New Jersey Department of Environmental Protection's use of Aircraft Remote Sensing and Real Time Water Quality Monitoring

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Water Monitoring and Standards
Bureau of Marine Water Monitoring

Overview

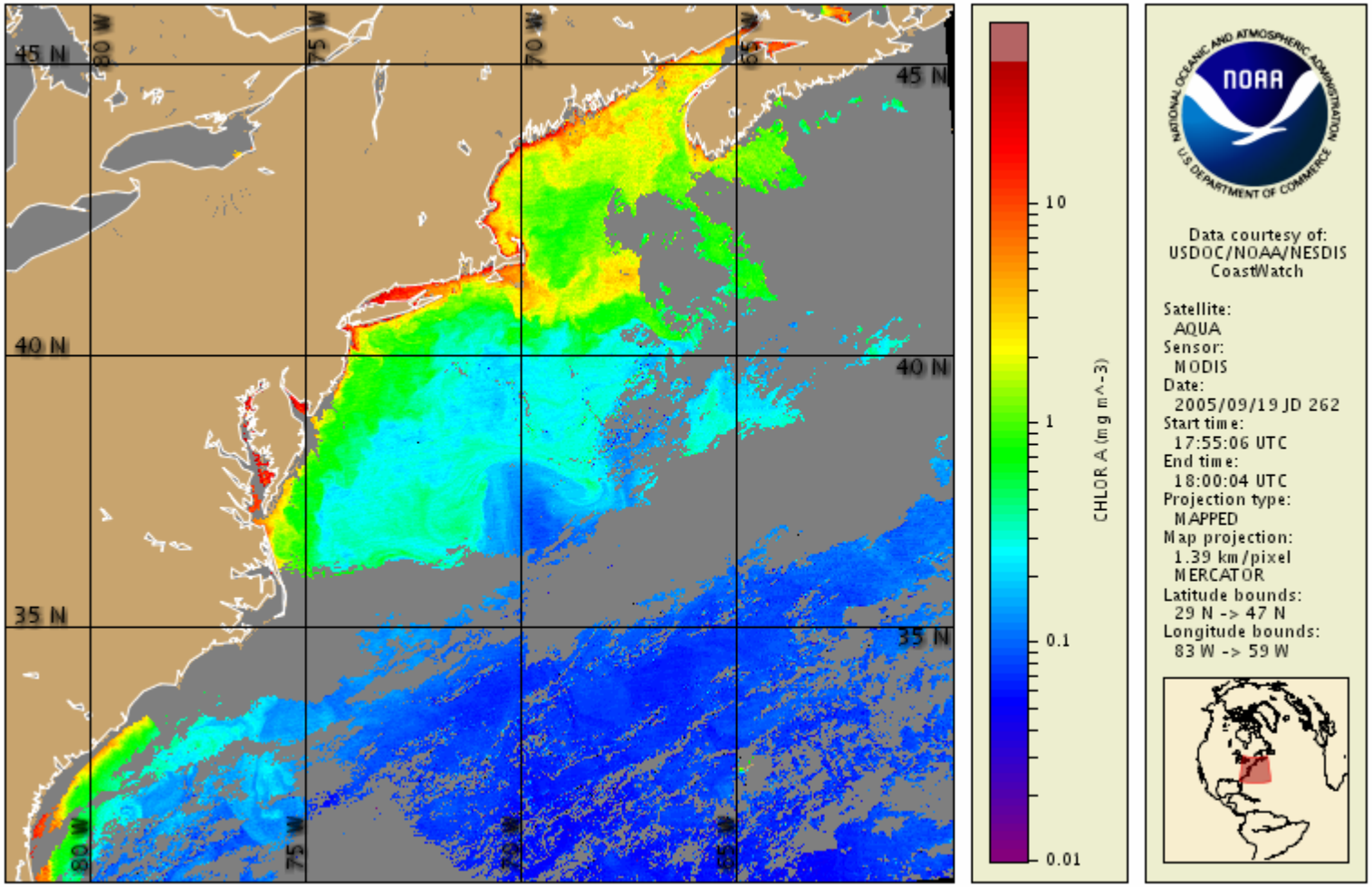
- Aircraft Remote Sensing and Real Time Water Quality Monitoring data can be used to assess ecological health and protect public health.
- Detection and monitoring of algal blooms. As part of the National Shellfish Sanitation Program, we are required to look for harmful algal blooms. Also used for the protection of recreational beaches.
- Data can be used to answer questions about fishkills or other ecological conditions.

Background

- For New Jersey, the concept of aircraft remote sensing started when we assisted NOAA and NASA by collecting ground truth data for airplane flights in 2001. After detecting an algal bloom we realized this could be a useful tool.
- Real time water quality monitoring started in 2002 as part of a USEPA EMPACT grant. The data collected filled gaps by measuring continuous water quality data.

Examples

Typical Satellite Image



Aircraft Remote Sensing

- Better resolution of chlorophyll than satellite imagery, flight is at 500 feet.
- Not routinely hindered by cloud cover due to low altitude flights.
- New Jersey Forest Fire Service Aircraft is used, plane is normally active for Forest Fire Surveillance.
- Aircraft flights, 6 days/week for coastal floatable surveillance between Memorial Day and Labor Day.

Aircraft Remote Sensing

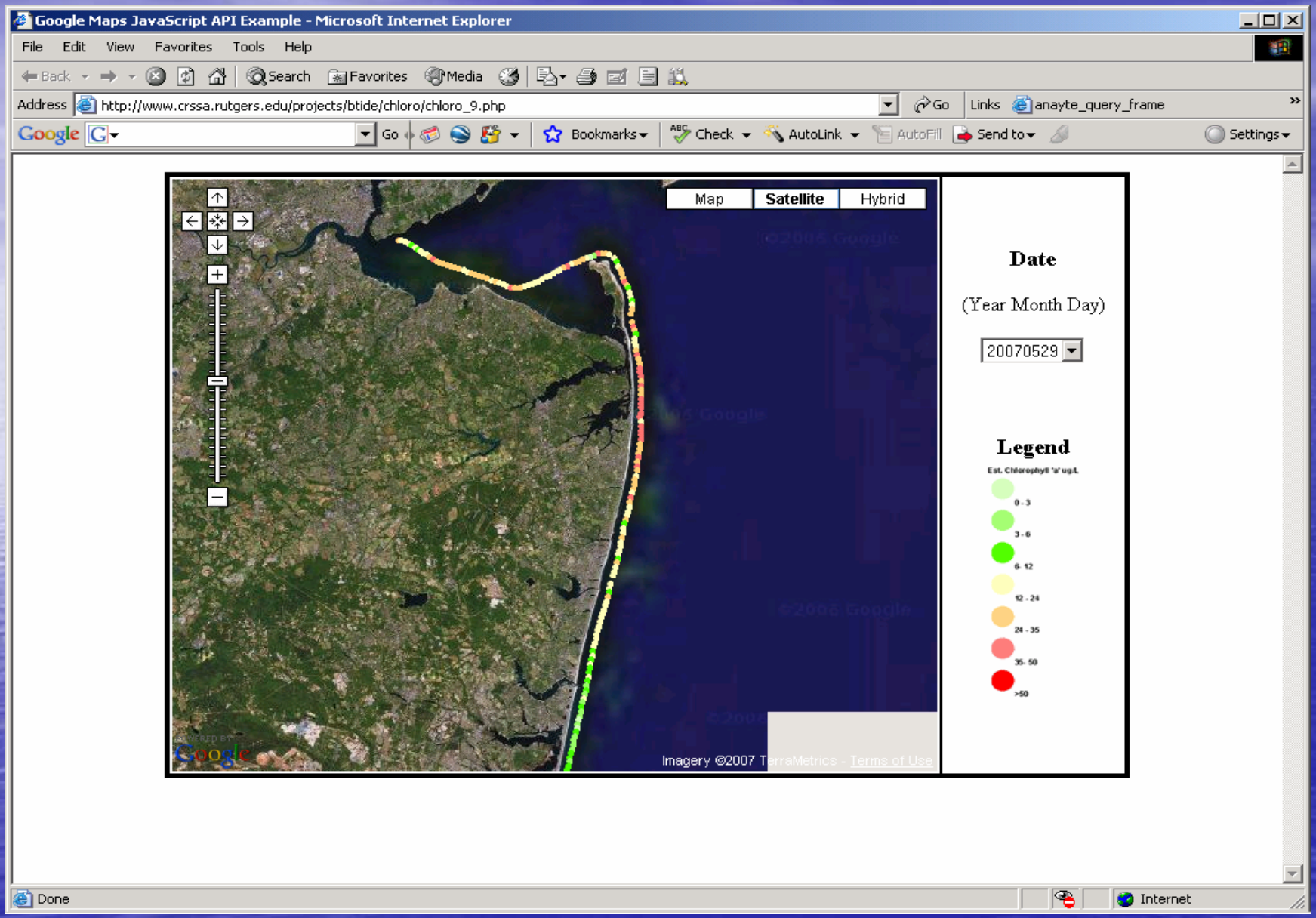
Aircraft Remote Sensing

2007 Aircraft Remote Sensing

- The data was used in response to algal blooms and a fish kill event in the summer of 2007.
- Two events are described in detail.
- One was a large algal bloom that occurred on Memorial Day weekend, the imagery showed the spatial extent and intensity of the bloom.
- The other event was a fish kill of unknown cause. The imagery was used to rule out the possibility of an algal bloom being the cause of the event.

