Remote Sensing of Environmental Vibrio in the Chesapeake Bay

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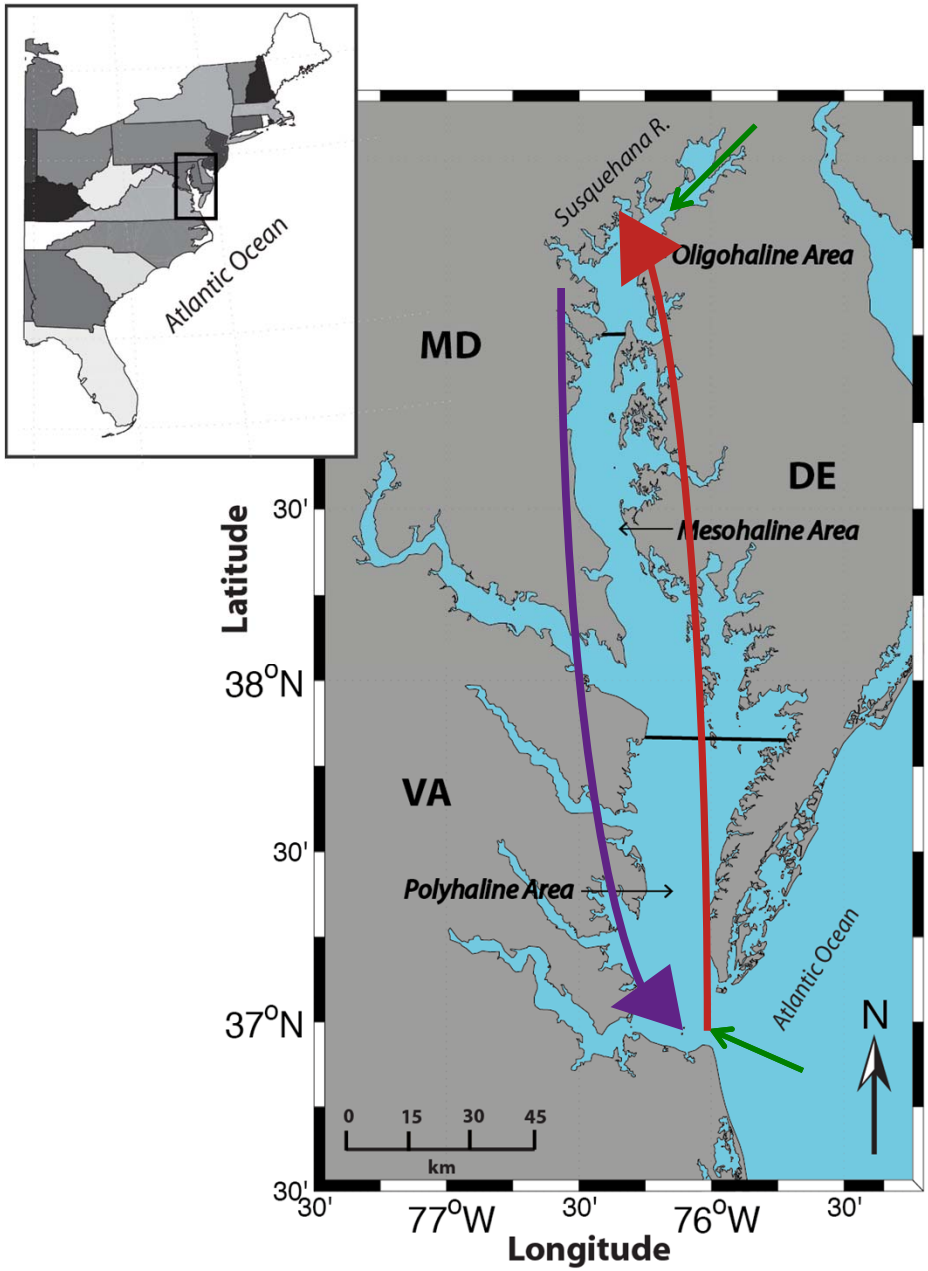
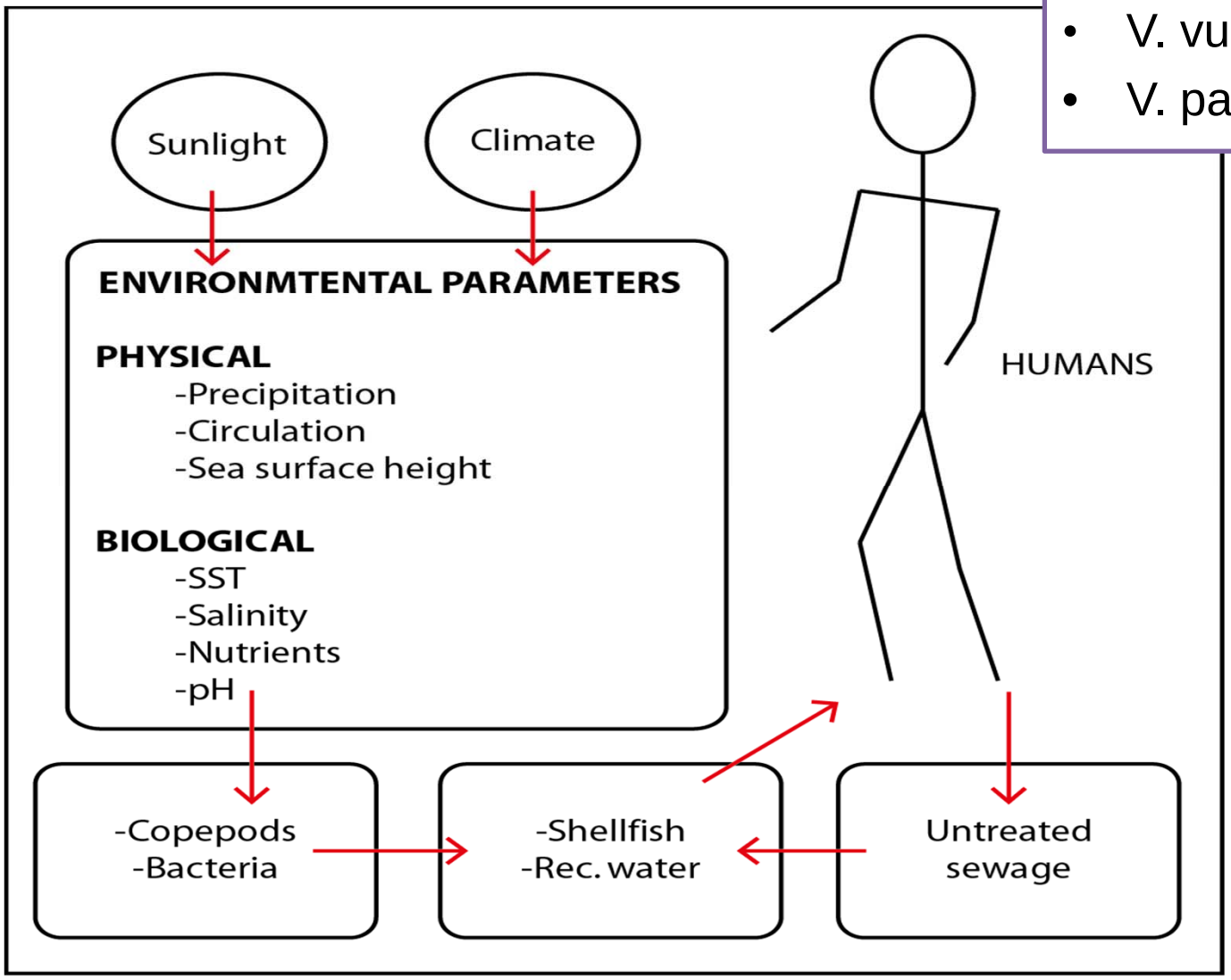
Study Area
(The Chesapeake Bay)

