

REMOTE SENSING TO ASSESS MICROBIAL WATER QUALITY AT BEACHES AND SHELLFISH BEDS

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- Scot Loehrer (GIS and webpage development)
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- Marcia Pendleton, Ph.D. student (Jan. 2010)
The University of Southern Mississippi

Hypothesis

Environmental data derived from satellite remote sensing can be used to monitor (“nowcast”) and someday predict (forecast) the presence of indigenous pathogenic bacteria in the ocean.

Research Plan

- NASA Applied Sciences is funding this RS applications project
- NSF Ecology of Infectious Diseases Program is funding research that is “ground truthing” the RS predictions
- NOAA Oceans and Human Health Initiative through NCAR/EOL is funding the webpage development

Vibrios live in the ocean!

(and they can ruin your day – whether you're
a human, marine mammal, fish or coral)

What are the Health Risks from Marine Vibrios?

The “big three”

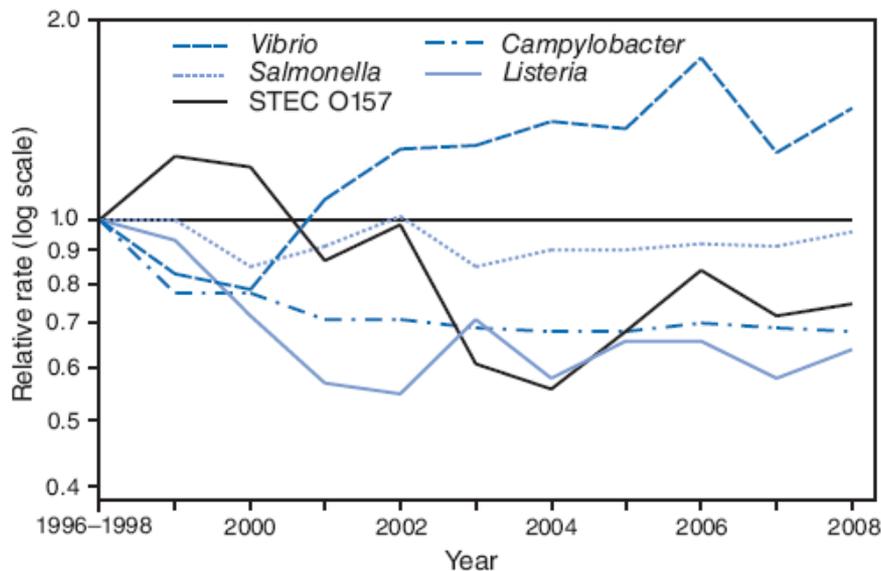
- *Vibrio cholerae*
 - Cholera
 - Wound infections
 - Gastroenteritis
- *Vibrio vulnificus*
 - Primary septicemia^a
 - Wound infections^b
 - Gastroenteritis??
- *Vibrio parahaemolyticus*
 - Gastroenteritis
 - Wound infections



(Over 50 *Vibrio* species have been described, 11 of which are human pathogens.)

Temperature Determines Abundance and Distribution of *Vibrio parahaemolyticus*

FIGURE 2. Relative rates of laboratory-confirmed infections with *Vibrio*, *Salmonella*, STEC* O157, *Campylobacter*, and *Listeria* compared with 1996–1998 rates, by year — Foodborne Diseases Active Surveillance Network, United States, 1996–2008†



* Shiga toxin-producing *Escherichia coli*.

† The position of each line indicates the relative change in the incidence of that pathogen compared with 1996–1998. The actual incidences of these infections can differ. Data for 2008 are preliminary.