Memorial Day Weekend Bloom 2007

- An algal bloom occurred at the end of May, off the coast of Monmouth County, NJ.
- With the remote sensing data we were able to track the size, location and status of the bloom, and respond with sampling as necessary.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Imagery ©2007 TerraMetrics - Terms of Use
Date
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0 - 3
3 - 6
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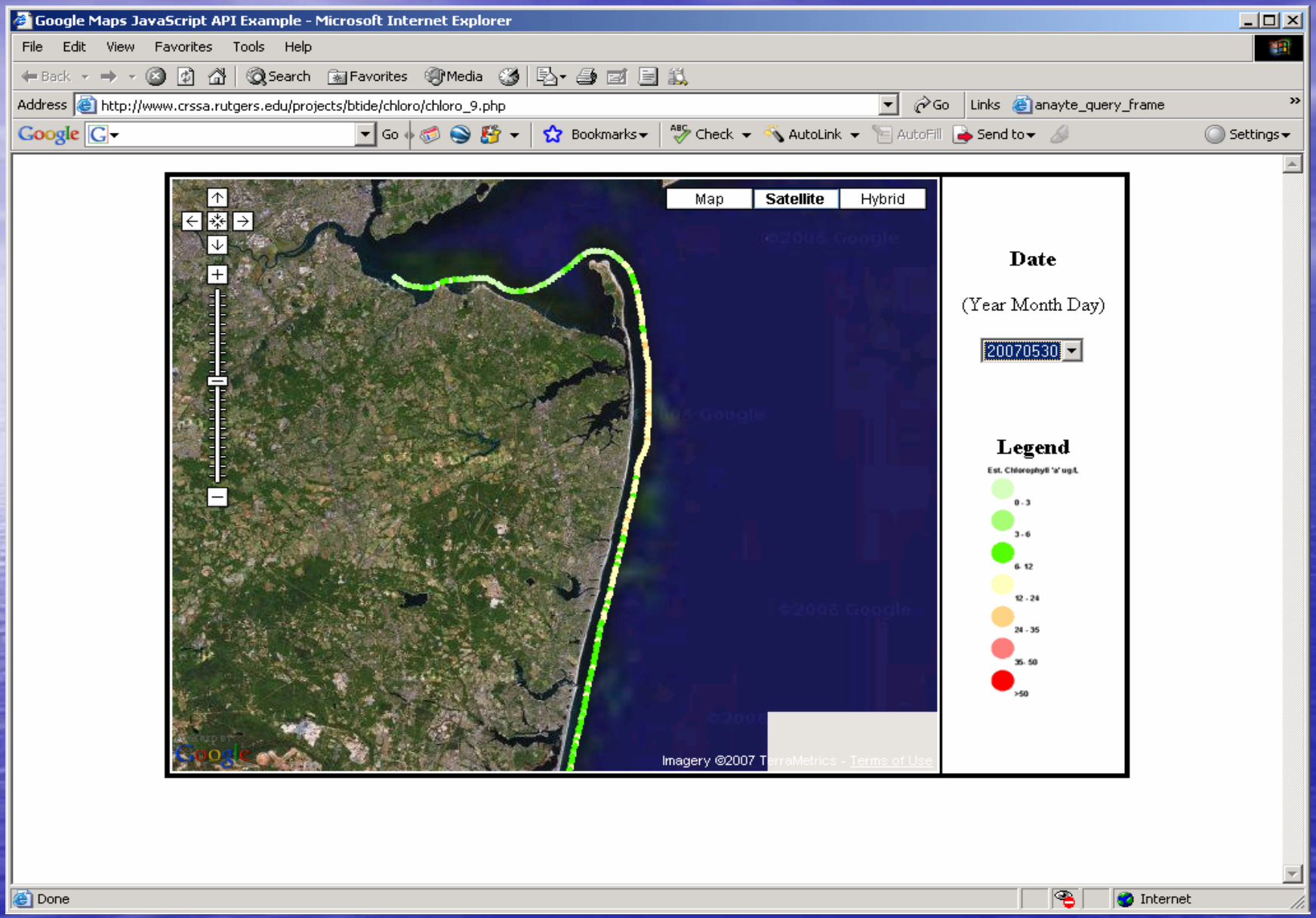
12 - 24
24 - 35
35- 50
>50
Done
Internet


Google Maps JavaScript API Example - Microsoft Internet Explorer
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Imagery ©2007 TerraMetrics - Terms of Use
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Est. Chlorophyll 'a' ug/L
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6- 12
12 - 24
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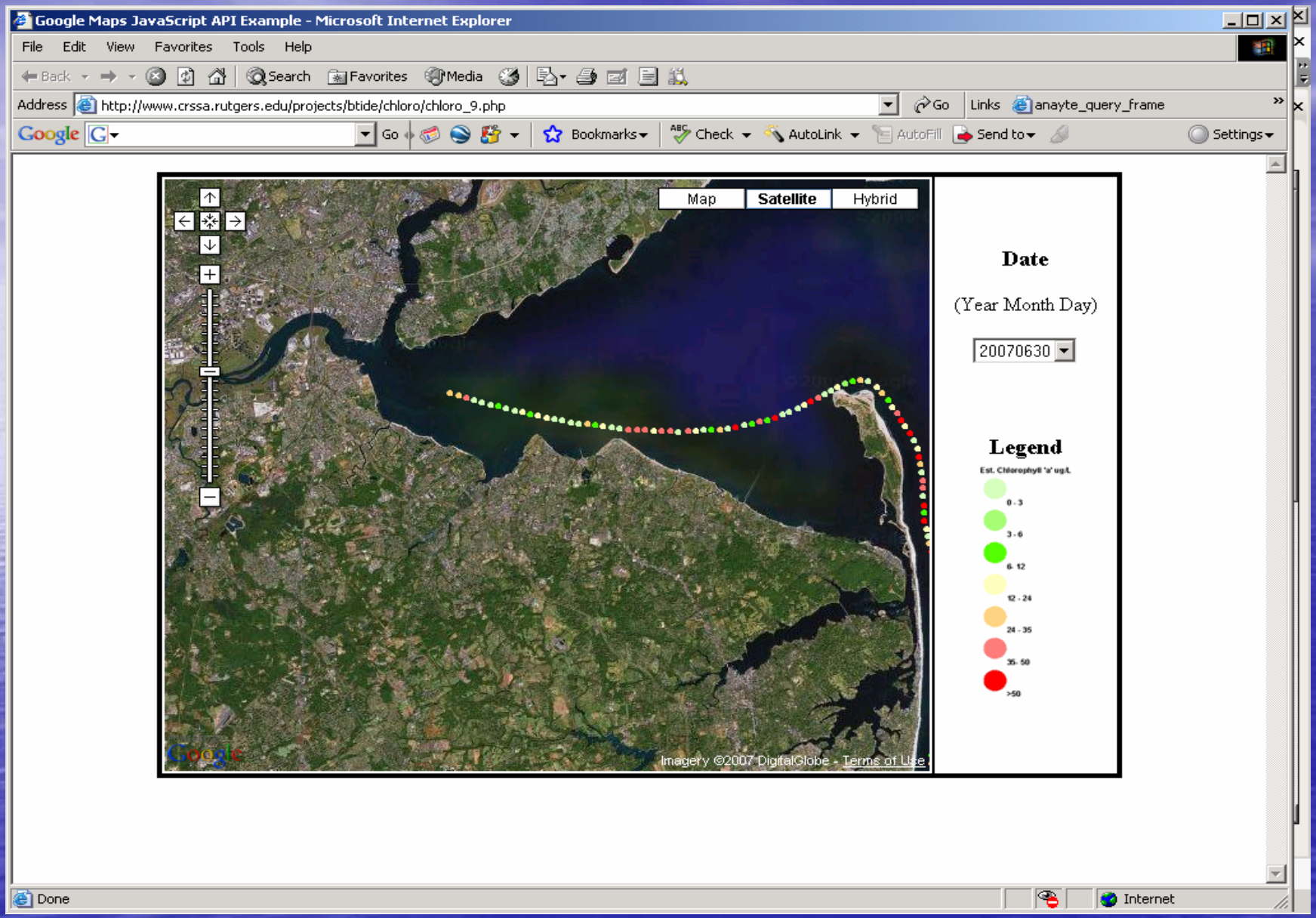
35- 50
>50
Done
Internet