- **Salinity gradient**
  - Oligohalic (0-6 ppt)
  - Mesohalic (6-18 ppt)
  - Polyhalic (18-30+ ppt)
- **Sea surface temperature**
  - -0.5°C to 31°C
- **Major inputs**
  - Atlantic Ocean
  - Susquehana River
- **2-Layer gravitational circulation scheme**

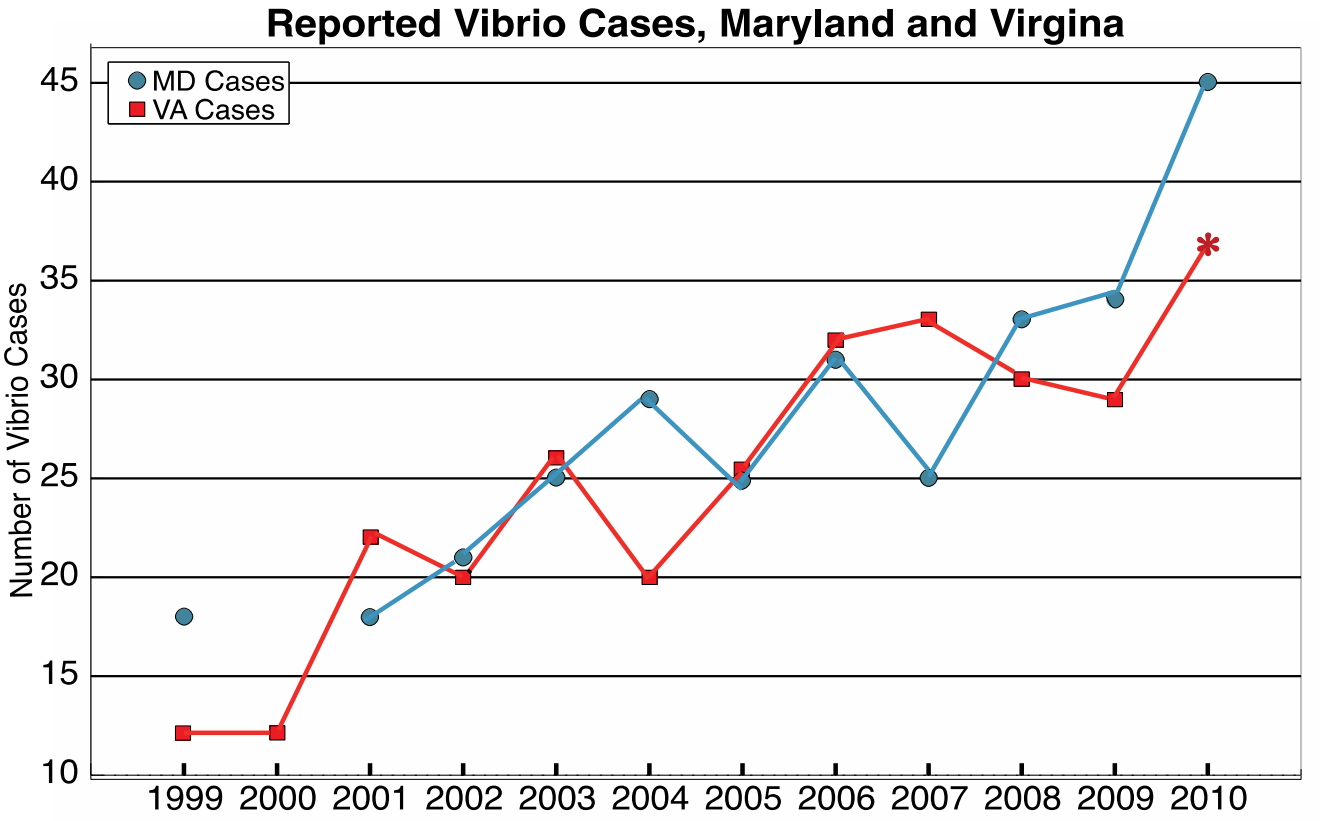


Vibrio in the Chesapeake Bay

- V. cholerae
- V. vulnificus
- V. parahaemolyticus



Vibrio in the Chesapeake Bay



Maryland Dept. of Health and Mental Hygiene
Virgina Department of Health.

* Estimated 2010 VA Cases

Pre-existing Empirical Vibrio Models

$$z(\text{V.v}) = -7.867 + (0.316 * \text{Temp}) + (-0.342 * (|\text{Saln} - 11.5|)$$

(Jacobs et al., 2010)

$$z(\text{V.c}) = -1.1939 + (0.1233 * \text{Temp}) - (0.1997 * \text{Saln}) - (0.0324 * (\text{Temp} * \text{Saln})$$

(Louis et al., 2003)

$$f(z) = e^z/(1 + e^z)$$

- **In situ** and **modeled** temperature and salinity inputs
- Probability of occurrence Vibrio spp. models
- Historical cruise (V.c) and CBay Program (V.v) bacteria collection

