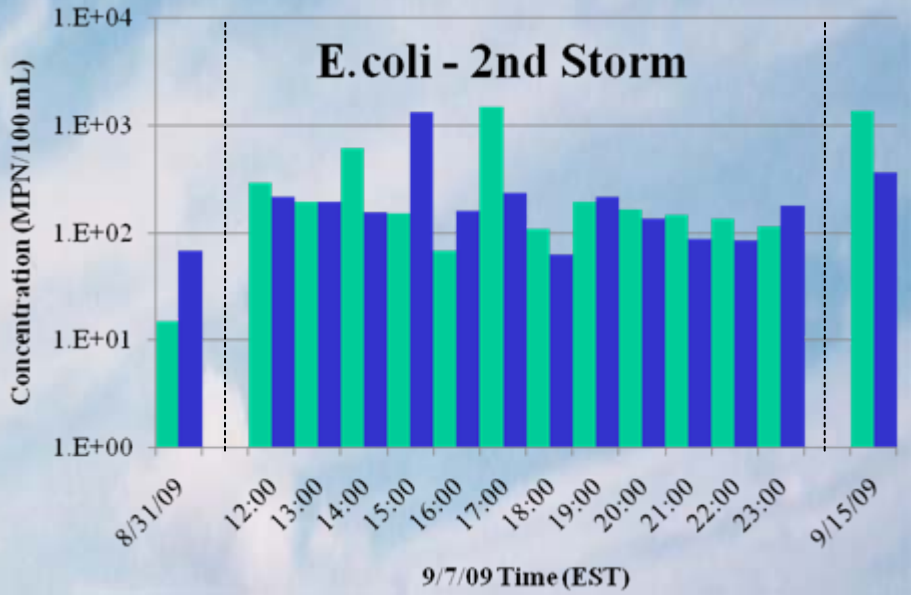

9 Nov 2010
Depth (m)
Salinity
Chlorophyll Fluorescence (μg L-1)
Distance Downstream (km)
0
-2
-4
-6
-8
0
10
20
30
40
50
60
70
20
16
12
8
4
0
22
18
14
10
6
2