Keyport Harbor Fish kill 2007

- A fish kill consisting of Menhaden (bunker), occurred in the Keyport Harbor area of Raritan Bay at the beginning of July 2007.
- In many cases, fish kills are the result of algal blooms.
- The remote sensing data, was used to determine if any algal bloom conditions were evident around the time of the event.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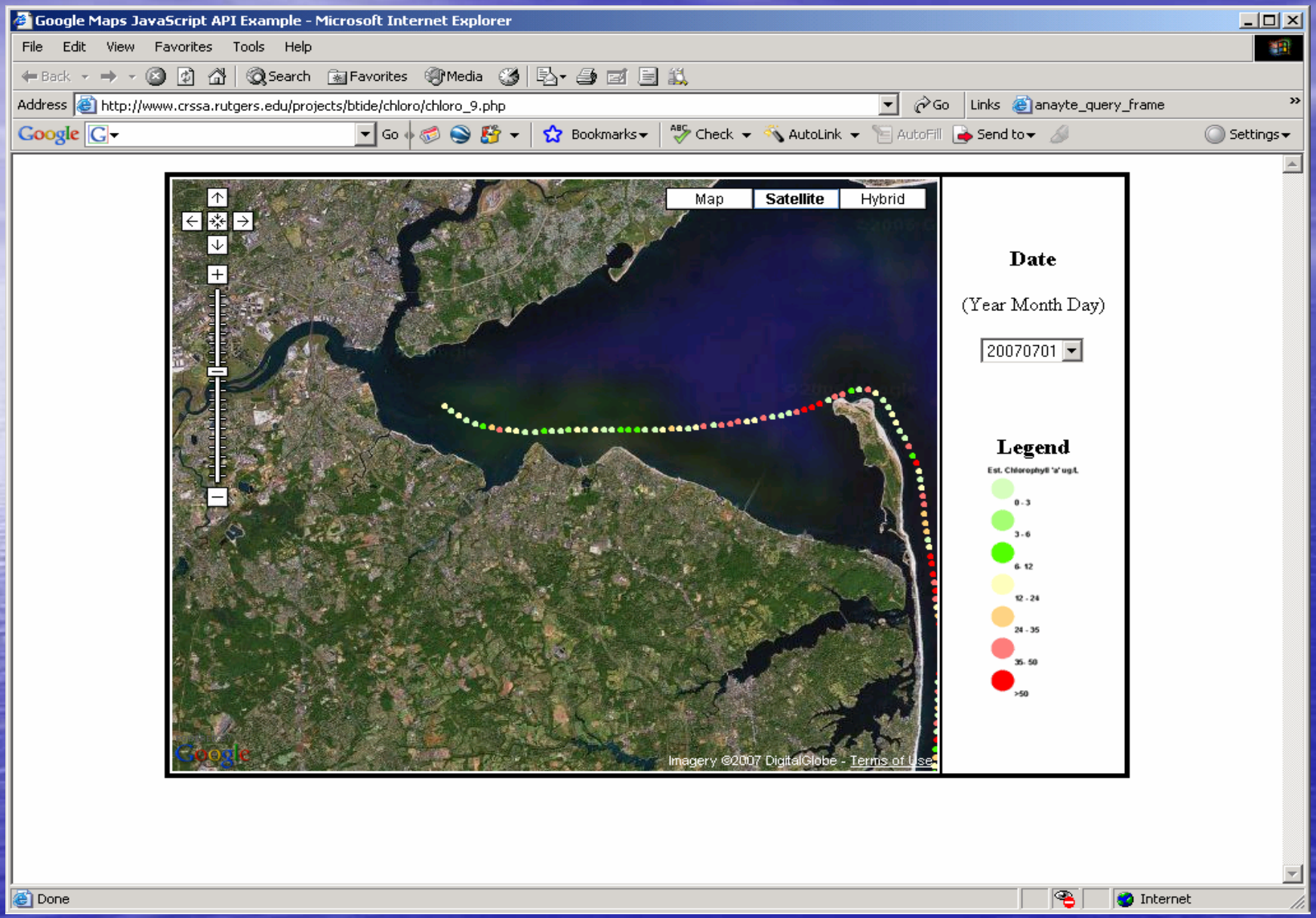
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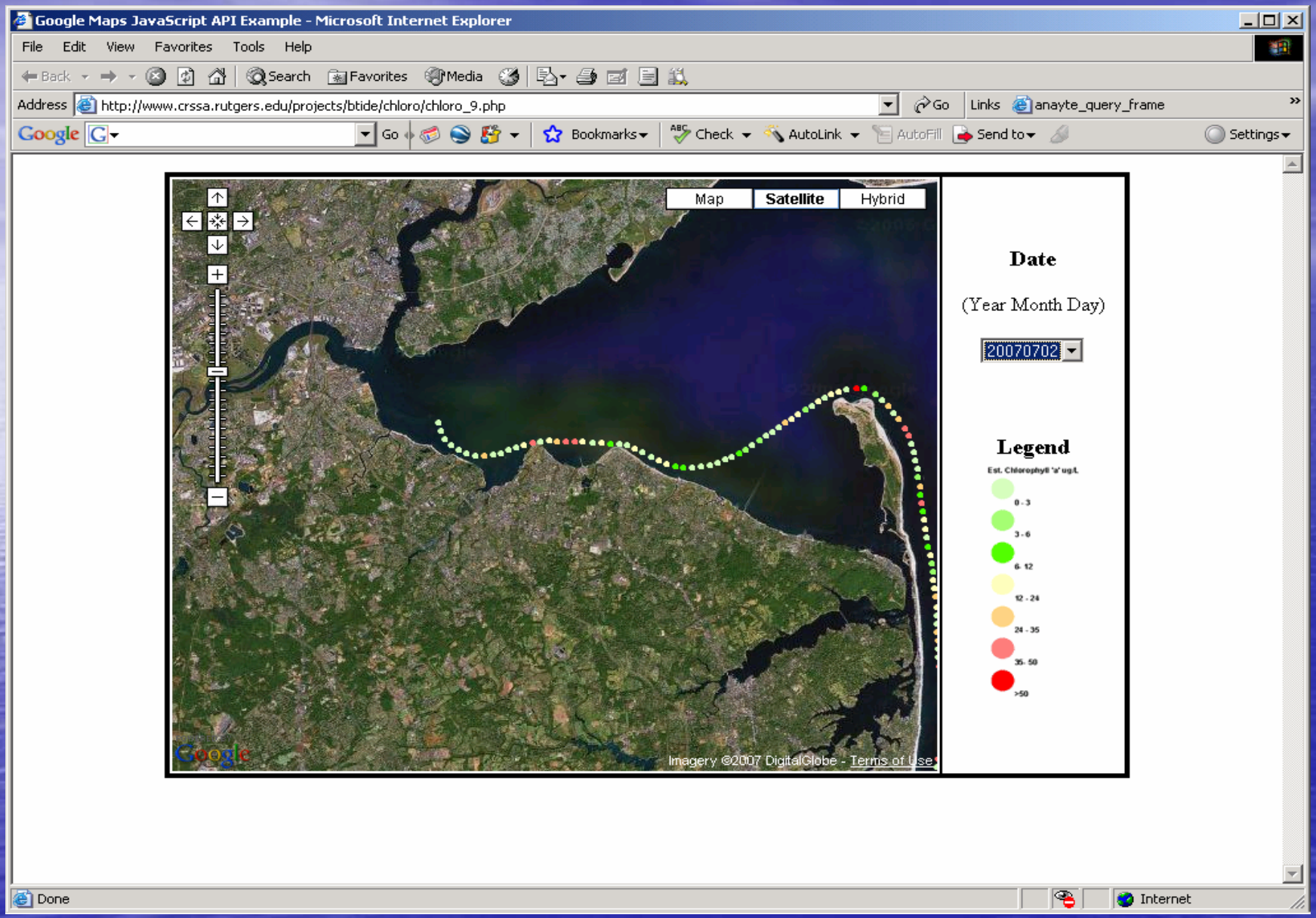