Remote Sensing of Vibrio in the Chesapeake Bay

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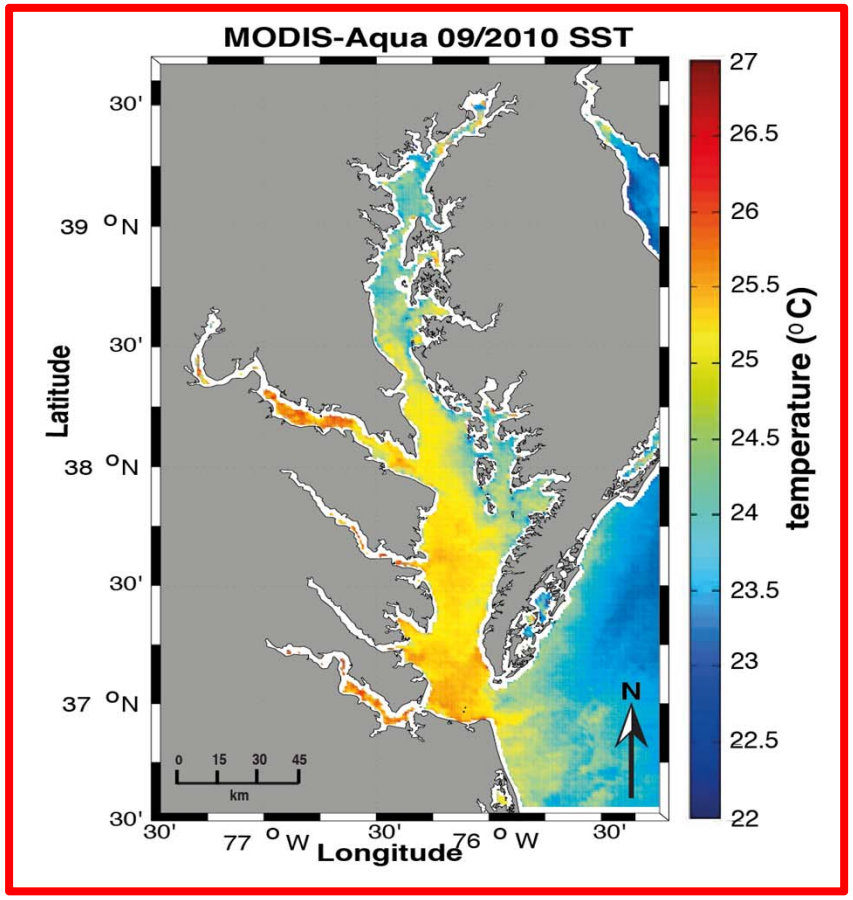
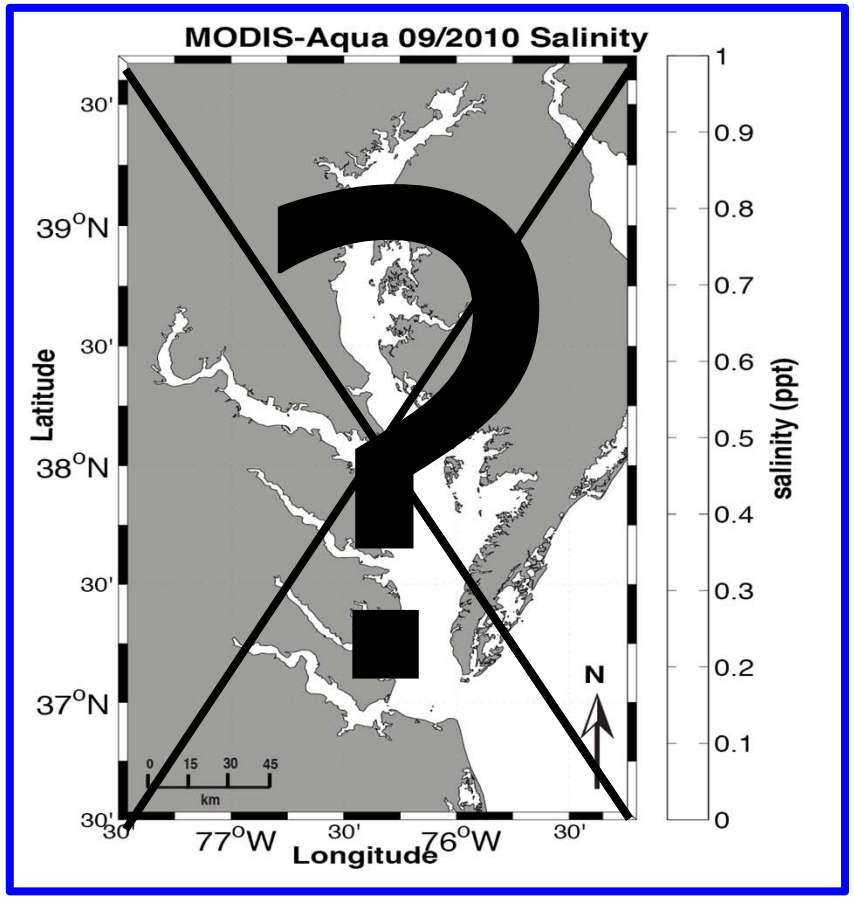
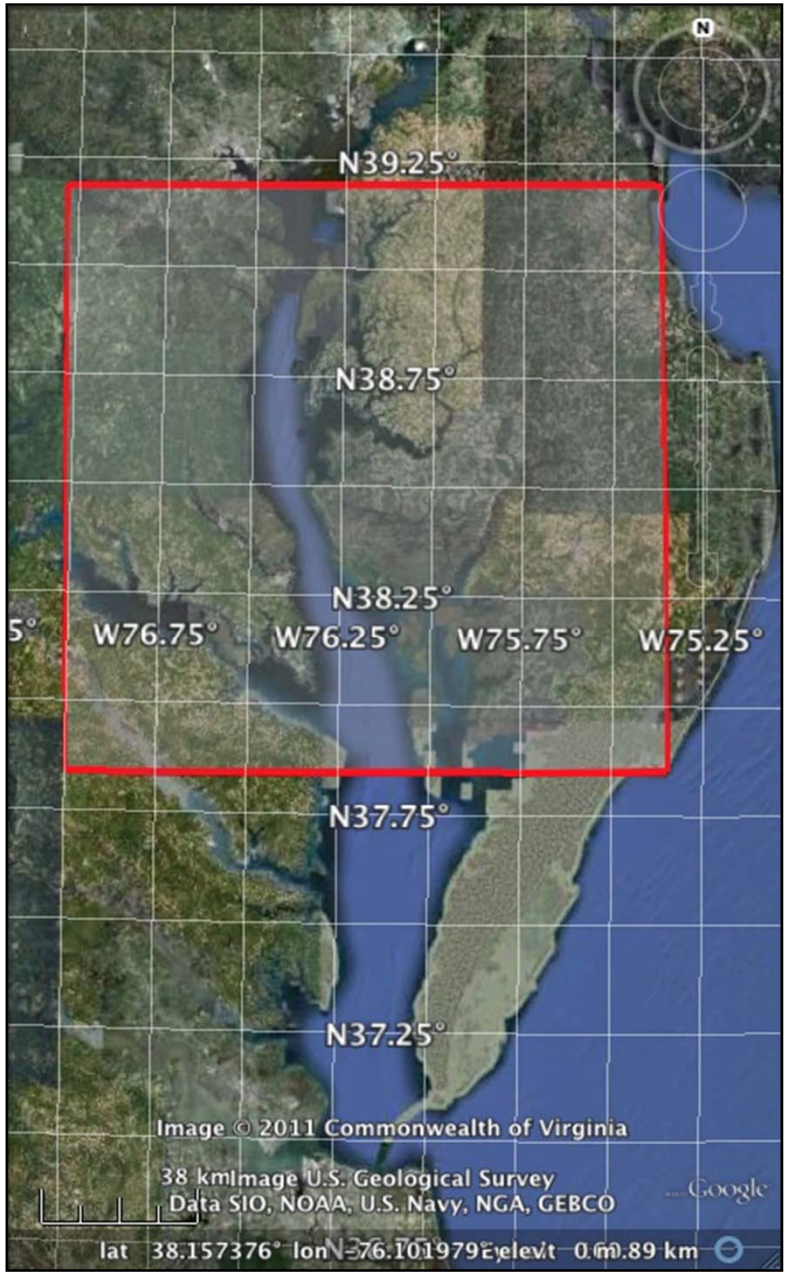