E.coli

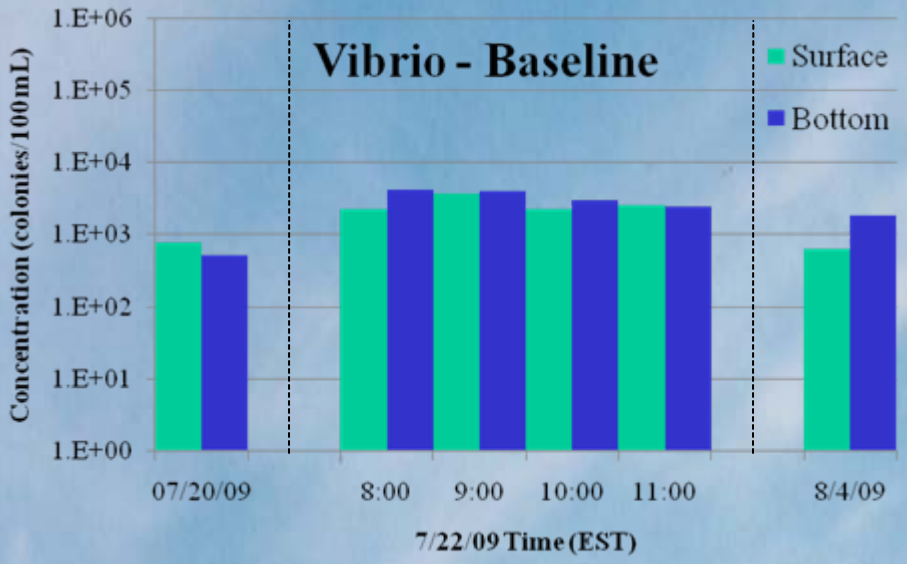


✓ Higher concentrations during storms as compared to baseline

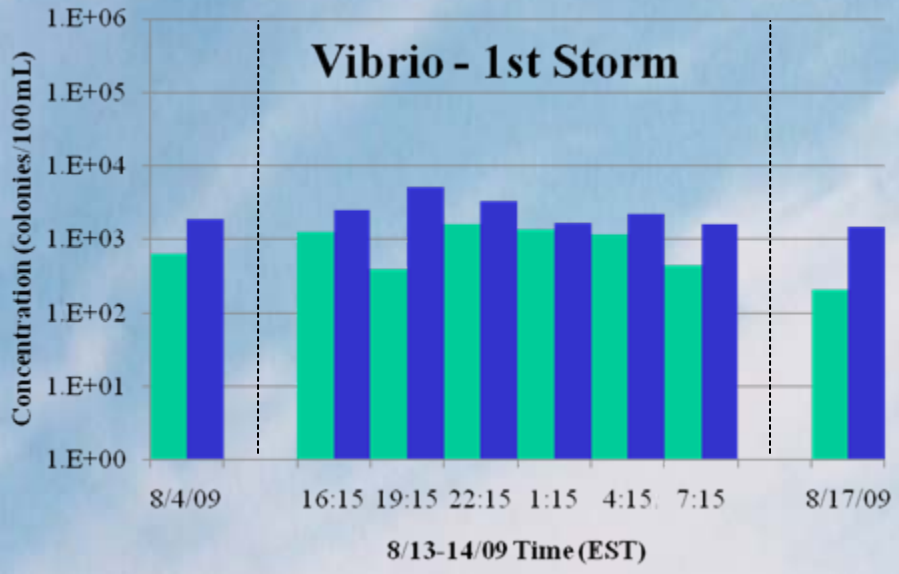


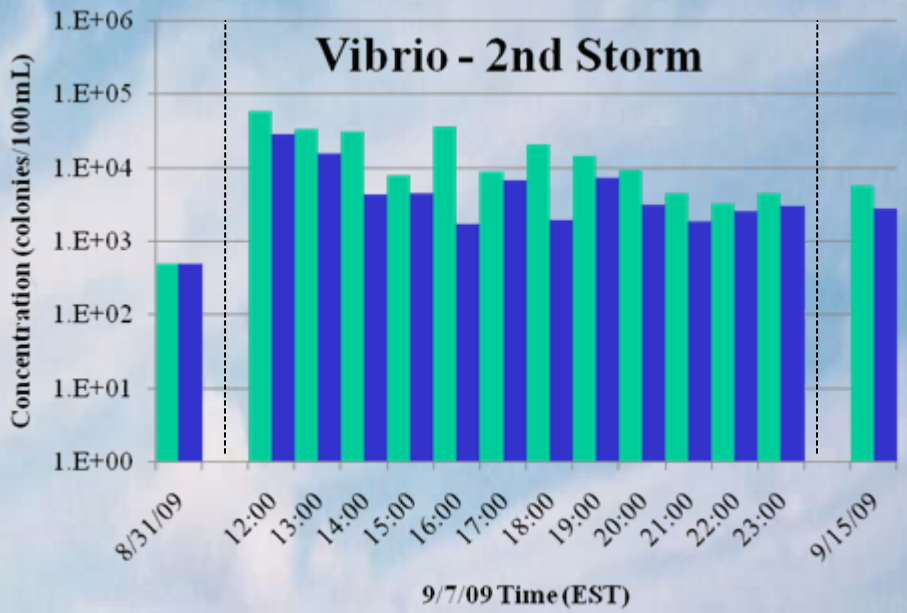


Vibrio spp.



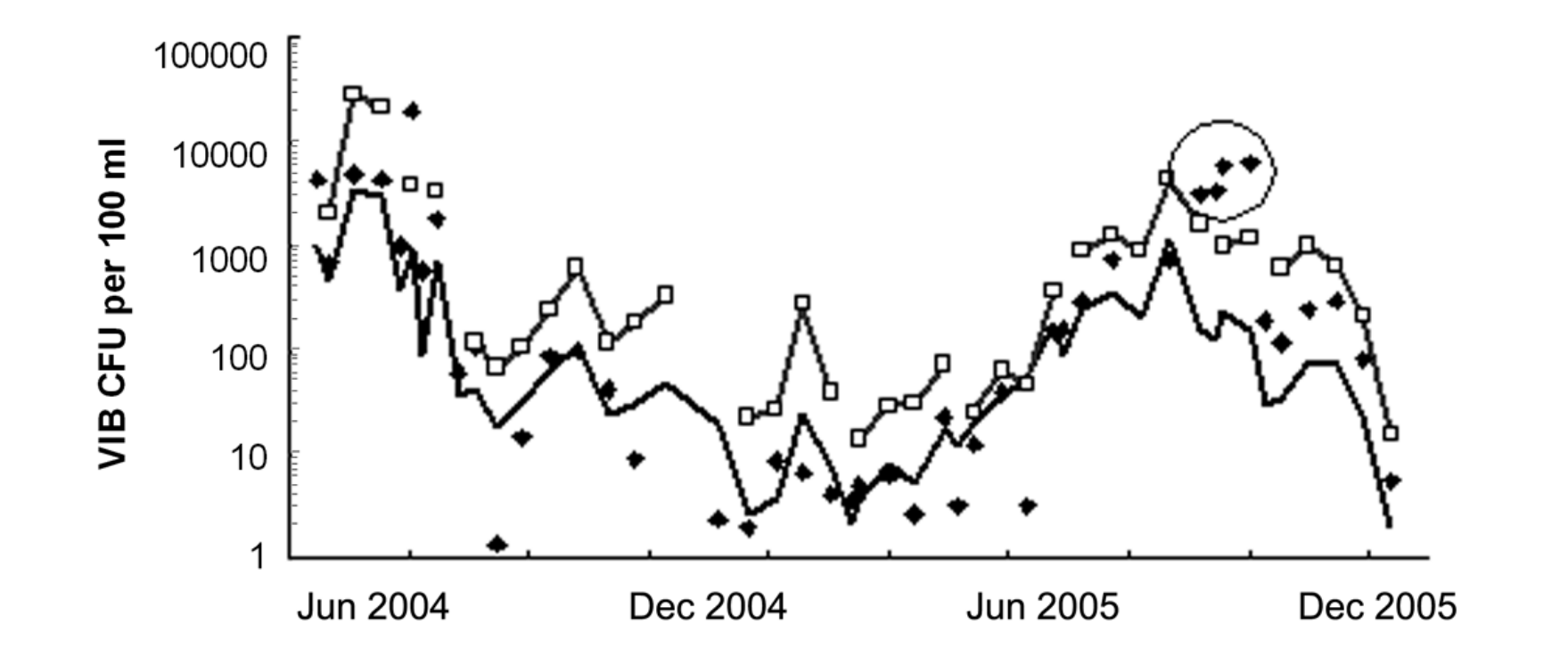
✓ Higher concentrations during second storm