Google Maps JavaScript API Example - Microsoft Internet Explorer
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24 - 35
35- 50
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Done
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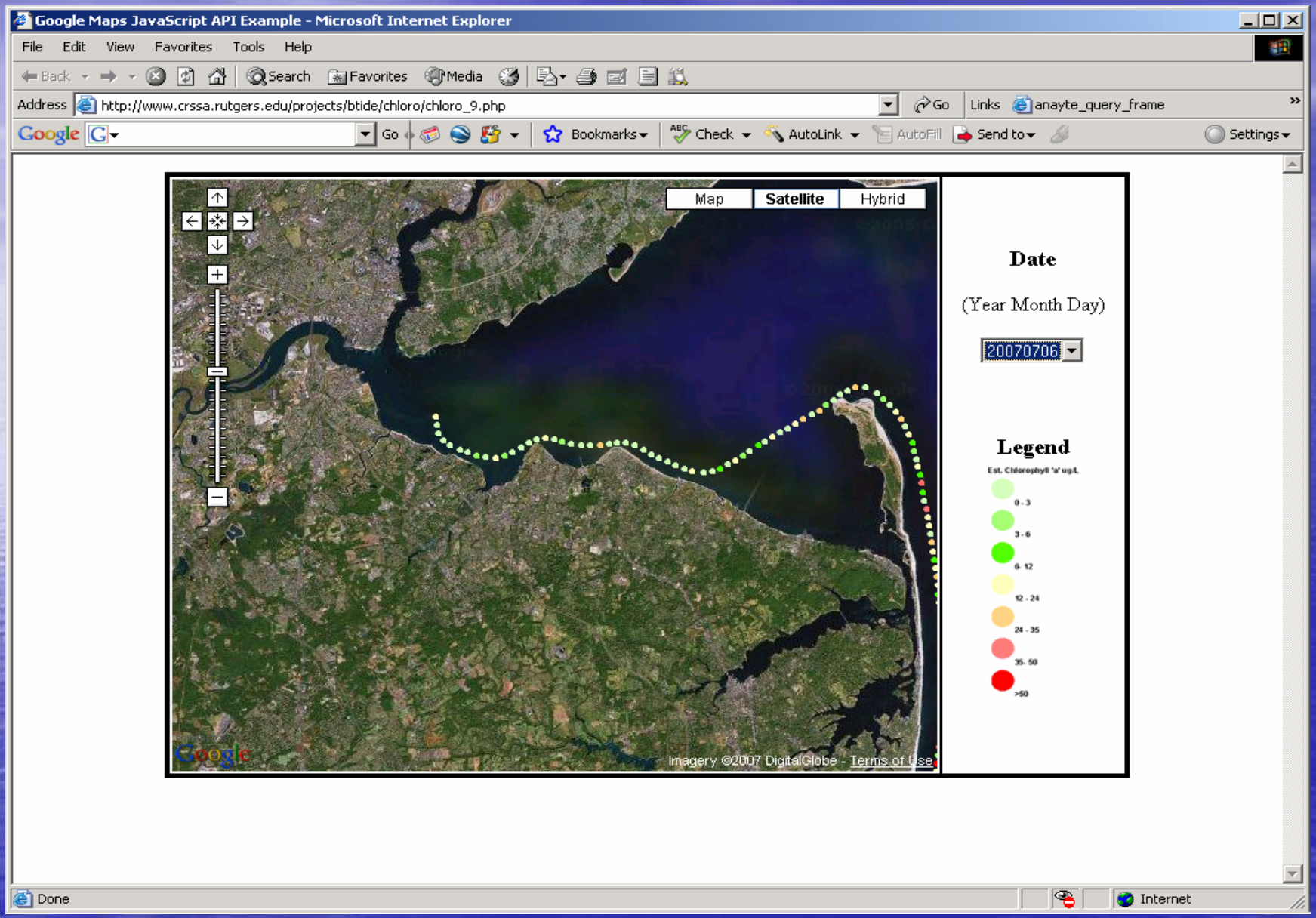
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Imagery ©2007 DigitalGlobe - Terms of Use
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Legend
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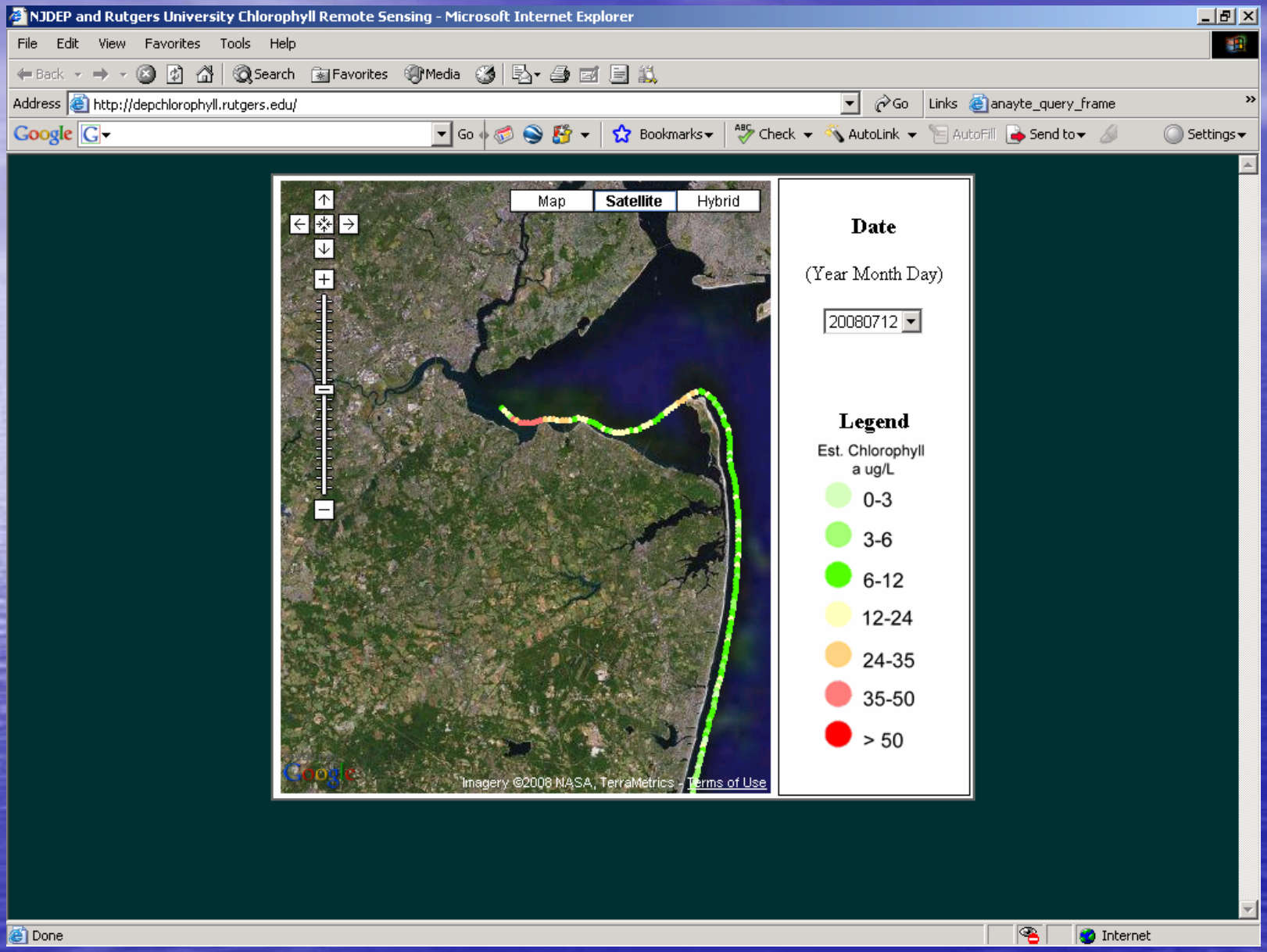
6- 12
12 - 24
24 - 35
35- 50
>50
Done
Internet