Remote Sensing of Sea Surface Salinity

- **NASA Aquarius Salinity Product**
  - 150 km spatial resolution
  - Monthly composites

- **Neural Network Salinity Product**
  - Geiger et al. (2011): UDEL
  - Statistically Derived from MODIS-Aqua Ocean Color
    - Additional RS input products
    - Trained on Mid-Atlantic region
    - Historical cruise data



Satellite Based Salinity Algorithms

- MODIS-Aqua Ocean Color Standard Products

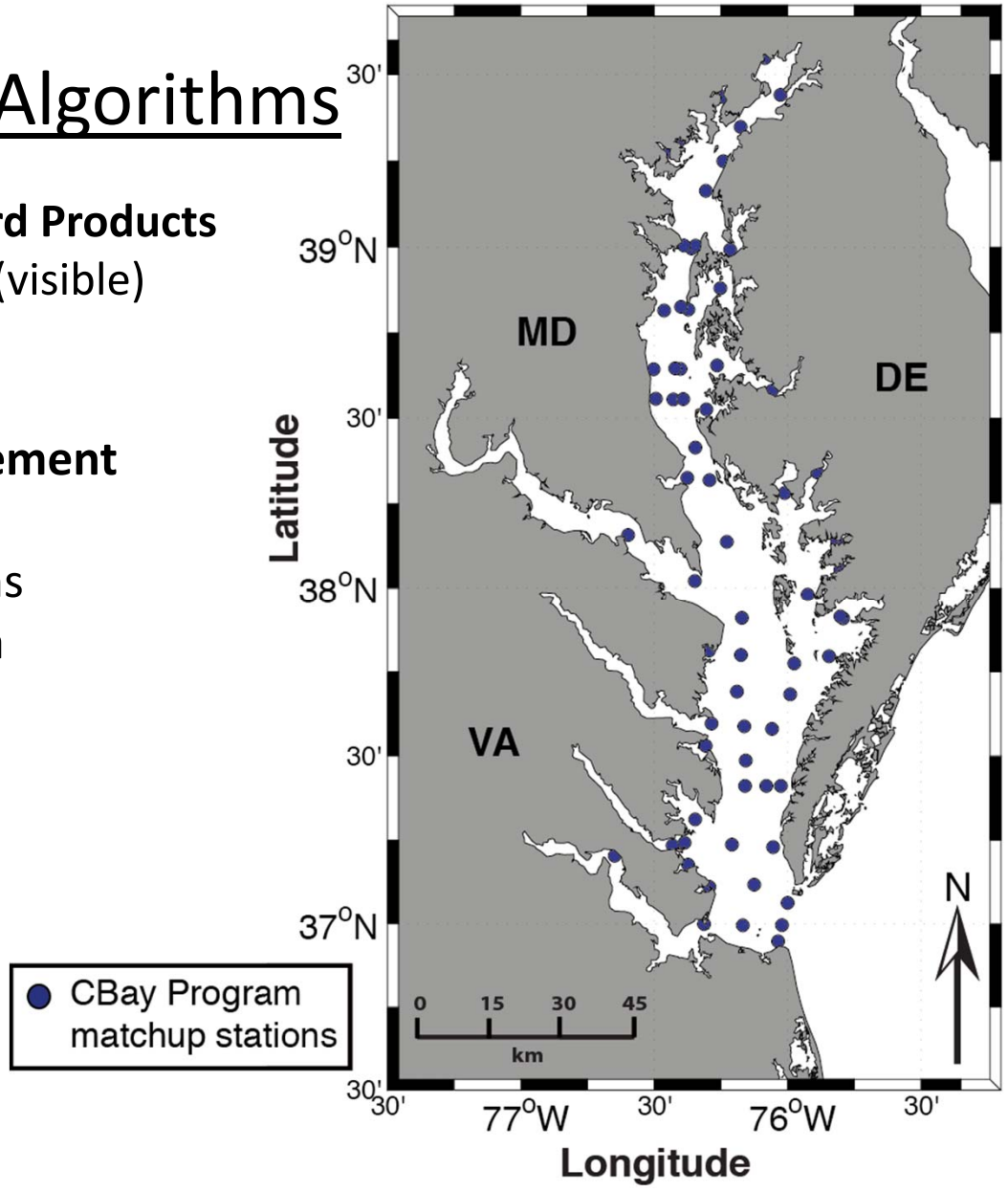
- 10 Remote sensing reflectances (visible)
- 2003-2010

- In situ – remote sensed measurement matchups

- 68 CBay Program in situ stations
- Single pass RS ocean color data
- 1km radius RS averaging
- 2003-2010

- Salinity Prediction Models

- GLM
- GAM
- CART
- BCART
- BART
- RF
- ANN
- MARS



Satellite Based Salinity Algorithms

- Generalized Linear Model (GLM)
- Generalized Additive Model (GAM)
- Artificial Neural Network (ANN)
- Multivariate Adaptive Regression Spline (MARS)

Tree-Based Data Mining

- Categorical and Regression Tree (CART)
- Bagged Categorical and Regression Tree (BCART)
- Bayesian Additive Regression Tree (BART)
- Random Forest (RF)

Satellite Based Salinity Algorithms

	GAM	ANN	GLM	CART	BCART	RF	MEAN	BART	MARS
MAE	**1.82**	**1.85**	1.93	2.39	2.38	2.06	3.72	2.04	1.98
RMSE	**2.38**	**2.50**	2.53	3.03	3.01	2.67	4.69	2.60	2.52
MSE	5.67	6.28	6.40	9.17	9.08	7.14	22.07	6.77	6.33

- Top performing prediction models: **GAM** and **ANN**
- GAM and ANN are not statistically different
- All models outperform the mean salinity prediction