(from MMWR, April 10, 2009, CDC
http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5813a2.htm?s_cid=mm5813a2_x#tab2)

In general, vibrio diseases in the U.S. have been increasing since the El Niño years of 1997–98

- The overall increase is approx. 50%
- Most of this vibrio disease is seafood-borne *Vp* gastroenteritis
- In 2007, the largest number of clinical isolates (233) was *Vp*
- In 2007, the next highest numbers of clinical isolates were *V. vulnificus* (107), *V. alginolyticus* (101) and non-toxicogenic *V. cholerae* (49) out of a total 573 *Vibrio* species isolated
- The incidence of cholera in the U.S. in 2007 was 7 cases (not counted by CDC in the 573 vibrio cases)

(from CDC

<http://www.aphl.org/aphlprograms/food/Documents/CSTEVibrio2007.pdf>)

RS Platforms

Two popular NASA satellite RS platforms used by oceanographers are SeaStar and Terra



SeaStar – the SeaWiFS platform

SeaStar carries SeaWiFS

- Launched August 1997
- 1-km² pixels, used for color
- Full global coverage every 2 days



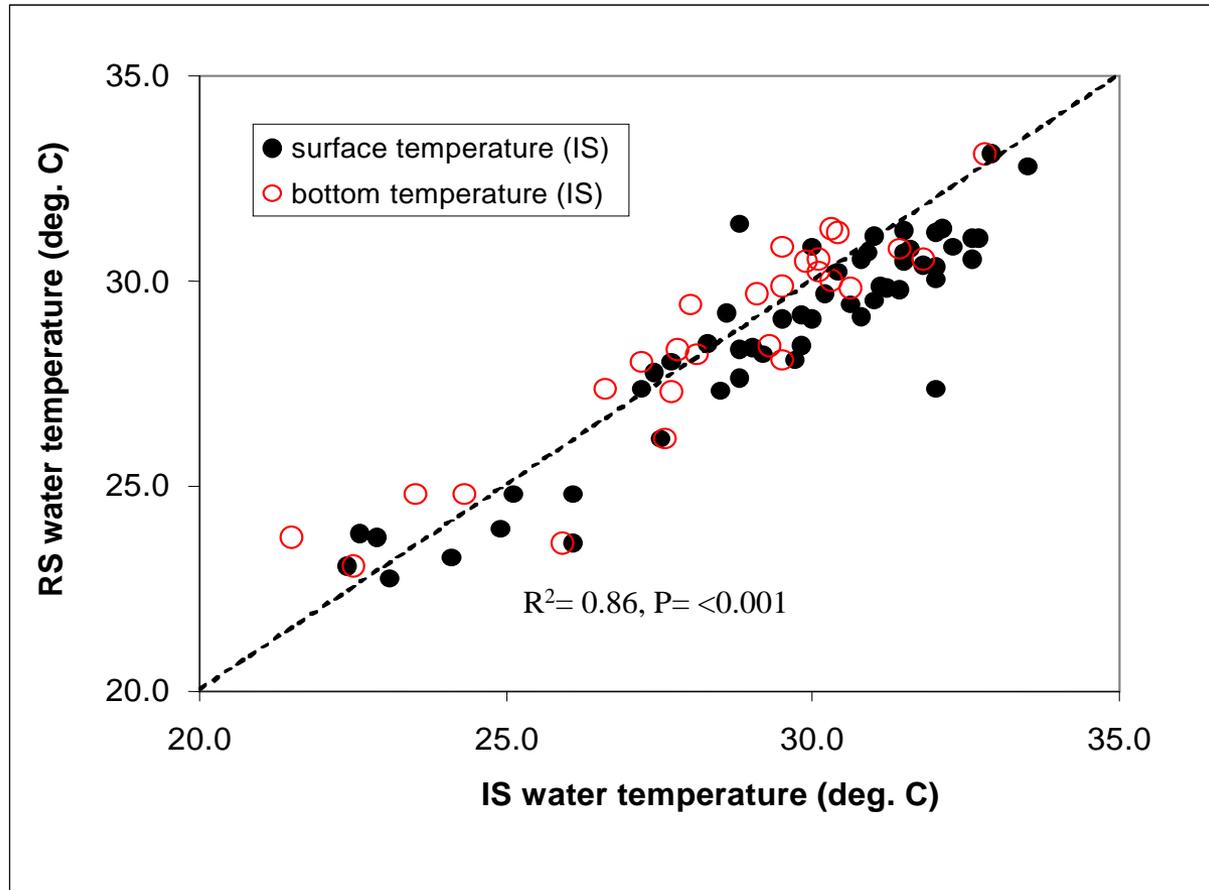
Terra – the MODIS platform

Terra carries MODIS

- Launched December 1999
- 1-km² pixels, SST & turbidity
- Sees entire world every 1-2 days