July 2008 Raritan Bay Algae bloom

Remote sensing data from Saturday July 12, 2008, showed the start of an algal bloom in the western end of Raritan Bay. Sunday the remote sensing data showed that the bloom had intensified some chlorophyll a values were estimated to be 100 ug/l. On Tuesday a boat was sent on the water to investigate the area, 22 samples were collected and analyzed for chlorophyll a, and a subset was looked at for species identification. Remote sensing data was also collected on Tuesday, and covered the area farther offshore than the boat.


NJDEP and Rutgers University Chlorophyll Remote Sensing - Microsoft Internet Explorer
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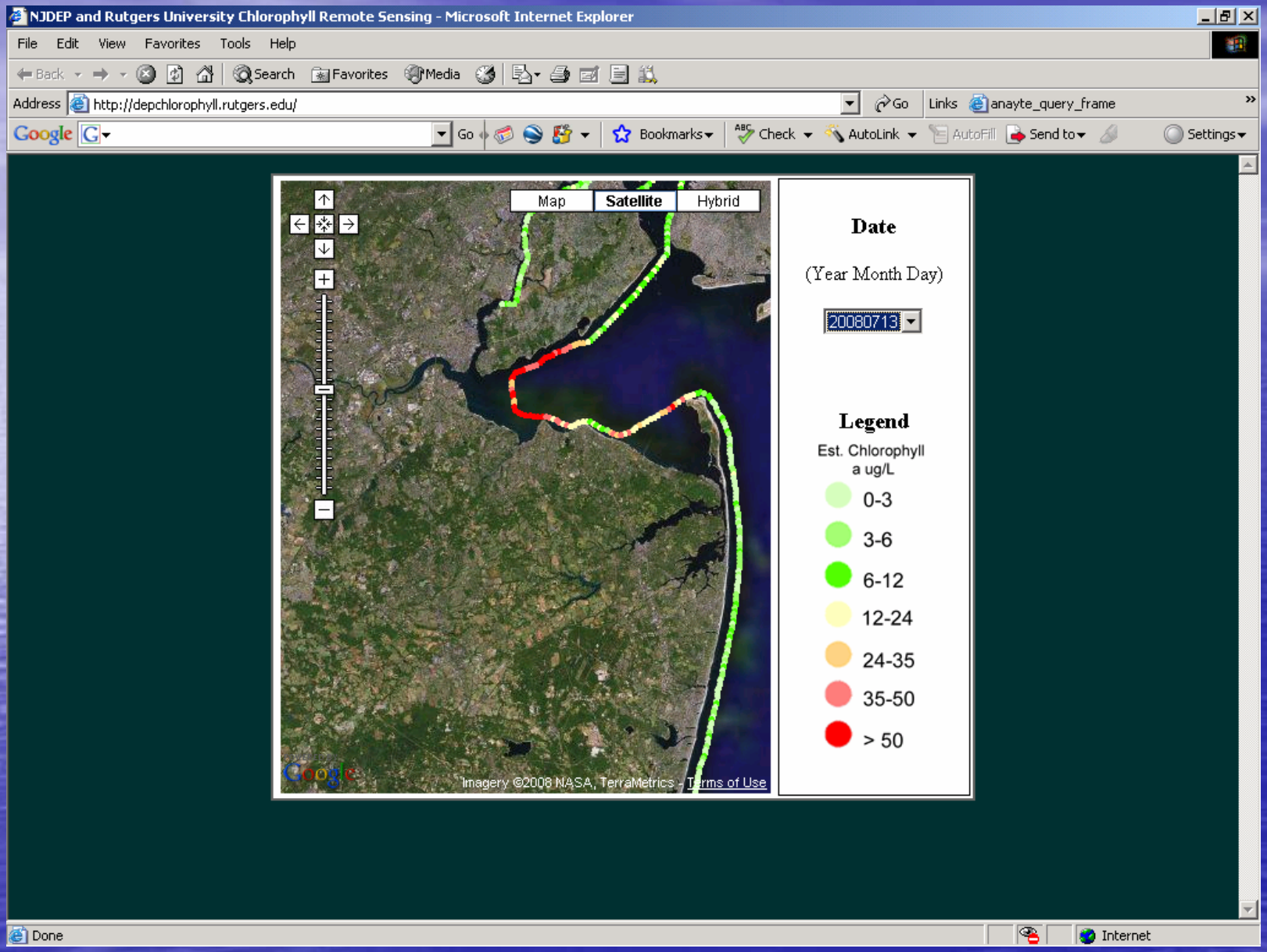
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Imagery ©2008 NASA, TerraMetrics - Terms of Use
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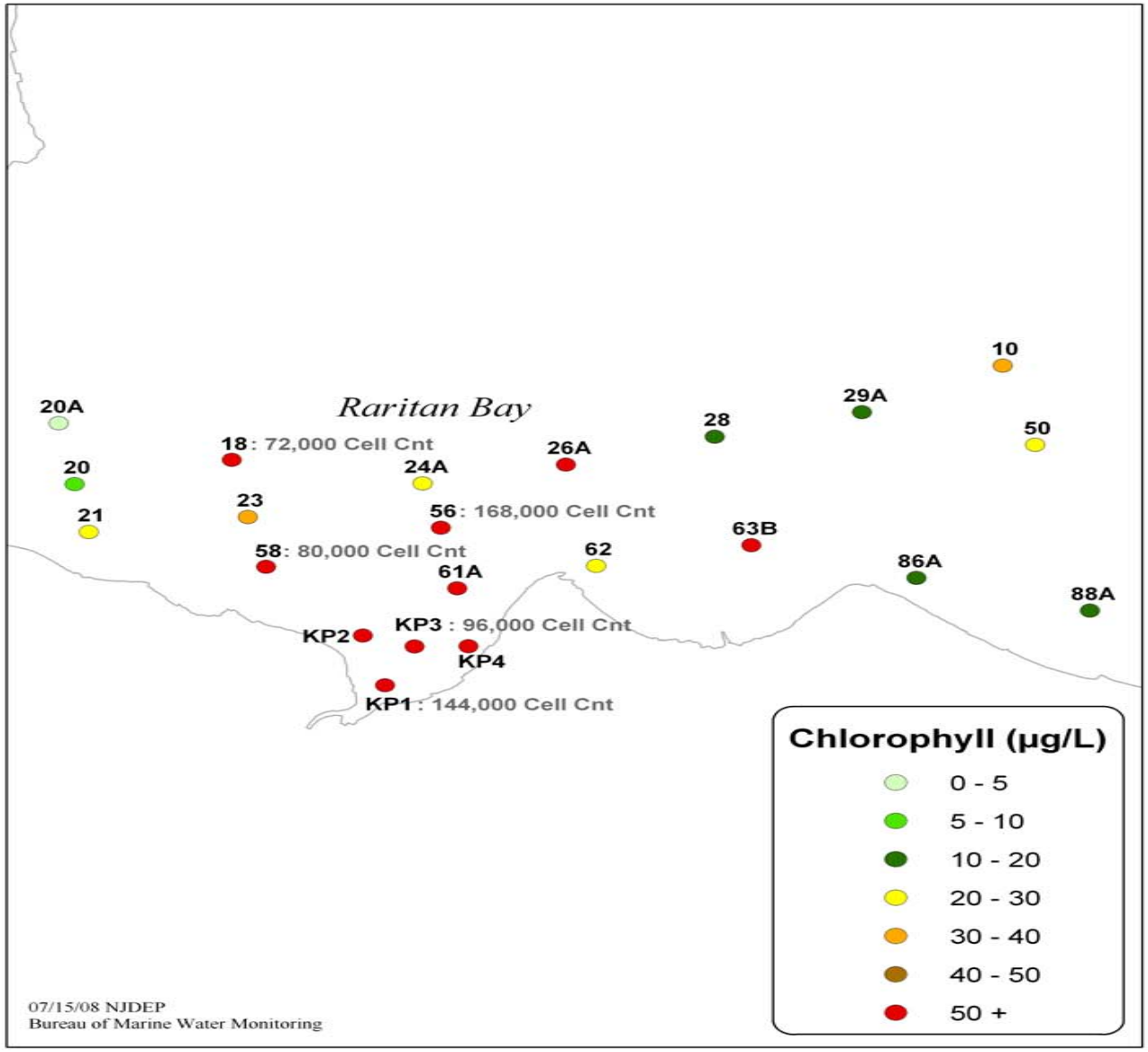
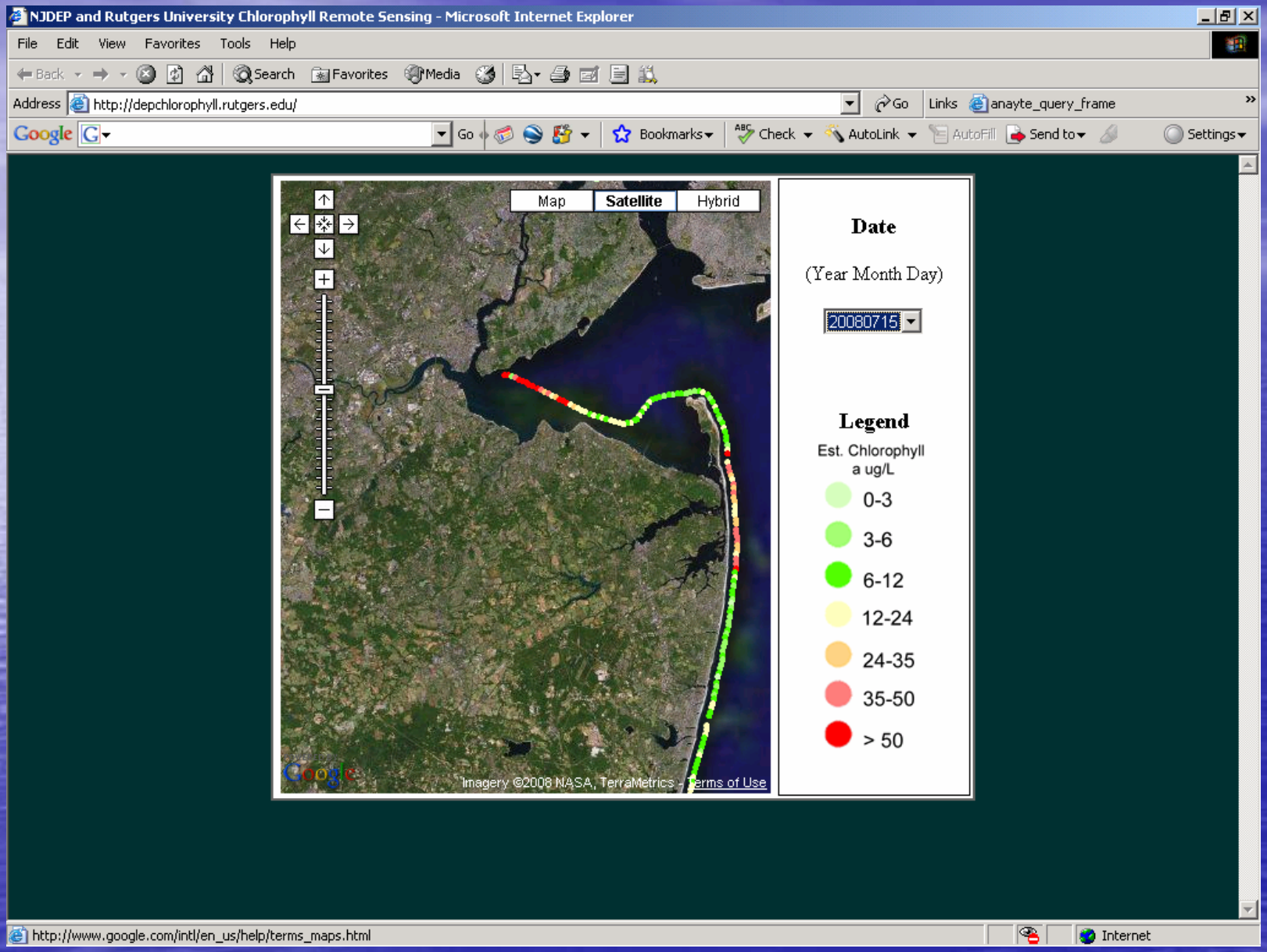