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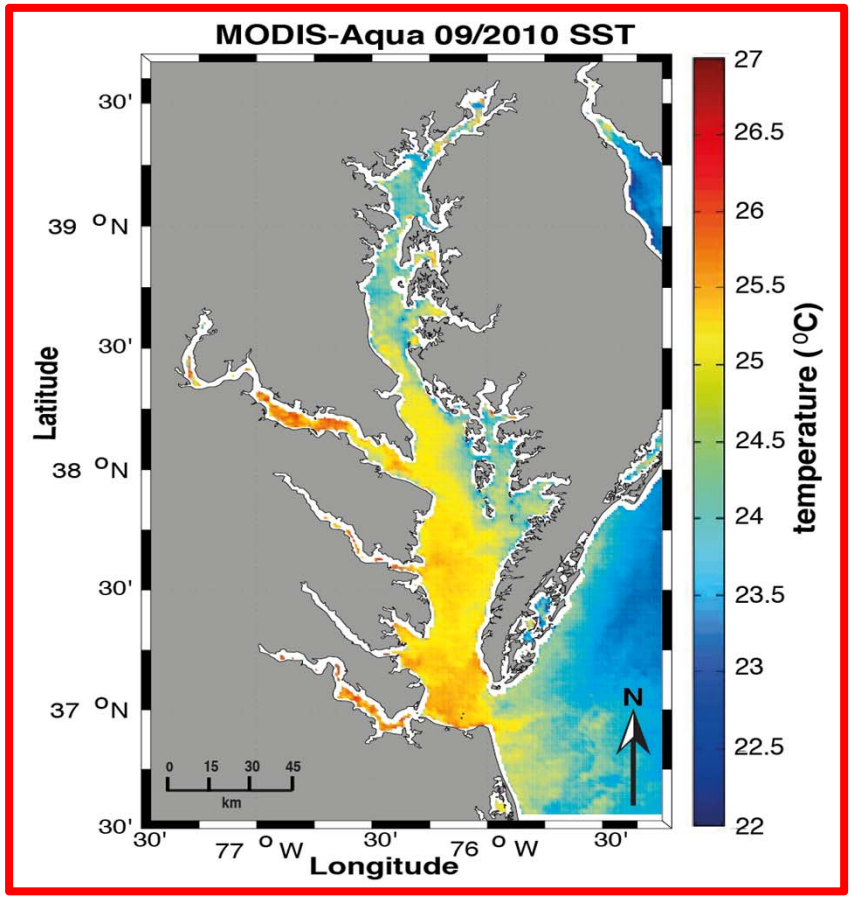
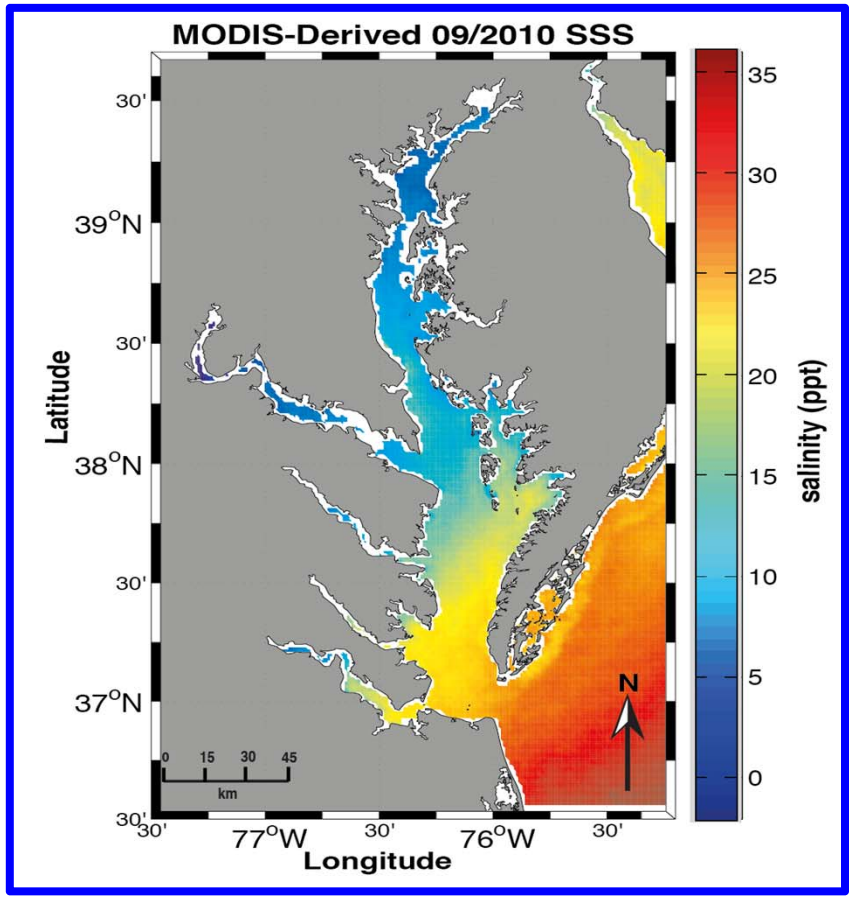
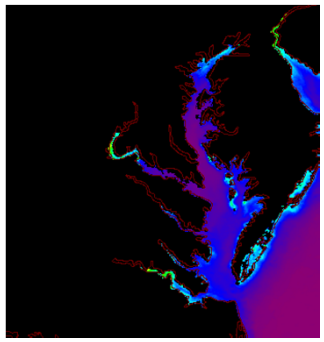
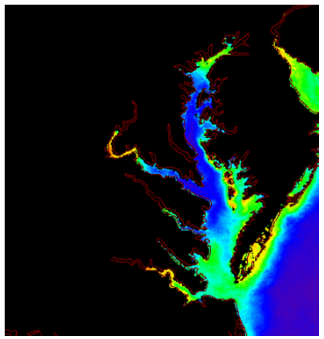
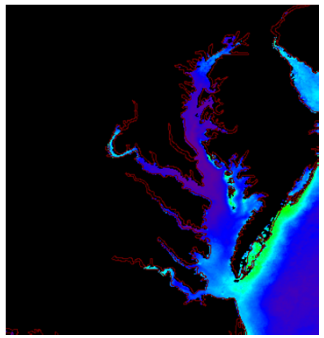




