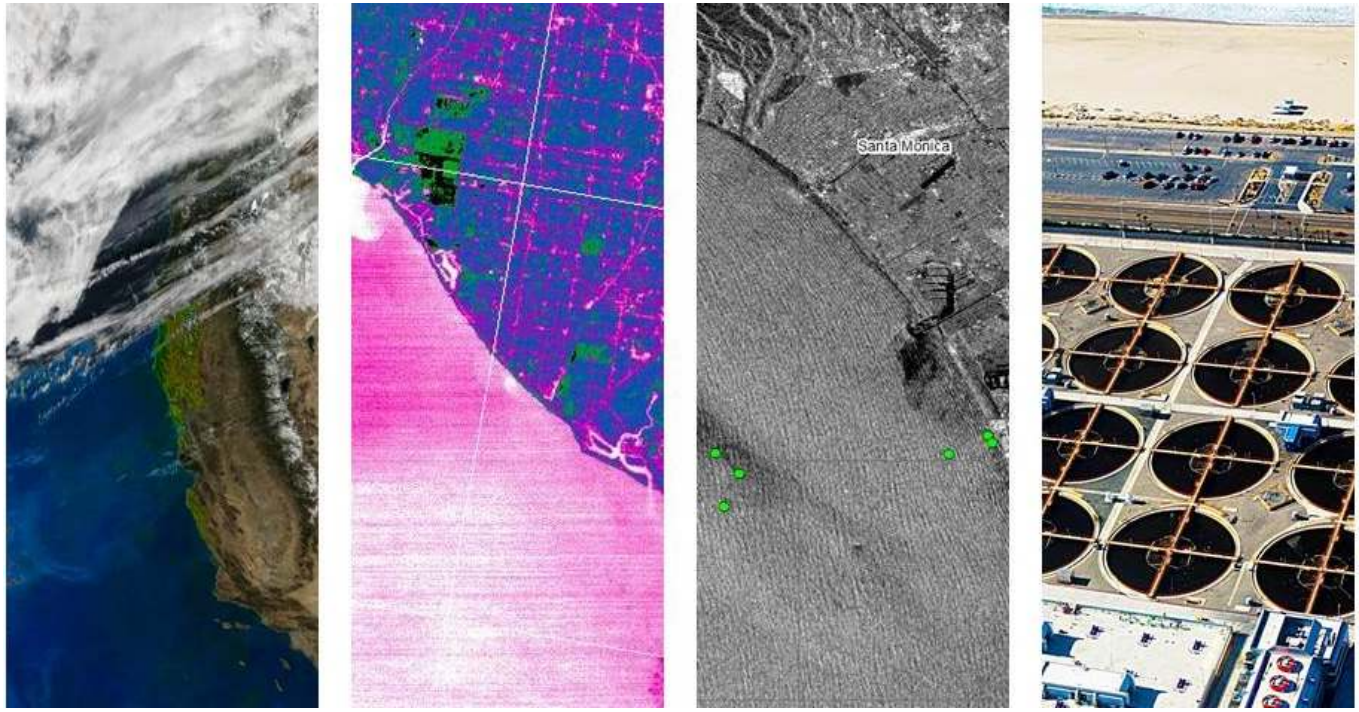
National Aeronautics and Space Administration

SOUTHERN CALIFORNIA OCEANS & WATER RESOURCES

Remote Sensing Detection of Wastewater Plumes to Assess Public Water Quality in Los Angeles and Orange Counties



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- **Rebecca Trinh** (University of California at Berkeley)