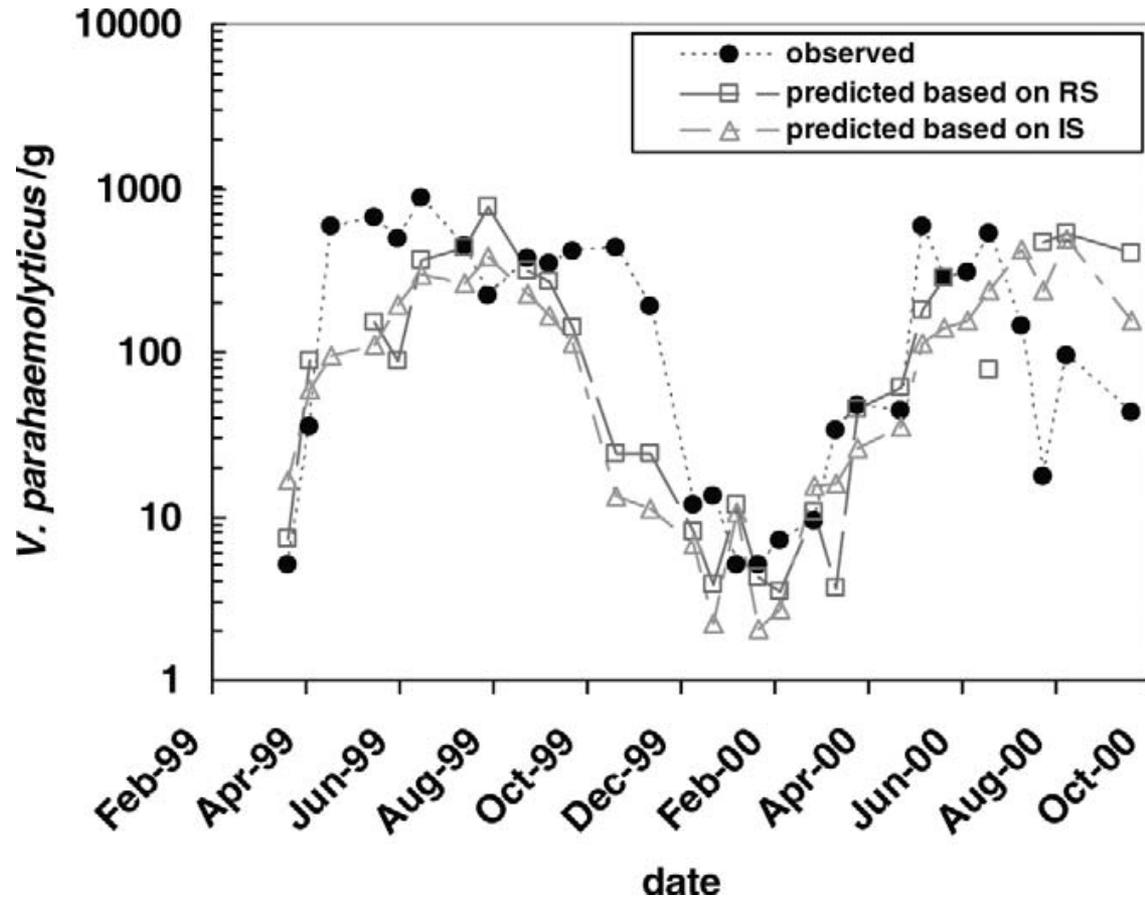
OHHI Results: RS versus *in situ* SST

correlated



OHHI Results: Predicted V_p vs. observed V_p (tlh^+) correlated

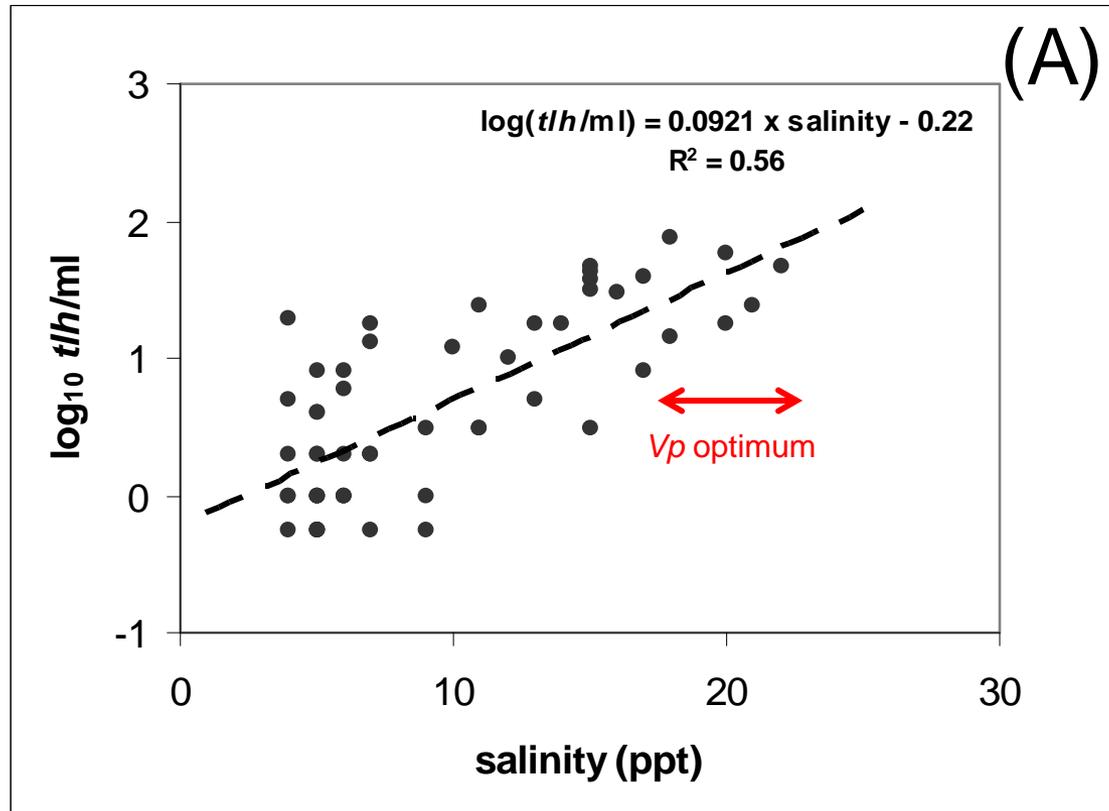
V. parahaemolyticus (observed) was detected by a gene probe that produces purple colonies when it binds with *tlh* (A. Flowers, Ph.D. research)



$$\text{Mean log}_{10} V. \text{parahaemolyticus/g} = -0.84 + 0.11 \times \text{SST}$$

$r = 0.692$ for IS and $r = 0.673$ for RS

OHHI Results: Relationship between total *V. parahaemolyticus* (*tlh*⁺) and salinity



Relationships: total *V. parahaemolyticus* (*tlh*⁺) and temperature and salinity

- At present, approximately 50% of *Vp* abundance and distribution can be explained by SST

- This relationship is explained by a FDA model:

mean *V. parahaemolyticus*/gram = 0.871 x exp[0.2648 x SST]