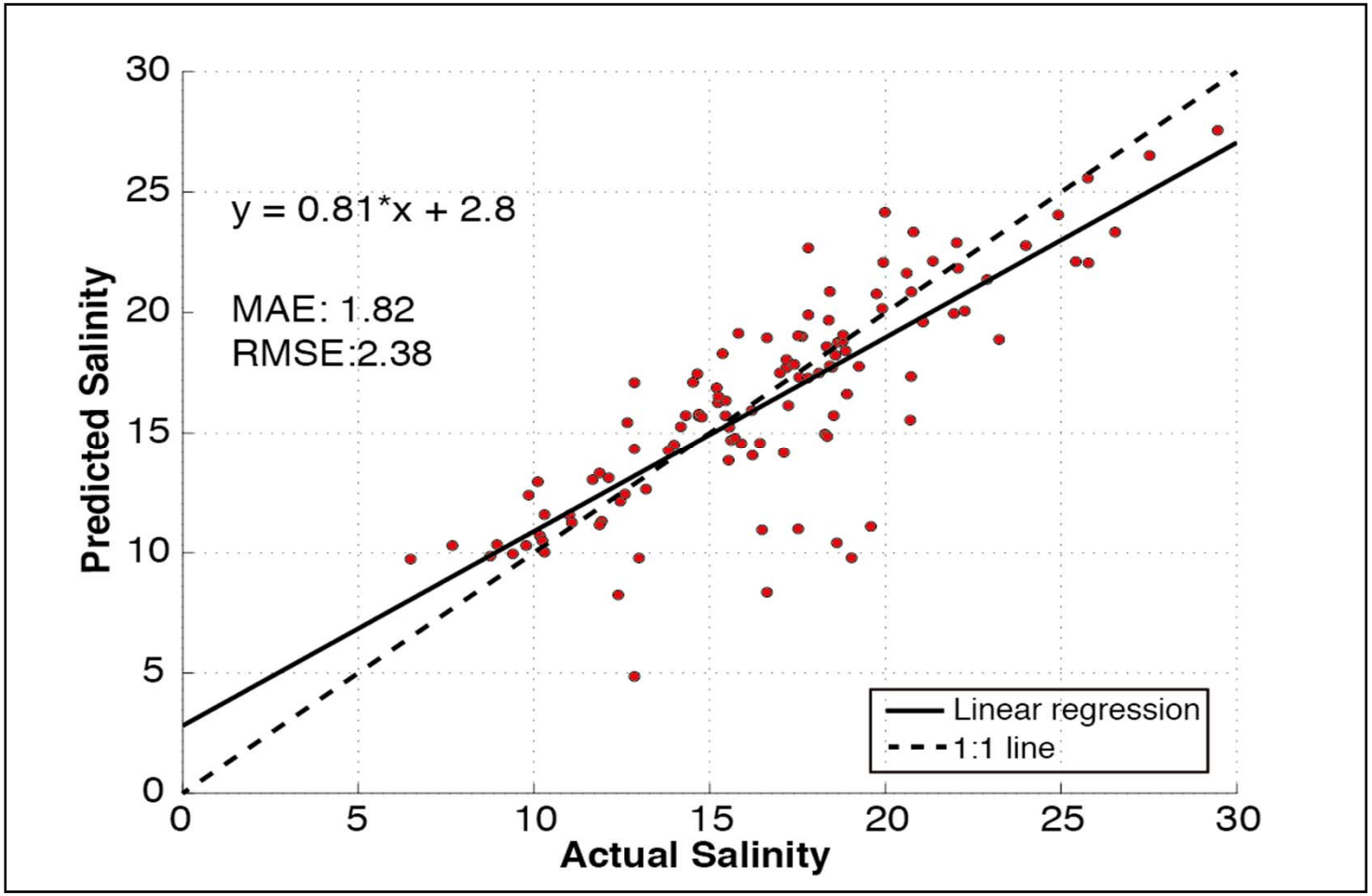
General Additive Model (GAM) for Predicting Salinity