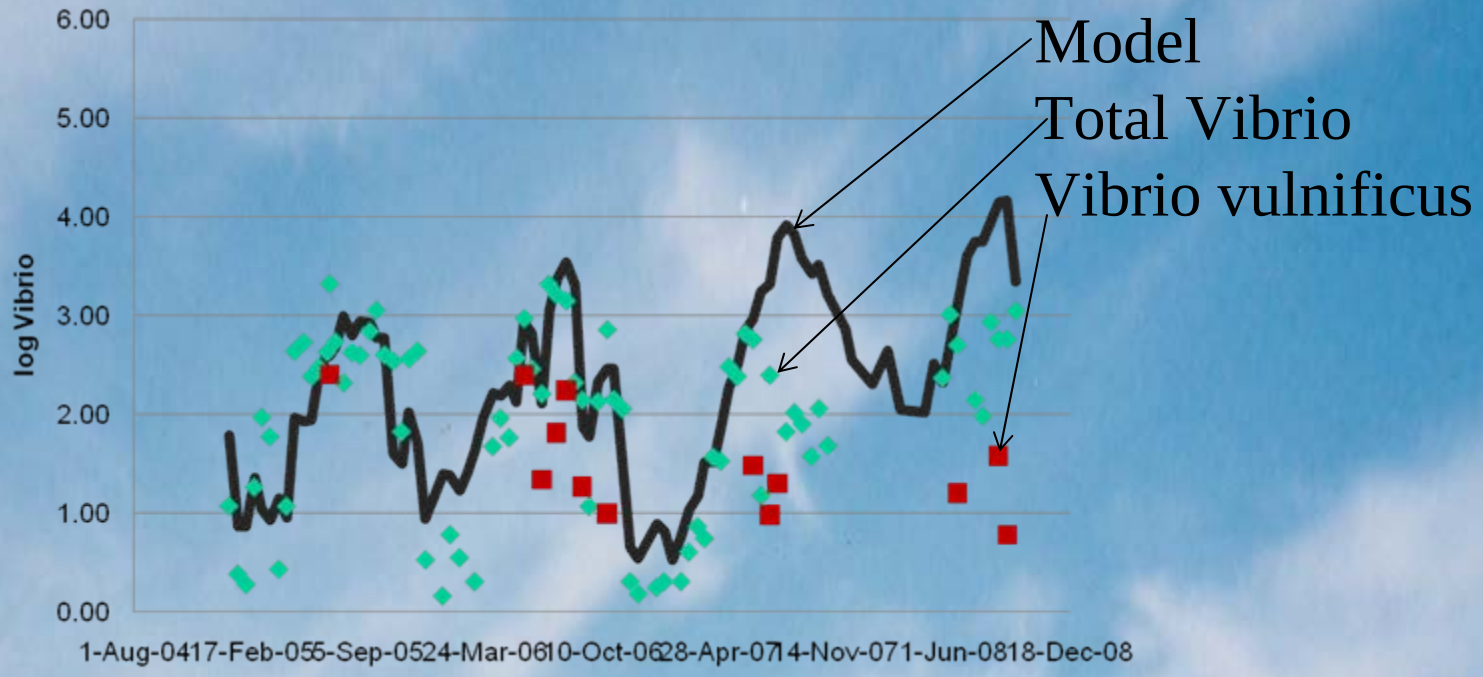
Vibrio Model

- Seasonal and spatial trends captured by salinity and temperature model
- Predictive model explains 65-80% of variability
- Improve predictions of regions and months for safer shellfish consumption

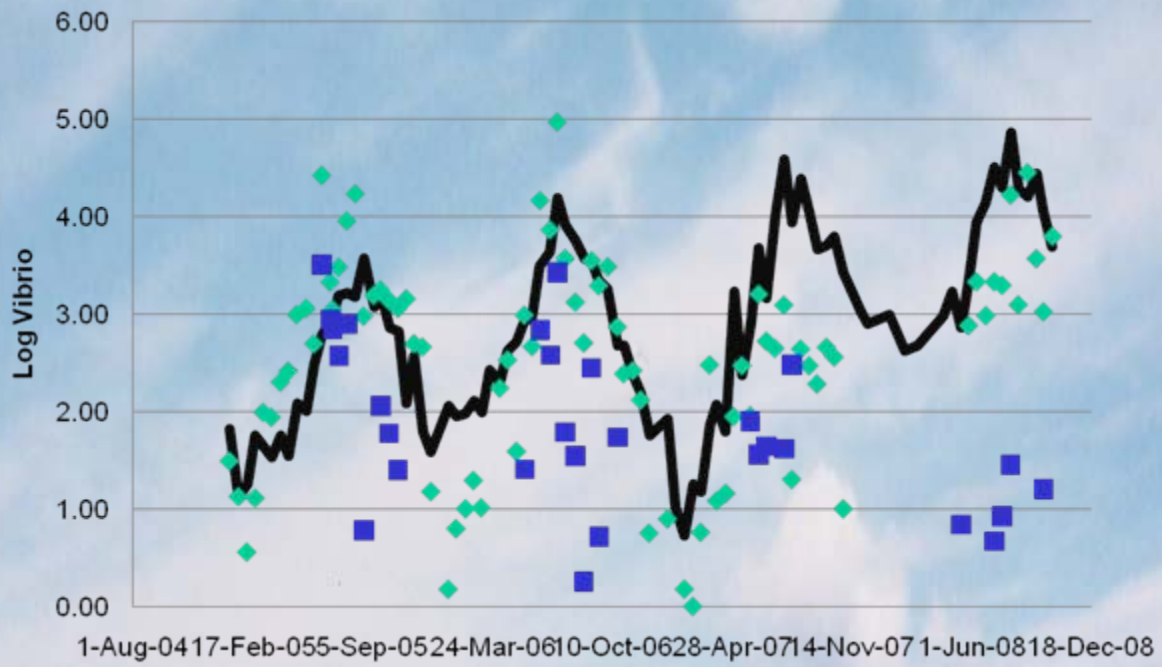


(Hsieh et al., Ecol. App., 2007; Hsieh et al., 2008, Wetz et al. 2008, Wetz et al submitted