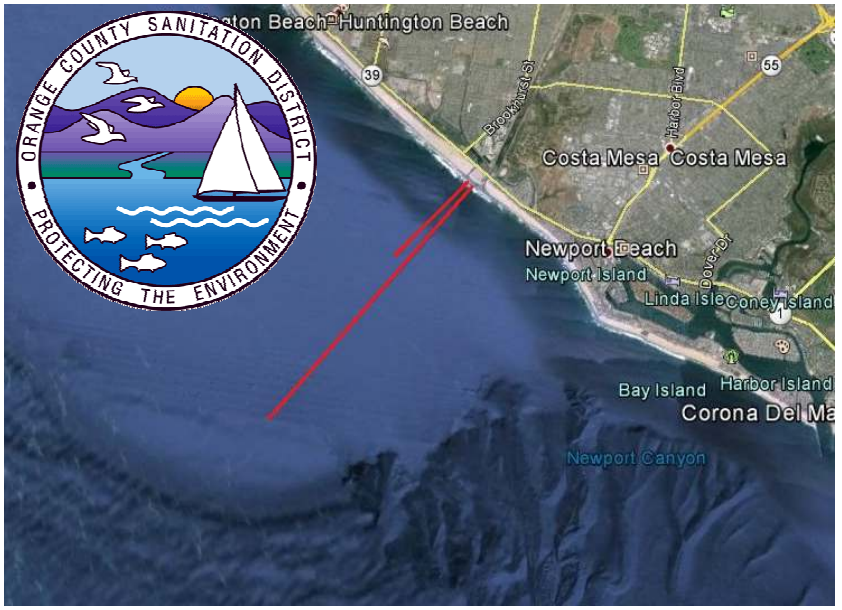
Jet Propulsion Laboratory
California Institute of Technology

Introduction

- Industrial, Commercial, and residential sewage in Los Angeles/Orange County is treated by Hyperion Wastewater Treatment Plant (HWTP) and the Orange County Sanitation District (OCSD) before it is released offshore.
- Treated sewage is released at the end of a 5-mile (~8km) outfall pipe in the deep ocean to prevent plume surfacing.
- During maintenance service, treated sewage is diverted to a 1-mile (1.6km) pipe that's much shallower, and close to shore.

Diversion events

- **Nov. 28–30, 2006 at HWTP** (3 days)
- **Sept. 11– Oct. 4, 2012 at OCSD** (24 days)



Introduction

- Field sampling is very labor intensive and time consuming.

  "When we diverted the outflow ... We literally had three boats taking samples around the clock."

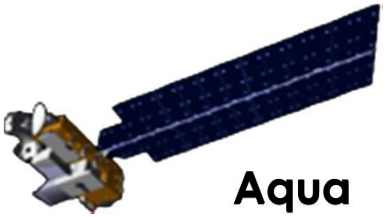
  -- Chris Cervellone, Engineering Supervisor at OCSD

- However, satellite remote sensing has the capability to sample large areas on a long time scale.

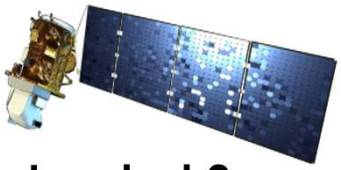
- Thus, NASA satellites could not only compliment in-situ analysis, but it could also potentially guide ground crew to the appropriate sampling site.

- Satellites in this study:
  - **Terra**: ASTER, MODIS
  - **Aqua**: MODIS
  - **Landsat 8**: TIRS
  - **ISS**: HICO
  - **Envisat**: ASAR, MERIS
  - **Radarsat-1**: SAR
  - **ALOS**: PALSAR

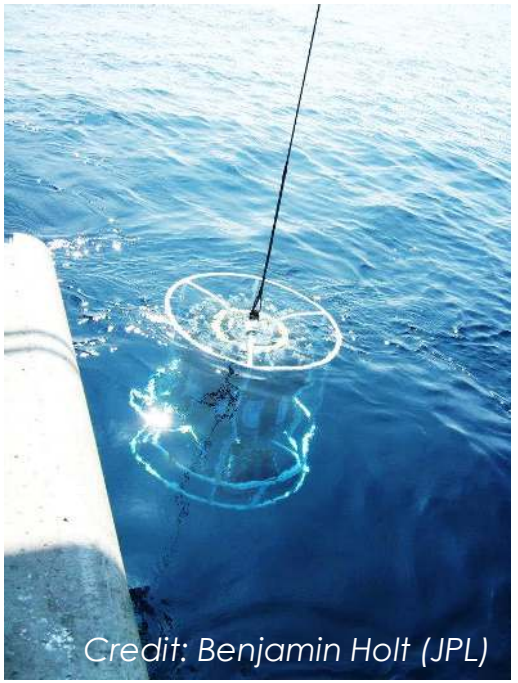
Terra



Aqua



Landsat 8



Credit: Benjamin Holt (JPL)