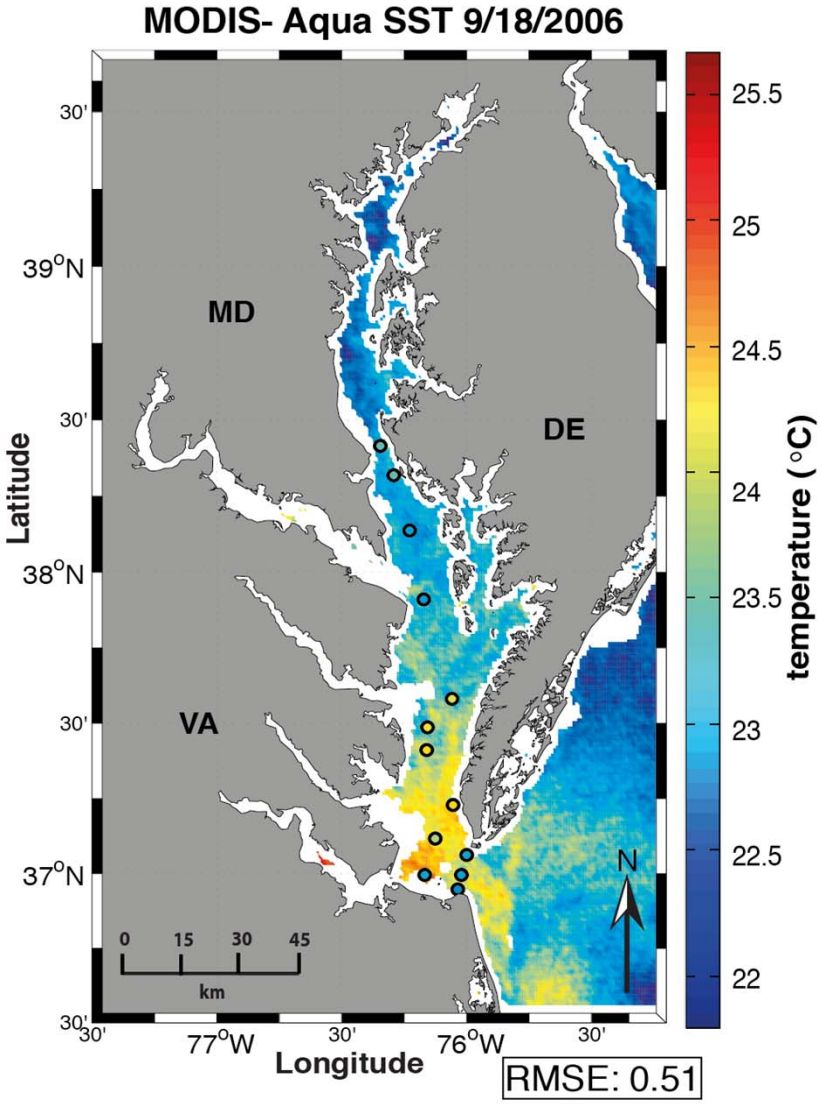


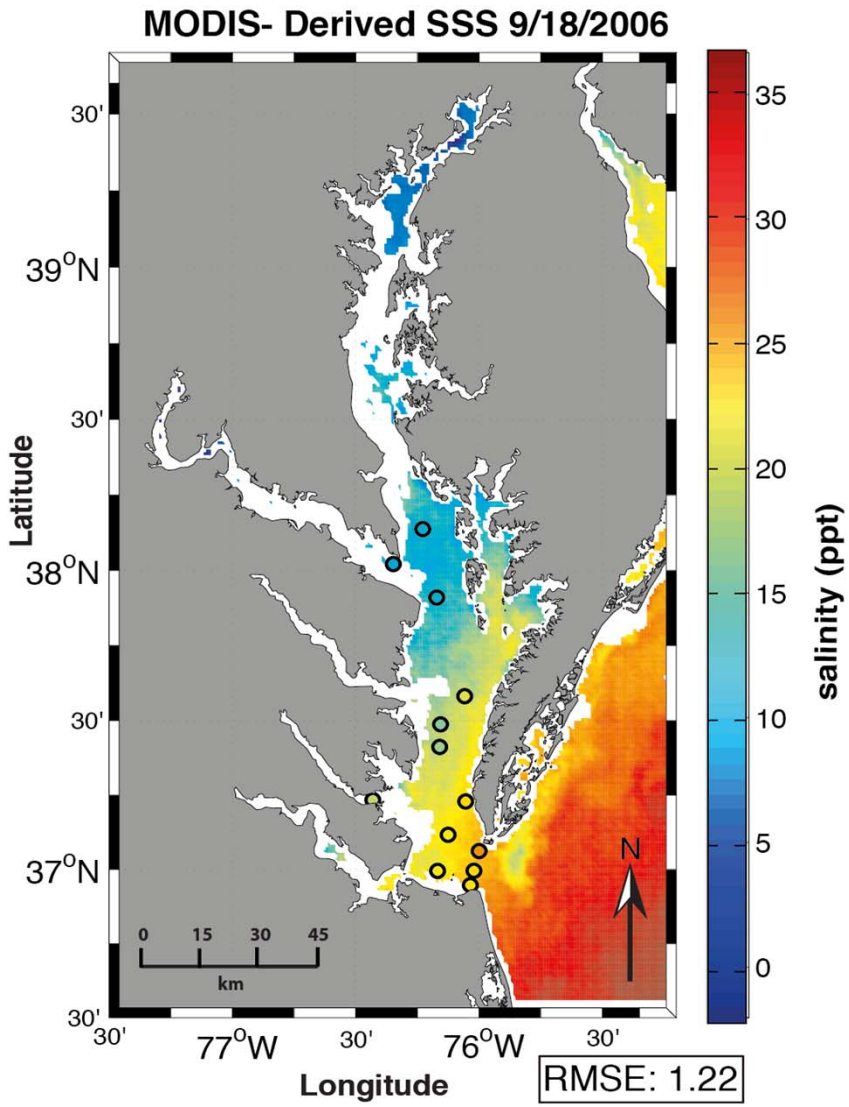


GAM.MODEL<-gam(Salinity~s(Rrs_678)+s(Rrs_547)+s(Rrs_488.....)