SURFACE



BOTTOM



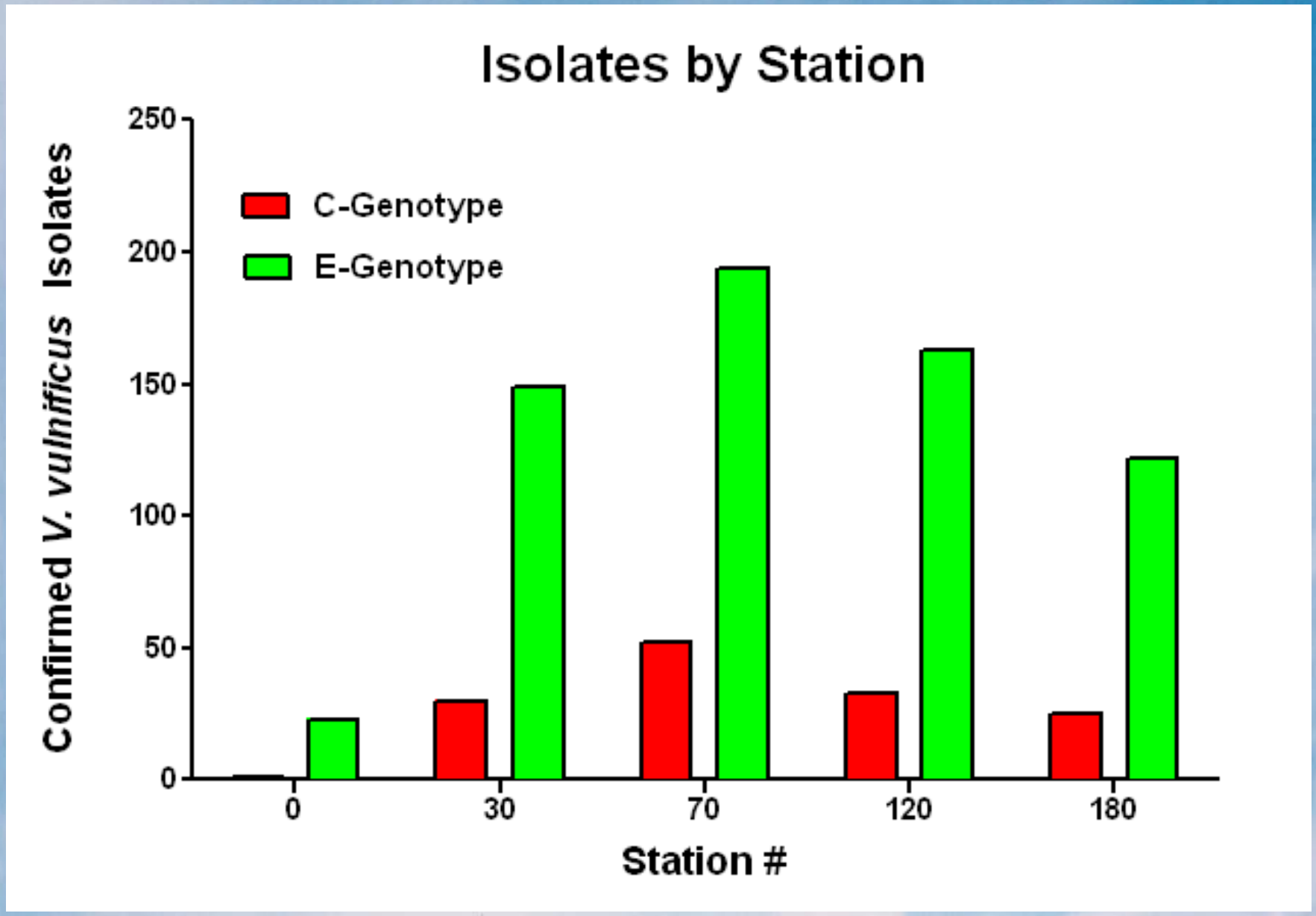
Results to Date

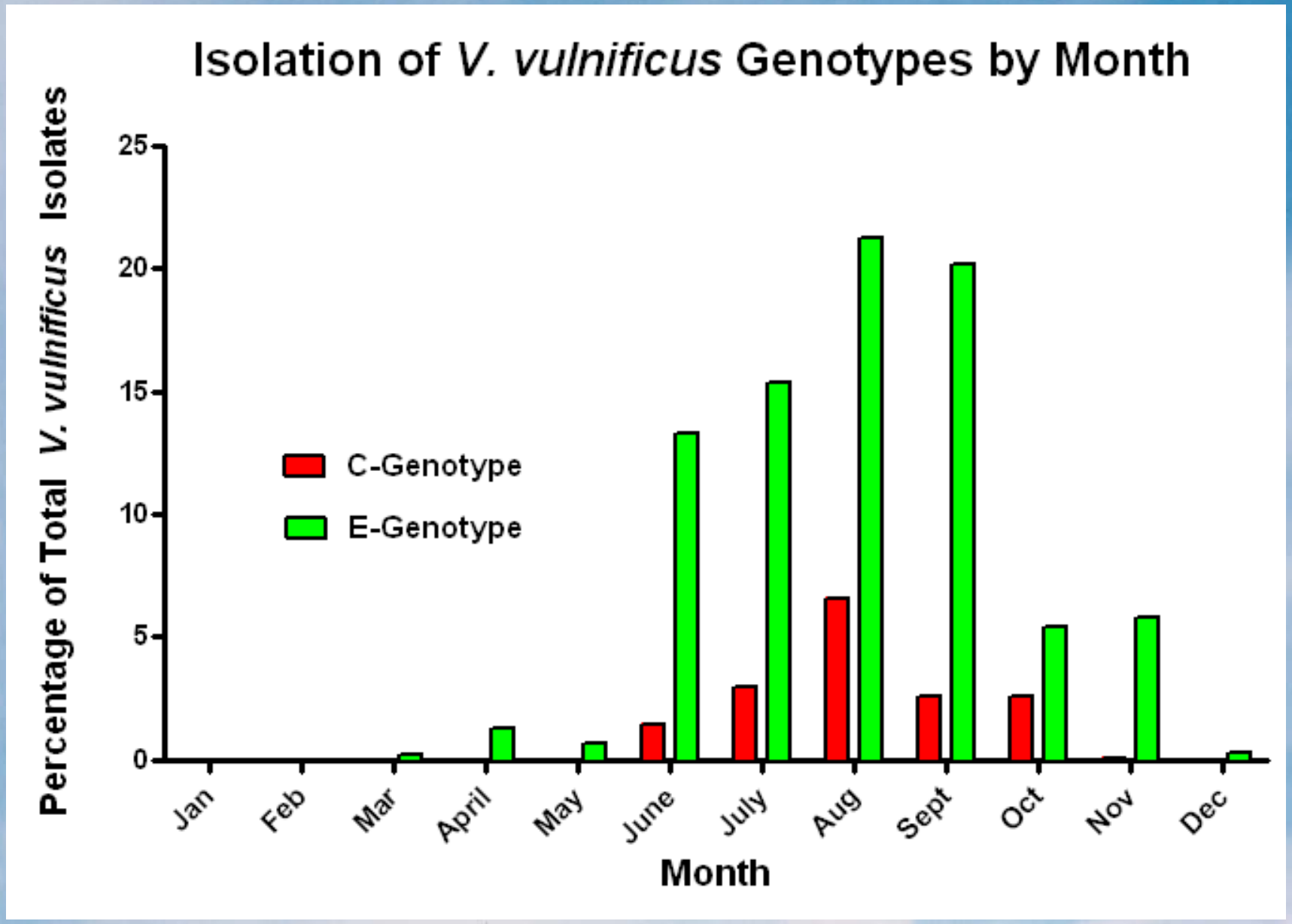
(9/2009-)