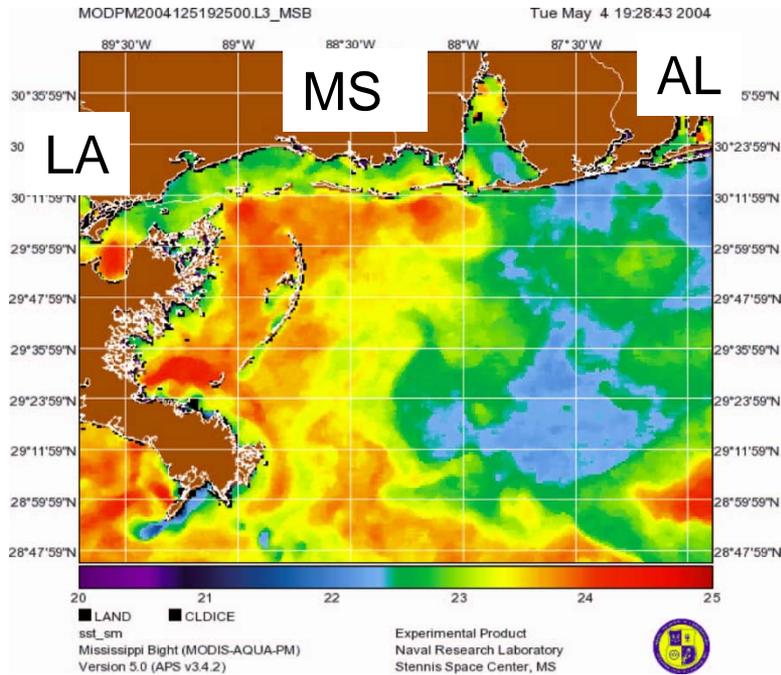
average log(*Vp*/g) = -0.63 + 0.1 * T_{WATER}

- Rigor of the model is improved if salinity is added:

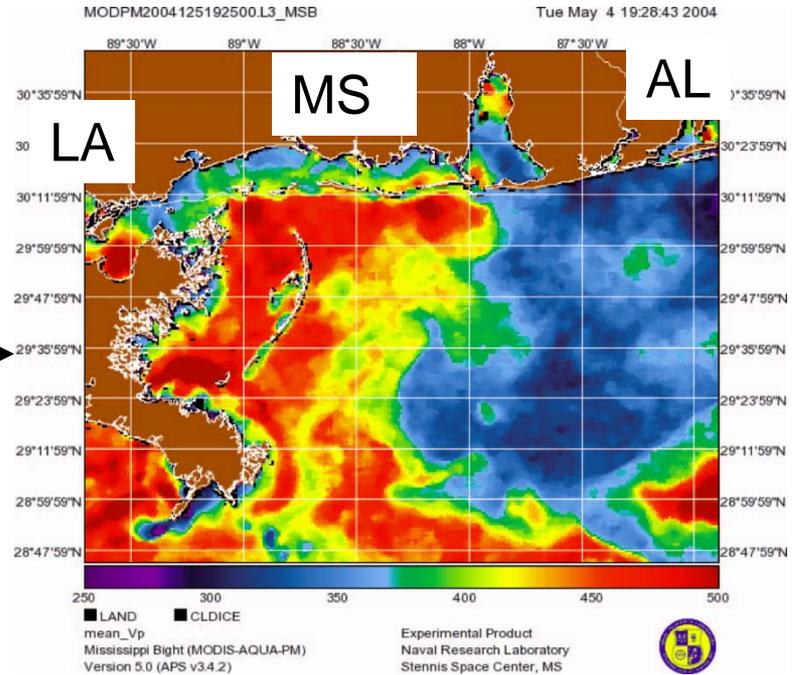
mean log *Vp*/g = -1.904 + 0.084 x (RS SST) + 0.242 x salinity - 0.006 x (salinity²)

average log(*Vp*/g) = -2.05 + 0.097 * T_{WATER} + 0.2 * SAL - 0.0055 * SAL²

OHHI Objective 3 Results: Risk Prediction Maps Generated by Remotely Sensed SST



SST – May 4, 2004



Mean Vp per g – May 4, 2004

$$\text{mean } V. \text{ parahaemolyticus/g} = 0.871 \times \exp[0.2648 \times \text{SST}]$$