Daily Remote Sensing of SST and Saln





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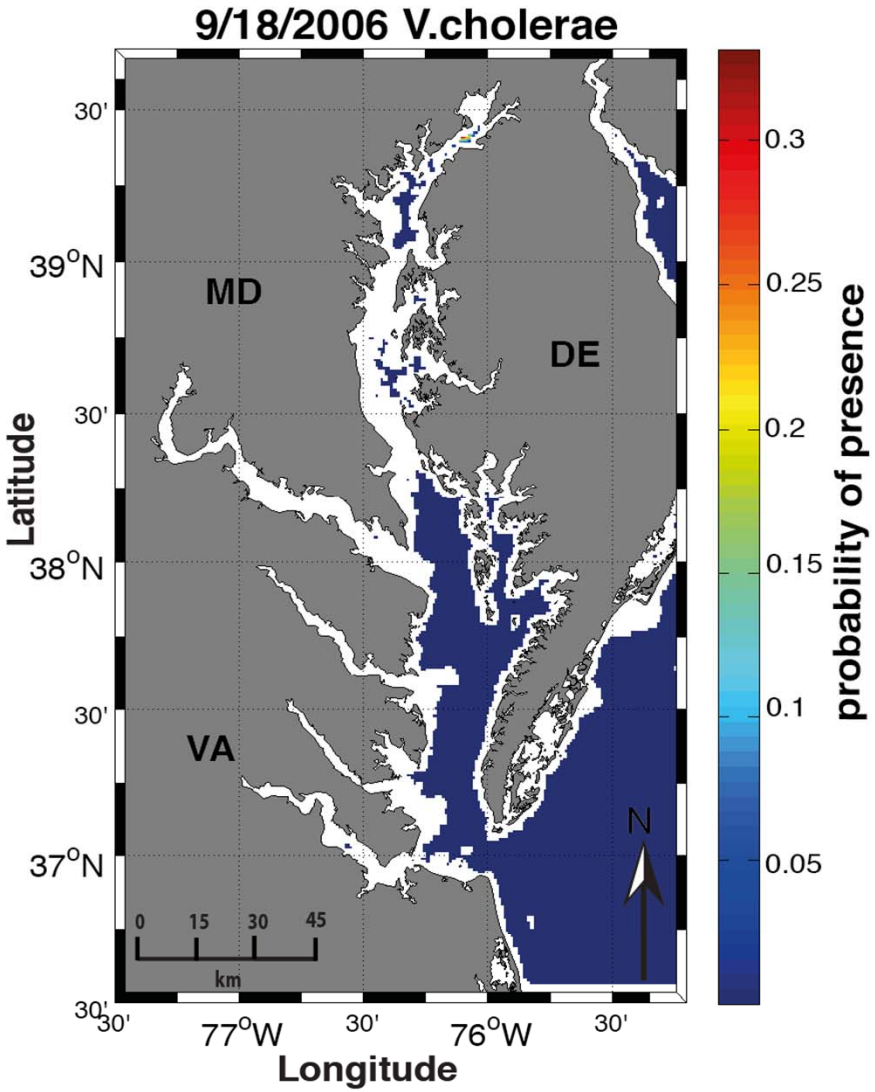
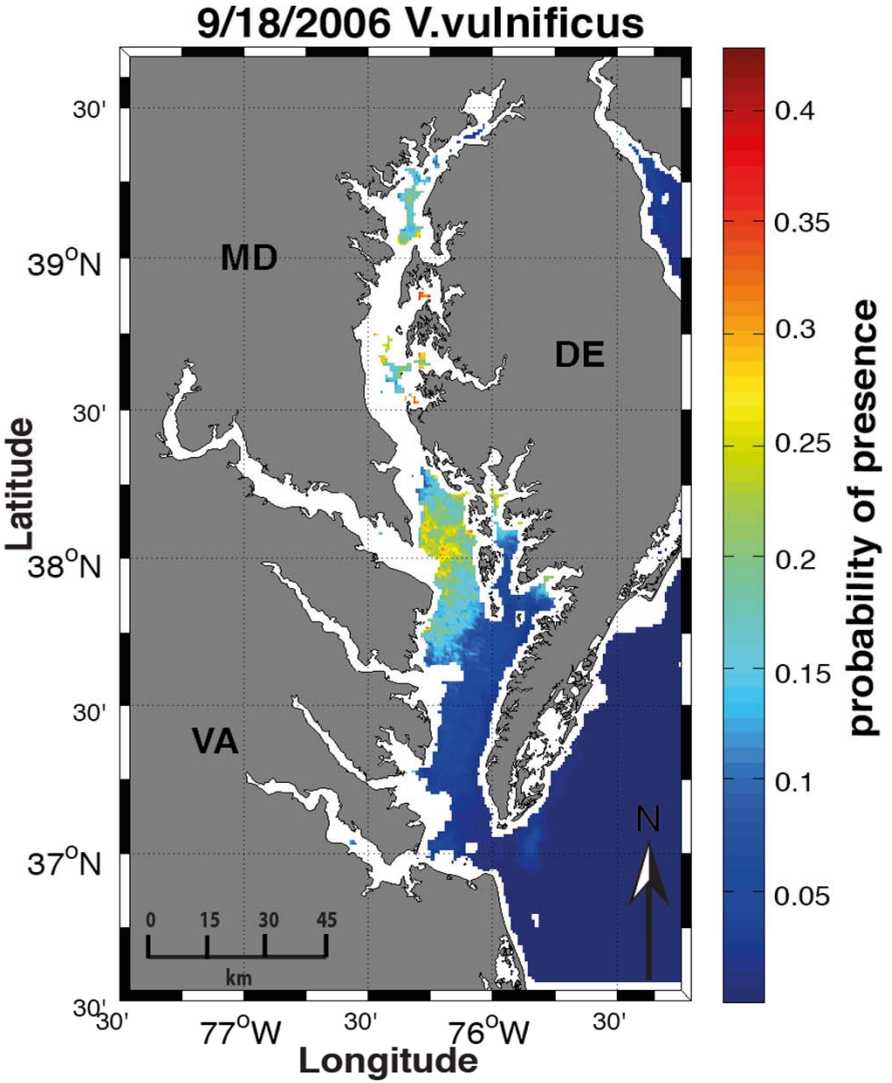
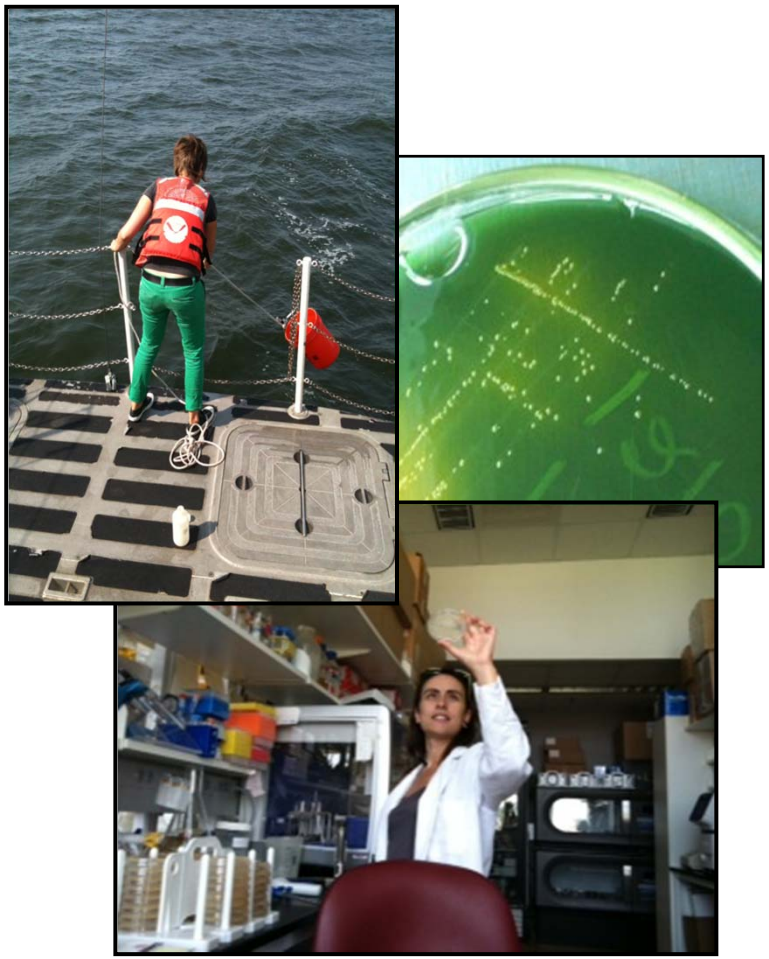
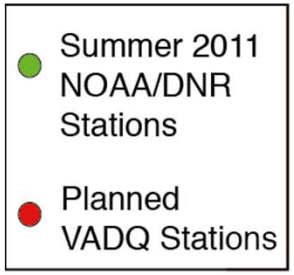
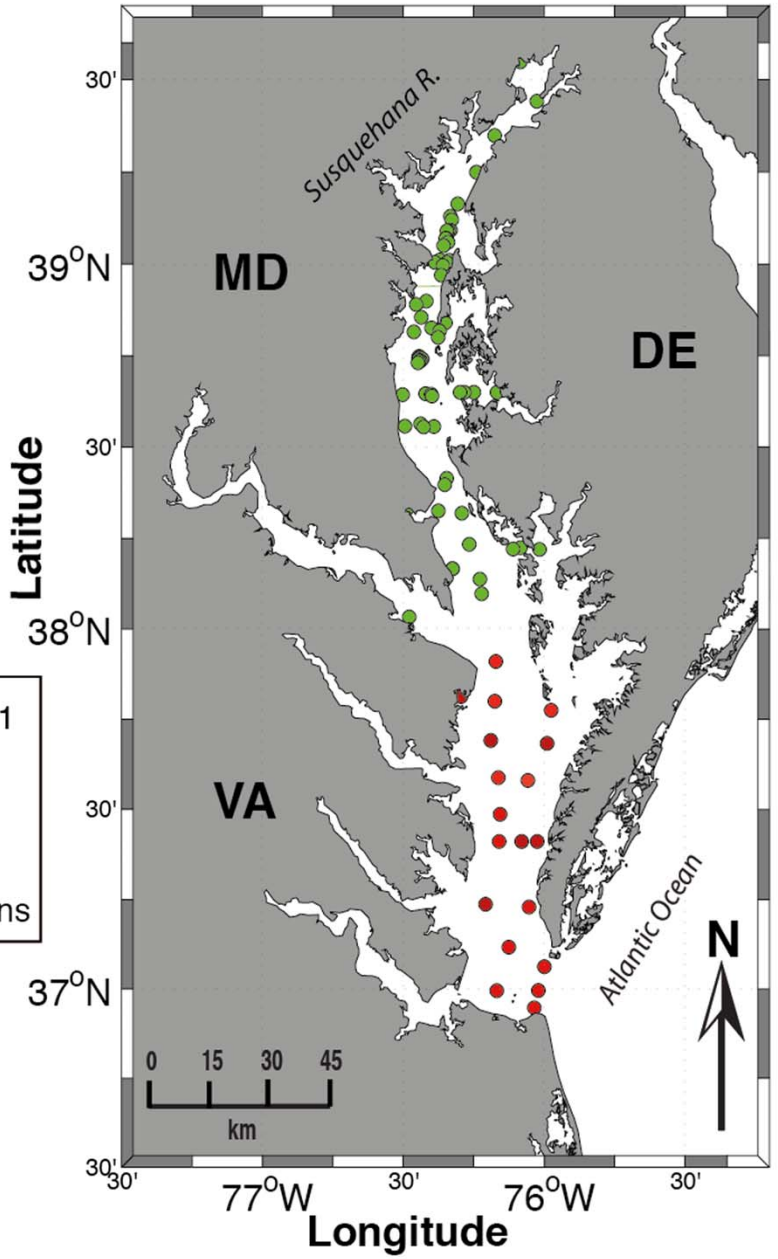




In situ Vibrio Sampling







Future Research Directions

- Salinity algorithm applications
- Applications within the Chesapeake Bay
- Applications beyond the Bay

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