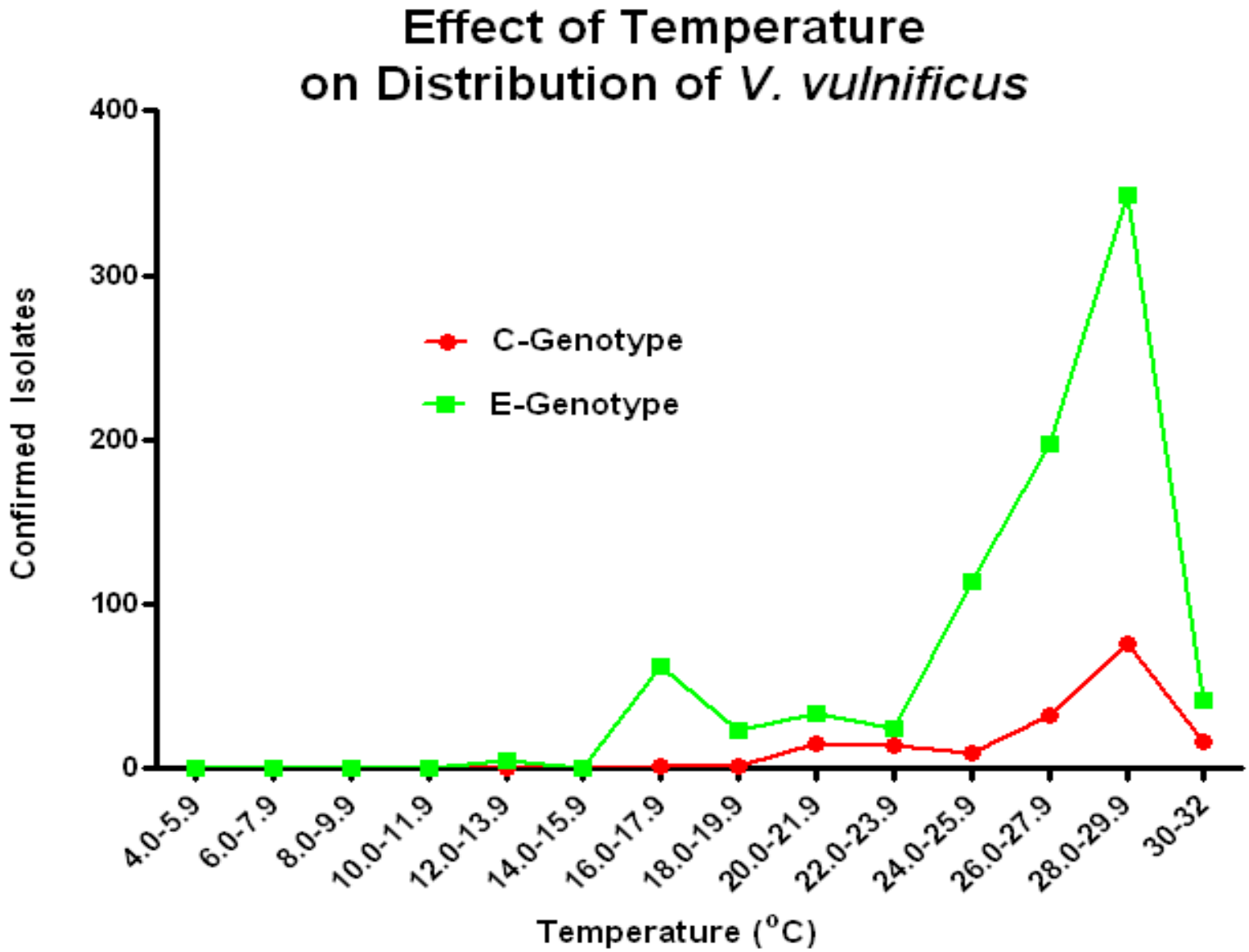
2398 presumptive *V. vulnificus* samples received