Vibrio Remote Sensing Report



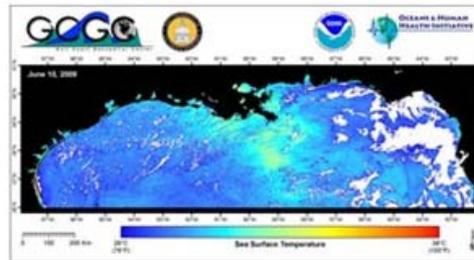
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Vibrio parahaemolyticus (Vp) and Oysters

Gulf Coast oysters (*Crassostrea virginica*), especially raw oysters on the half shell, top the list of favorites for many diners. Although these bivalves are safe for most people to eat, some consumers should avoid eating raw or undercooked seafood including oysters. These "at risk" consumers include diabetics, individuals that have liver disease and hemochromatosis (iron overload) and anyone with a weakened immune system. Oysters are filter-feeding animals and they sometimes accumulate large numbers of bacteria and viruses, including naturally occurring, disease-causing bacteria such as *Vibrio parahaemolyticus* (*Vp*), as they feed.

This potential bacterial content calls for simple safety steps such as keeping the oysters refrigerated or on ice after harvesting, and washing hands thoroughly with warm, soapy water after handling raw oysters and other raw seafood. If oysters containing naturally occurring bacteria such as *Vp* are harvested and not refrigerated or kept on ice, elevated temperatures (greater than 15C or 59F) may allow the *Vp* to grow to high levels. *Vp* in high enough densities can cause diarrhea and vomiting in consumers who eat raw oysters, especially in those individuals with pre-existing health problems.

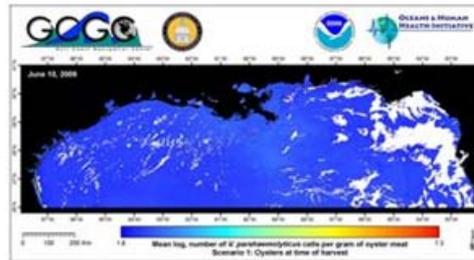
Latest MODIS SST



(click for full resolution)

[SST Product Archive](#)

Latest Mean log Vp at Harvest



(click for full resolution)

[Mean log Vp at Harvest Product Archive](#)

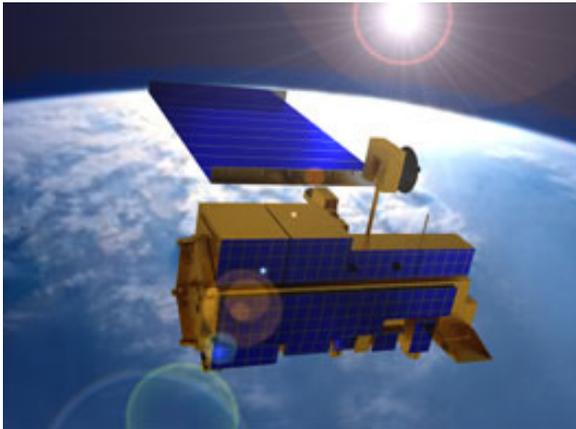
[See results of using various mitigation scenarios](#)

Website

- Being constructed by Dan Holiday (USM), John Bowers (FDA), Greg Carter (USM), and Scot Loehrer (NCAR)
- Contract to USM from OHHI through UCAR
- Initially will use SST to predict *Vp* abundance and distribution
- Very soon salinity will be added to improve the model
- [Will be password protected](#)

Nowcasting to Forecasting

- *V. cholerae* in the Chesapeake Bay
- *V. parahaemolyticus* in molluscan shellfish
- *V. vulnificus* in molluscan shellfish
- Vibrios in coastal water at bathing beaches



SST from MODIS (and other RS products)



10,000 *Vp/g* at
30°15'52"N,
89°06'48"W

Precise data from a "Tricorder"

Questions?