Raritan Bay
20A
20
21
23
18: 72,000 Cell Cnt
24A
26A
56: 168,000 Cell Cnt
58: 80,000 Cell Cnt
61A
62
28
63B
29A
10
50
86A
88A
KP2
KP3 : 96,000 Cell Cnt
KP4
KP1 : 144,000 Cell Cnt
Chlorophyll (µg/L)
0 - 5
5 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 +
07/15/08 NJDEP
Bureau of Marine Water Monitoring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Imagery ©2008 NASA, TerraMetrics - Terms of Use
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(Year Month Day)
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Est. Chlorophyll a ug/L
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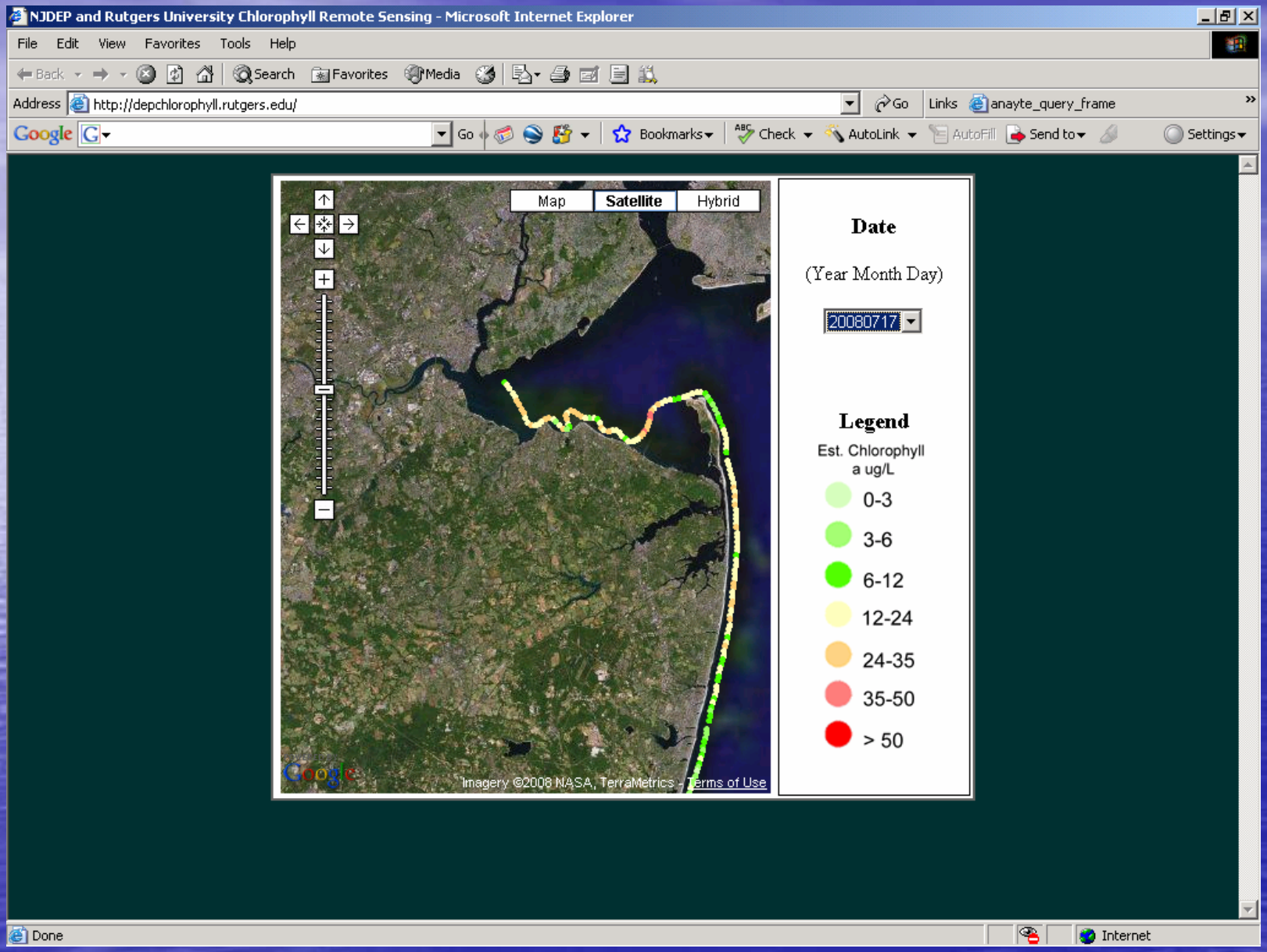
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Date
(Year Month Day)
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Legend
Est. Chlorophyll a ug/L
0-3
3-6
6-12
12-24
24-35
35-50
> 50
Done
Internet

Real time Water Quality Monitoring

Overview

- Continuous monitoring is needed in NJ's coastal waters for management decisions relating to:
  - Public Health
  - Fisheries Management
  - Ecosystem Health
- The NJDEP network of coastal, real-time monitors is now being augmented by a network being established by Monmouth University.
- Expansion of the existing network will be enhanced by the use of:
  - Open Source software
  - Data Standards
  - QA Standards

Why do we need continuous water quality monitoring?

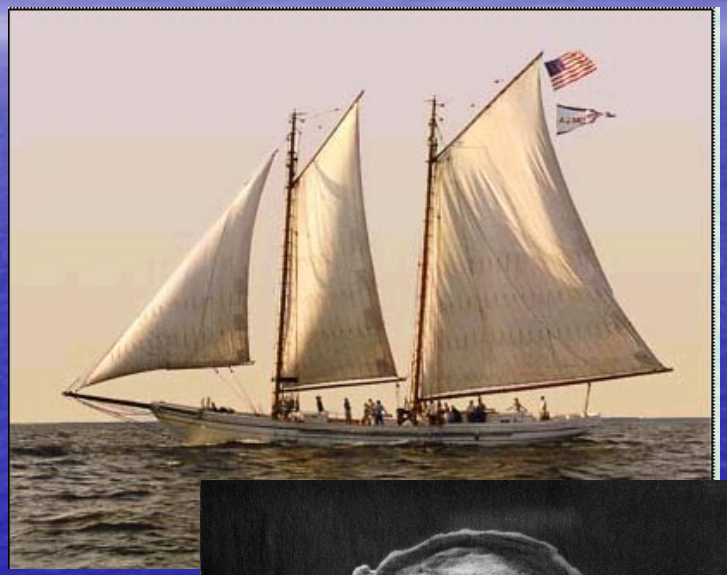
- Need to use where changes over time are more critical than changes spatially
- Need to characterize rapid water quality changes (on the order of hours or minutes vs days or weeks)
- Need to know conditions at a specific time
- Need to have concurrent measures of multiple parameters to establish relationships.

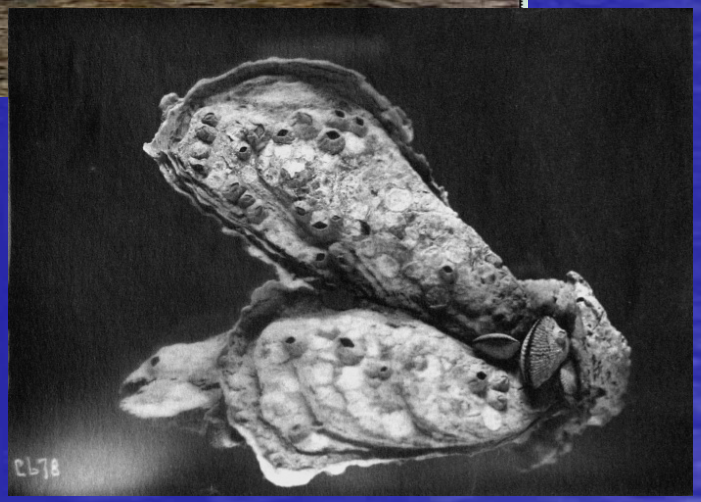
Some management applications for continuous monitoring data:

- Assess trends and patterns in water quality.
- Need water quality data for calibration of remote sensing.
- Providing data necessary for assessing the impacts of fresh water withdrawal on estuarine fisheries.
- Recognizing high risk periods for pathogens in seafood.
- What are the average and min/max DO, chlorophyll and turbidity levels for development of eutrophication indicators and reference conditions?

Shellfish harvesting is a significant part of NJ's coastal economy

- About 30,000 metric tons harvested in 2006
- Dockside value of $100,000,000 annually
- Eastern oyster in Delaware Bay is a part of NJ's harvest

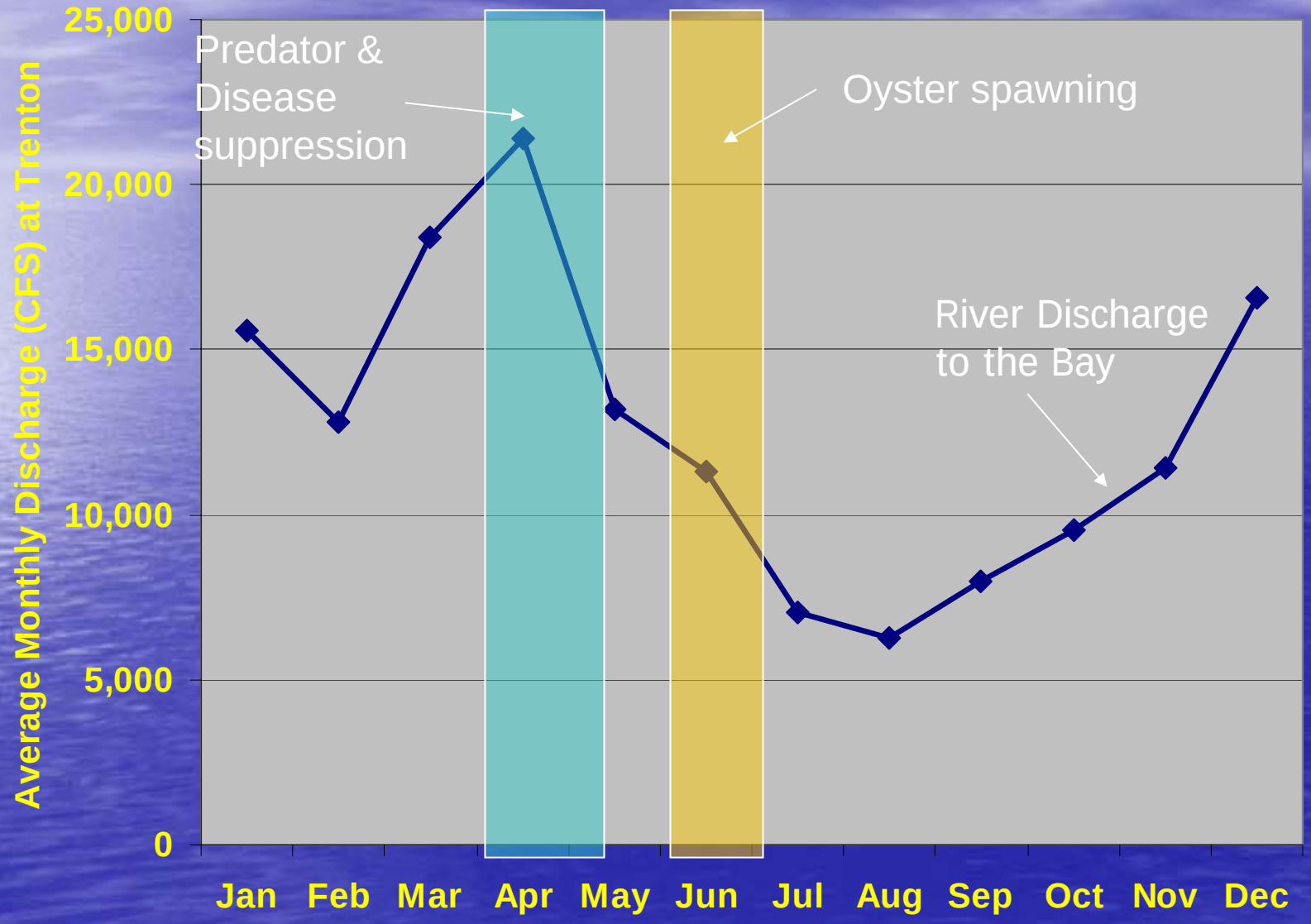




Fisheries Management
Water Withdrawals – Delaware Watershed

- NY and PA would like to retain more water in the Spring and release in the Summer for trout production
- No net change for withdrawal, just a change to seasonal withdrawals

How much water can be withheld during peak flow before predators and disease interfere with successful reproduction of oyster populations?