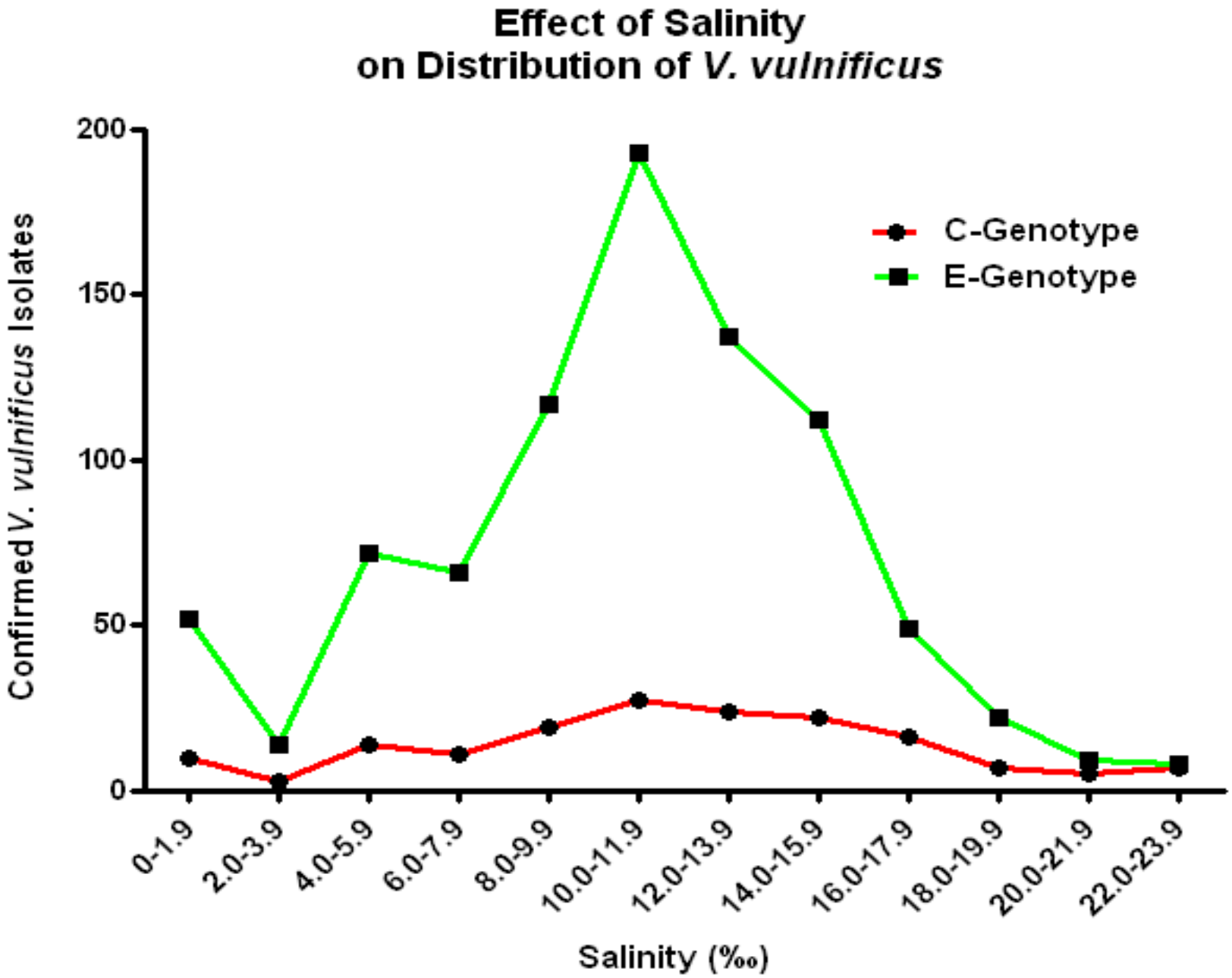
1016 (42%) = *Vibrio vulnificus*

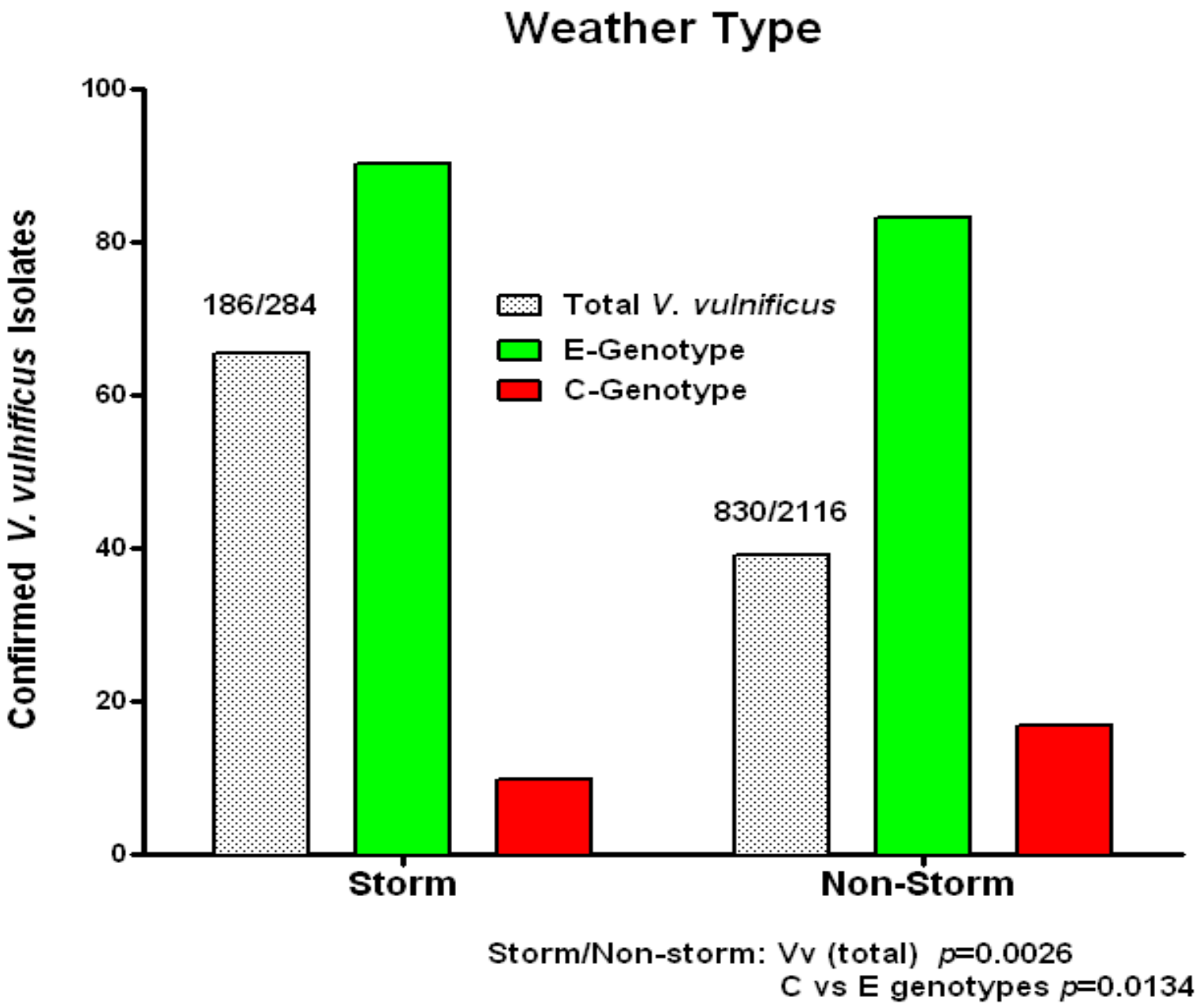
E-genotype strains: 839 (84.5%)

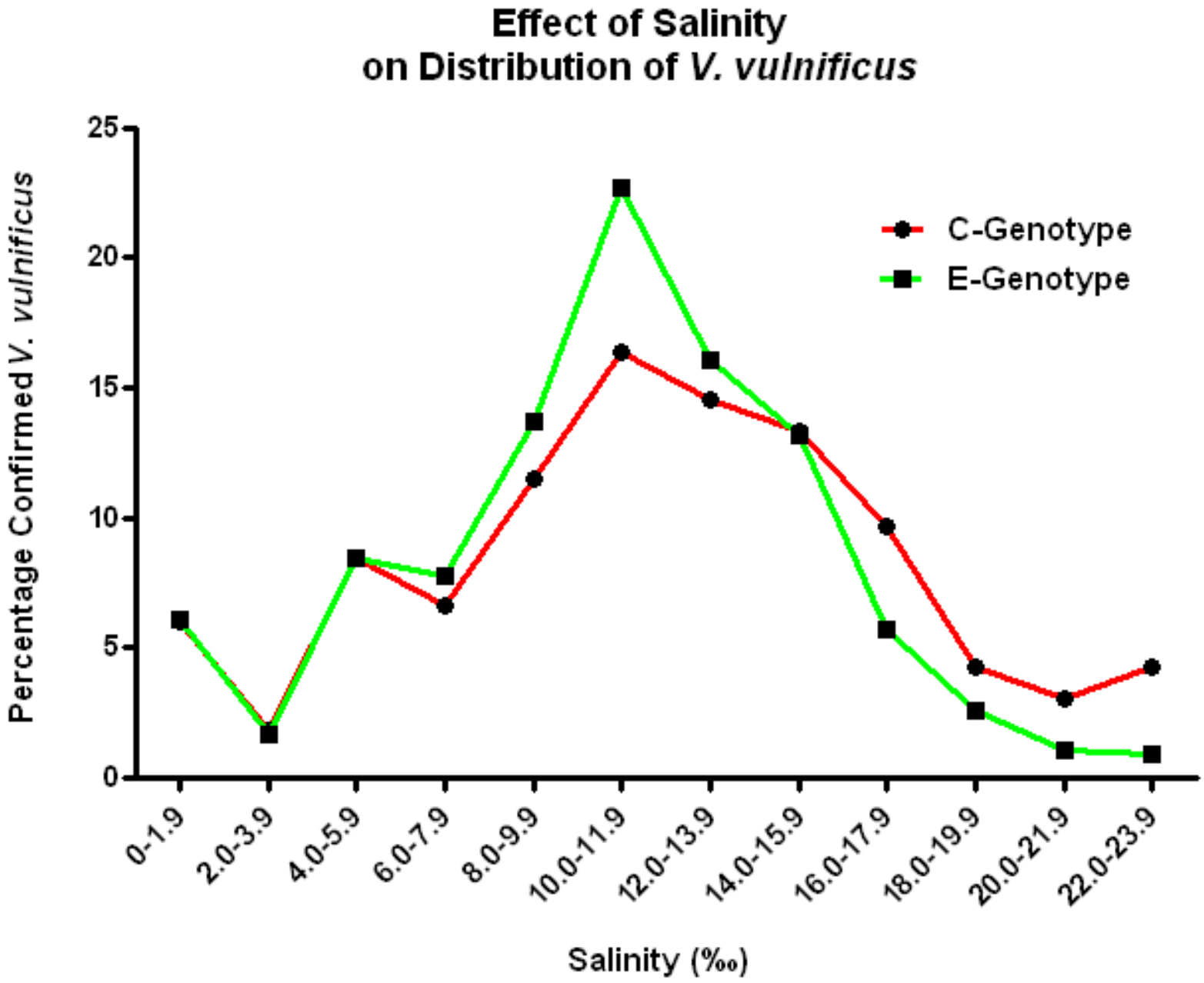

Isolates by Station
Confirmed V. vulnificus Isolates
250
200
150
100
50
0
C-Genotype
E-Genotype
0
30
70
120
180
Station #