Need for Continuous Monitoring Data

Need continuous measurements of salinity over the oyster beds during various flow conditions to accurately model the response of salinity to water withdrawals upstream and to determine the risk to the oyster resource posed by the withdrawals.

Public Health
Predicting Pathogen Risk

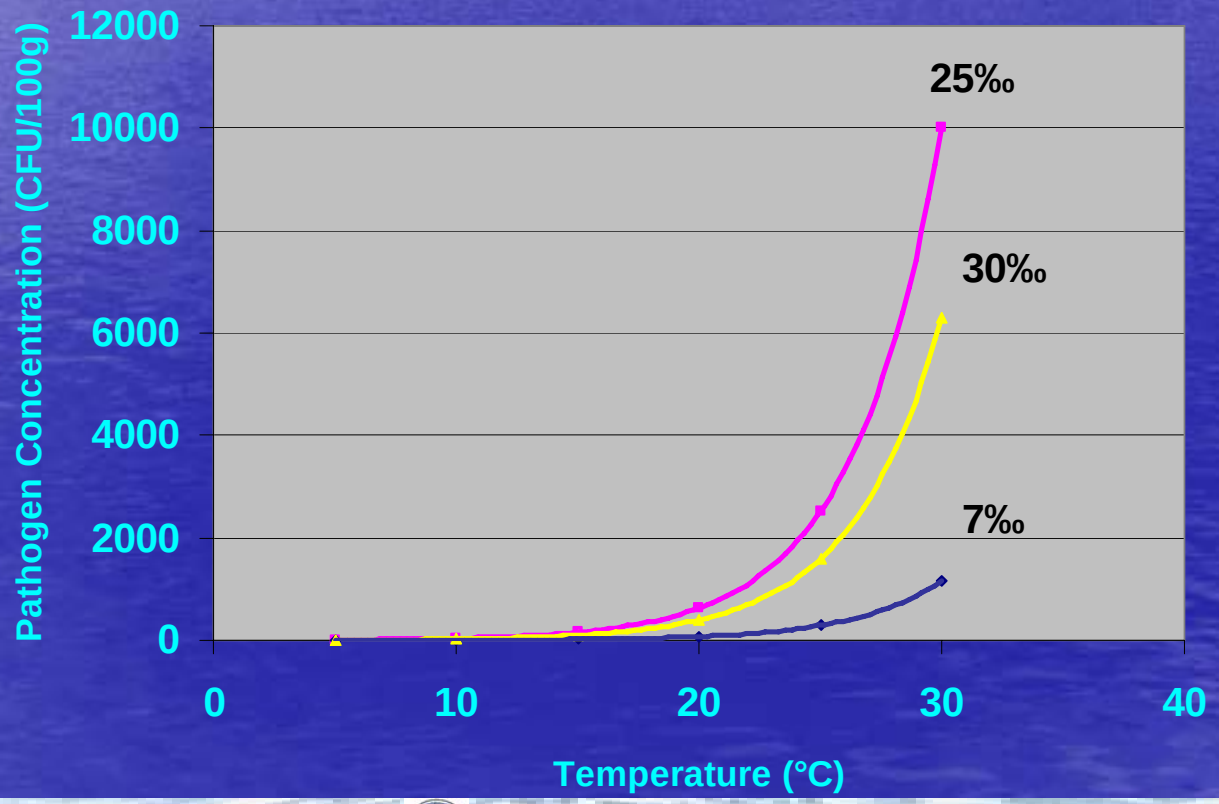
- *Vibrio parahaemolyticus (Vp)*
  - Bacterium that occurs naturally in coastal waters and can be filtered from the water by molluscan shellfish (such as oysters).
  - Growth is primarily in response to temperature and salinity conditions.
  - Consumption of Vp by humans can results in nausea, vomiting, and other symptoms.
  - Shellfish harvest can be limited during periods of high growth of this pathogen, thereby protecting public health.

Pathogen Growth Model

$$\log([pathogen]) = -2.6 + 0.12(Temp) + 0.18(Sal) - 0.004(Sal^2) + 1$$

Where:

Temp = temperature (°C)
Sal = salinity (‰)



Need for Continuous Monitoring Data

By knowing the temperature and salinity conditions over oyster beds, we can more accurately determine when there is a need to restrict harvest or implement other Vibrio control measures.

Continuous monitoring can provide the necessary data.

Continuous Monitors in NJ Coastal Waters

- Readings every 15 minutes
- Updates posted to the Internet every hour.
- Eight different parameters are recorded by the buoys these include:
  - Dissolved oxygen
  - pH
  - Salinity
  - Temperature
  - Turbidity
  - Chlorophyll a

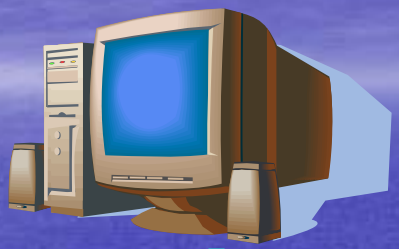
Internet

Cell Phone Telemetry

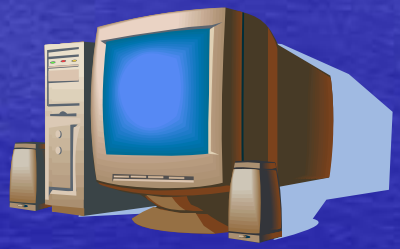
Telemetry

Data Acquisition

Sensors



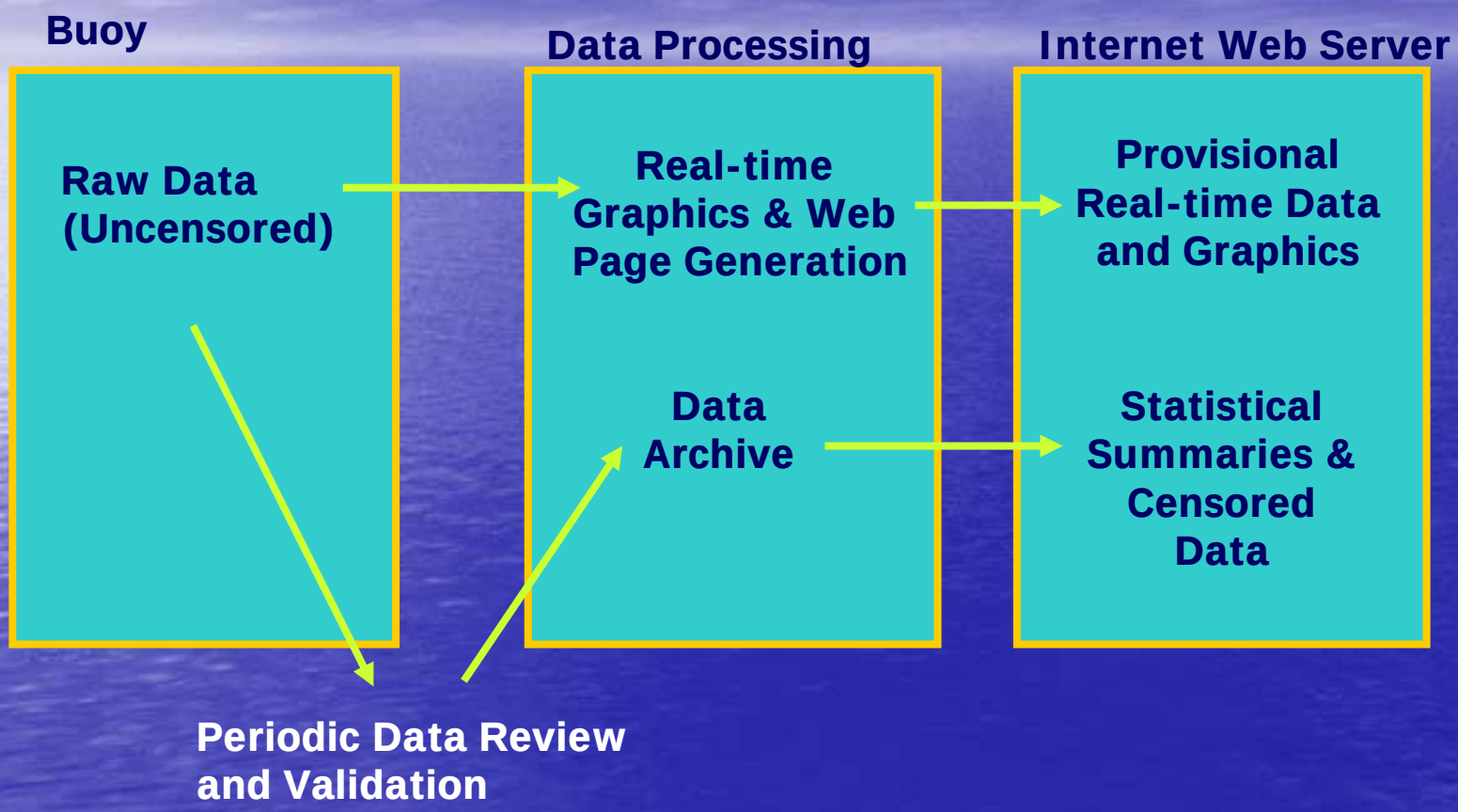
Data Acquisition Server (Windows)



Web Server (Linux)

Data Users

Data Flow:


Buoy
Raw Data (Uncensored)
Data Processing
Real-time Graphics & Web Page Generation
Data Archive
Internet Web Server
Provisional Real-time Data and Graphics
Statistical Summaries & Censored Data
Periodic Data Review and Validation

User Interface

NJDEP Marine Water Monitoring - Water Quality Sensors - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address http://www.state.nj.us/dep/bmw/sensorhome.htm

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- About the Bureau
- News
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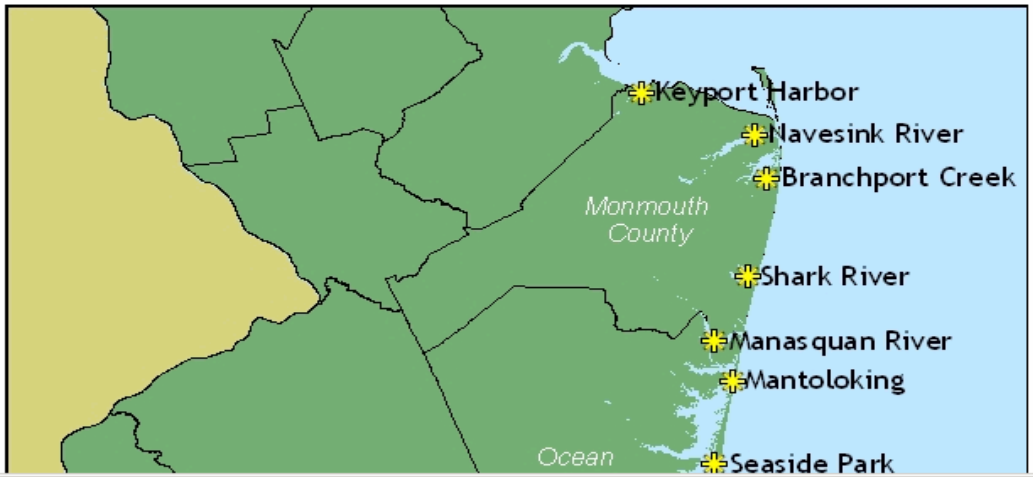
Water Quality Sensors

What are they? There are currently eleven water quality sensors in the coastal waters of New Jersey. Seven of these water quality sensors are owned and maintained by The Urban Coast Institute at Monmouth University. The remaining four are owned and maintained by NJDEP Marine Water Monitoring. The sensors are automatically updated (when operational). The automated sensors have a solar power source and telemetry for transmitting the data to a base station operated by the New Jersey Department of Environmental Protection.

What do they measure? Each unit is equipped with sensors to measure water temperature, salinity, dissolved oxygen, pH, turbidity and chlorophyll a. Temperature and salinity are very basic measurements that determine what types of marine animals and plants could thrive in the location. Dissolved oxygen and pH provide information how favorable the waters could be for the plants and animals that are present. Turbidity tells us how far light can penetrate into the water for plants to use. Chlorophyll a is a measure of the amount of plant material suspended in the water. Typically this suspended plant material is microscopic plants called phytoplankton.

Where are they?

County	Location	Status
Monmouth County	Raritan Bay - Keyport Harbor	Awaiting maintenance
Monmouth County	Navesink River	Awaiting maintenance
Monmouth County	Shrewsbury River - Branchport Creek	**Active**
Monmouth County	Shark River	**Active**
Ocean County	Manasquan River	**Active**
Ocean County	Barnegat Bay - Mantoloking	**Active**
Ocean County	Barnegat Bay - Seaside Park	**Active**
Ocean County	Barnegat Bay	Awaiting maintenance
Ocean County	Little Egg Harbor	Awaiting maintenance
Atlantic County	Absecon Inlet	Awaiting maintenance
Cape May County	Great Egg Harbor Bay	Awaiting maintenance



NJDEP Marine Water Monitoring - Automated Sensor - Shrewsbury River - Microsoft Internet Explorer

File Edit View Favorites Tools Help

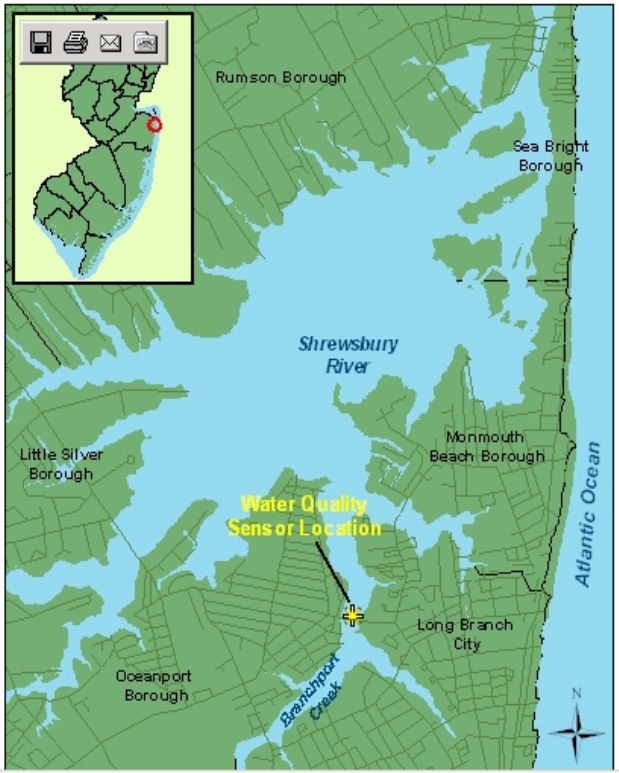
Address http://71.59.88.199/SondePages/502.htm

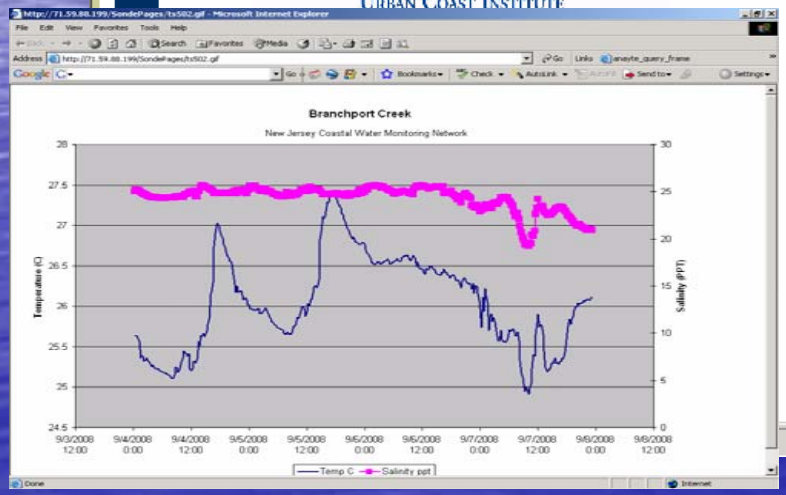
CURRENT CONDITIONS As of 9/7/2008 11:16:32 PM			
Temperature	26.11	°C	Chart
Salinity	20.91	PPT	Chart
Dissolved Oxygen	3.94	mg/L	Chart
pH	7.26		Chart
Turbidity	3.80	JTU	Chart
Chlorophyll a	32.91	µg/L	Chart
Depth	[depth]	ft.	

Real-time data have not been reviewed. They are Provisional Data. Use with caution.

URBAN COAST INSTITUTE

SENSOR INFORMATION	
Location:	Shrewsbury River - Branchport Creek
Coordinates:	40° 19' 12.63 " N 73° 59' 46.46 " W
Sensors:	Temperature, conductivity, salinity, dissolved oxygen, pH, turbidity, chlorophyll a, depth
Status:	**Operational**





Internet

Lakes Bay
Sonde Water Quality Summary
NJDEP - Marine Water Monitoring

Statistical Summary for Lakes Bay from 1/1/2004 to 1/1/2006

Records shown 1 - 8 of 8

Parameter	Average	Minimum	Maximum	Readings
Chlorophyll ug/l	17.170285424515	0.11	54.6	20706
DO Conc	6.5916065158018	0.5	12.6	20504
DO%	84.601178946375	30	146.9	21146
pH	7.9450294018818	7.5	8.46	23808
Salinity ppt	26.009705208142	14.02	32.98	21812
SpCond mS/cm	40.625310537654	23.18	50.26	21817
Temp	19.275059719068	-0.57	29.61	23778
Turbidity NTU	19.065327820437	0	150.2	16930

Select parameter for data listing below:

Parameter: Chlorophyll ug/l

List Raw Data

Expansion of the network will require:

- Open Source software
  - Ability to share software with partners
  - Ability for partners to modify/improve software (development of a “community” approach)
- Data Standards
  - So that partners can speak the same “language”.
- Quality Assurance Standards
  - So that partners can compare and combine their data.

Summary

- There are a number of management applications for continuous monitoring data in NJ's coastal waters
- NJ has started a network of real-time, continuous monitors in its coastal waters.
- Expansion of this network will require new approaches that utilize software that can be readily distributed and data standards.

Conclusions

- Both real time water quality data and Aircraft remote sensing data can be applied in practical use for water quality managers.
- The data gathered can more efficiently answer questions about conditions, because the time coverage of continuous monitoring data and spatial coverage of the aircraft remote sensing.

Acknowledgements

- The staff of the Bureau of Marine Water Monitoring
- All Staff that works on the Coastal floatable flights
- NJ Forest Fire Service
- USEPA Region 2
- Rutgers CRSSA

Questions ?