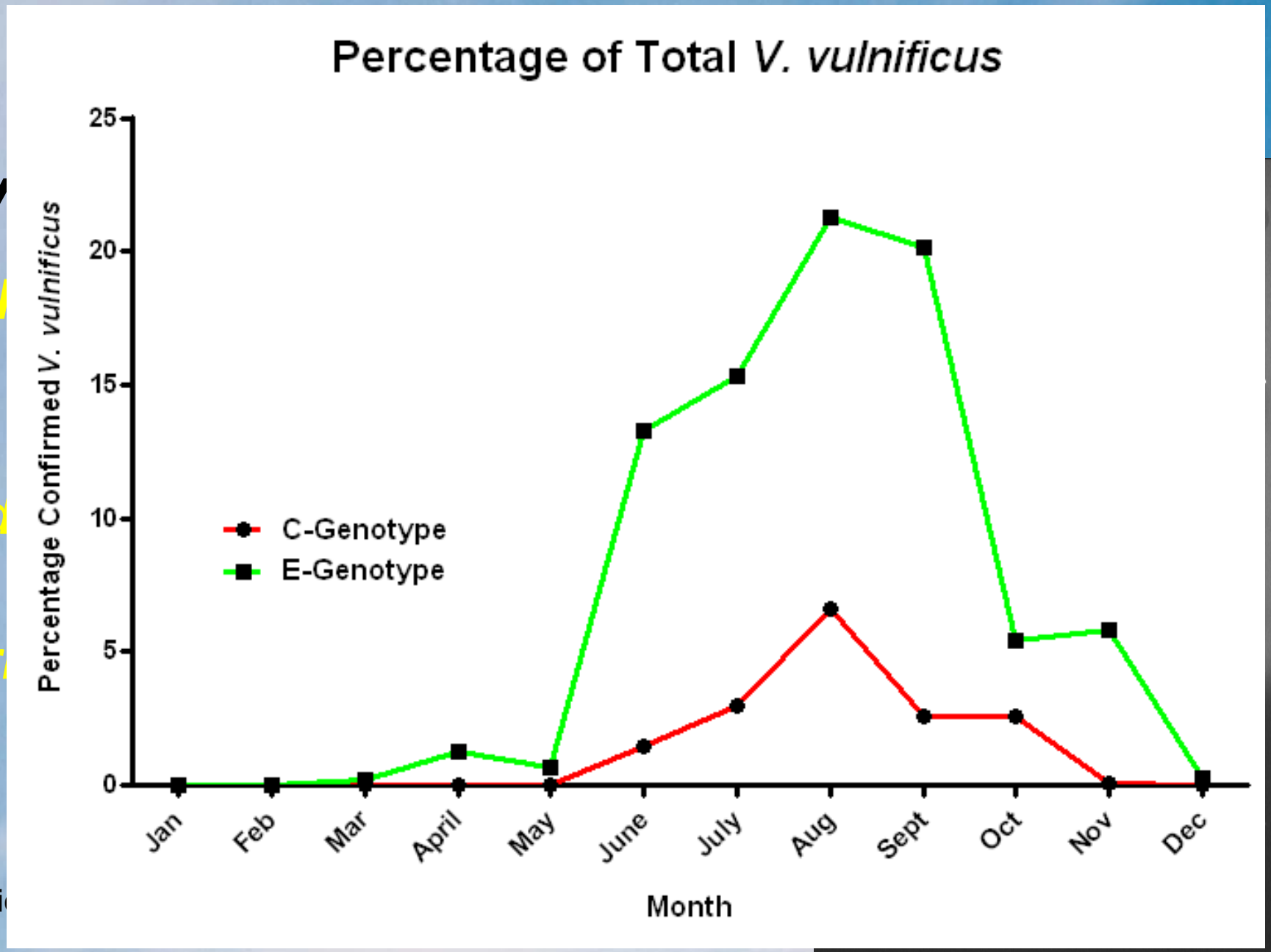

Isolation of V. vulnificus Genotypes by Month
Percentage of Total V. vulnificus Isolates
25
20
15
10
5
0
C-Genotype
E-Genotype
Jan
Feb
Mar
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month


Effect of Temperature
on Distribution of V. vulnificus
Confirmed Isolates
400
300
200
100
0
C-Genotype
E-Genotype
4.0-5.9
6.0-7.9
8.0-9.9
10.0-11.9
12.0-13.9
14.0-15.9
16.0-17.9
18.0-19.9
20.0-21.9
22.0-23.9
24.0-25.9
26.0-27.9
28.0-29.9
30-32
Temperature (°C)


Effect of Salinity
on Distribution of V. vulnificus
Confirmed V. vulnificus Isolates
200
150
100
50
0
C-Genotype
E-Genotype
0-1.9
2.0-3.9
4.0-5.9
6.0-7.9
8.0-9.9
10.0-11.9
12.0-13.9
14.0-15.9
16.0-17.9
18.0-19.9
20.0-21.9
22.0-23.9
Salinity (‰)


Weather Type
Confirmed V. vulnificus Isolates
100
80
60
40
20
0
186/284
830/2116
Total V. vulnificus
E-Genotype
C-Genotype
Storm
Non-Storm
Storm/Non-storm: Vv (total) p=0.0026
C vs E genotypes p=0.0134


Effect of Salinity
on Distribution of V. vulnificus
Percentage Confirmed V. vulnificus
25
20
15
10
5
0
C-Genotype
E-Genotype
0-1.9
2.0-3.9
4.0-5.9
6.0-7.9
8.0-9.9
10.0-11.9
12.0-13.9
14.0-15.9
16.0-17.9
18.0-19.9
20.0-21.9
22.0-23.9
Salinity (‰)


Percentage of Total V. vulnificus
Percentage Confirmed V. vulnificus
25
20
15
10
5
0
C-Genotype
E-Genotype
Jan
Feb
Mar
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month

Conclusions

- Total *Vibrio*, significant and predictable relationship to salinity and temperature
- Complex role of weather, resuspension, and estuarine dynamics on *Vibrio* spp.
- *Vibrio vulnificus* appears to have more complex relationship with multiple parameters
- Clinical ecotypes of *Vibrio vulnificus* appear to be much more prevalent in fall months, linkage to public health?
- Storm sampling redux: ISCO, AVP, LISST particle analyzer provides incredible real time data, ongoing

Acknowledgements

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Water Resources Research Institute of The University of North Carolina