ASTER Results

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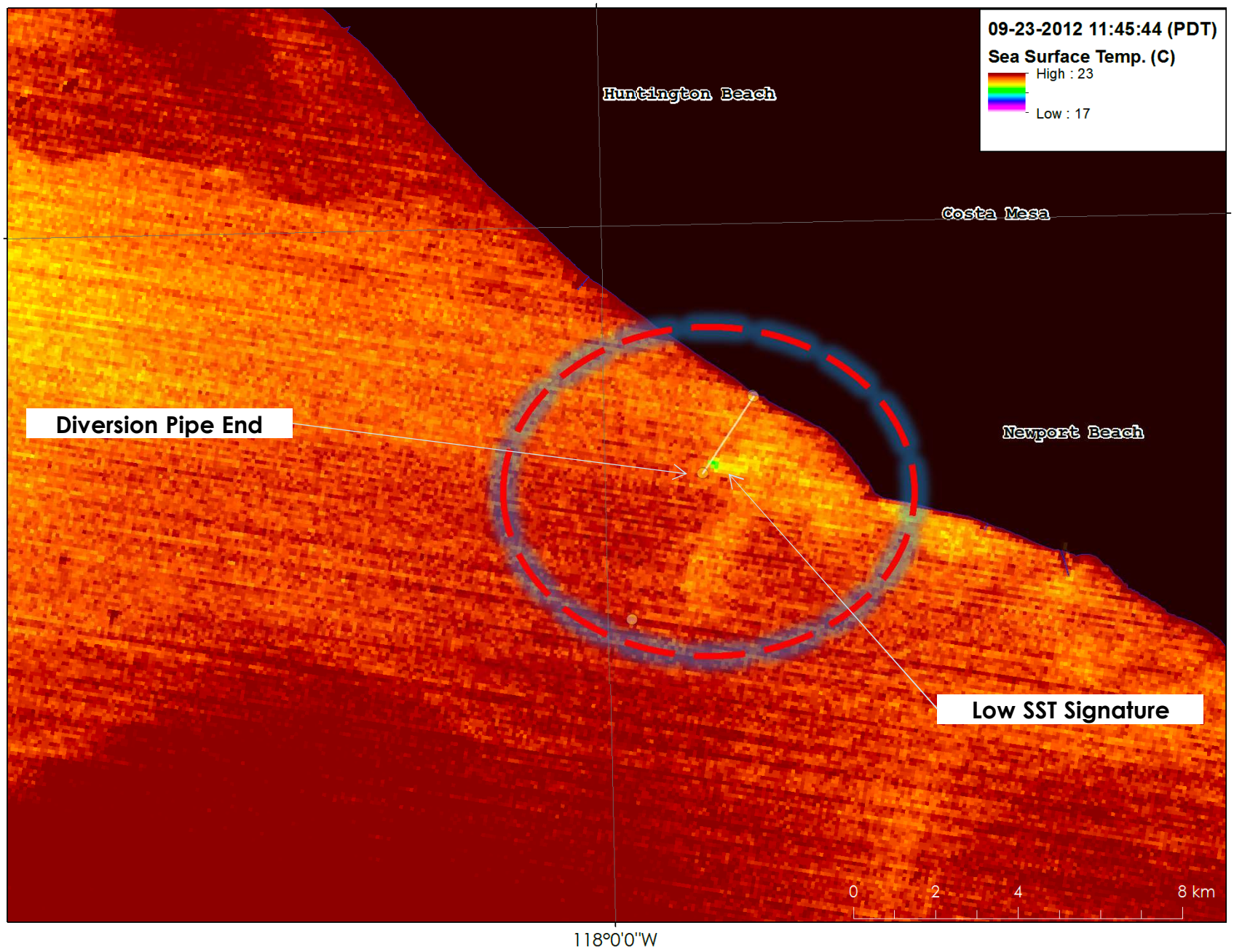
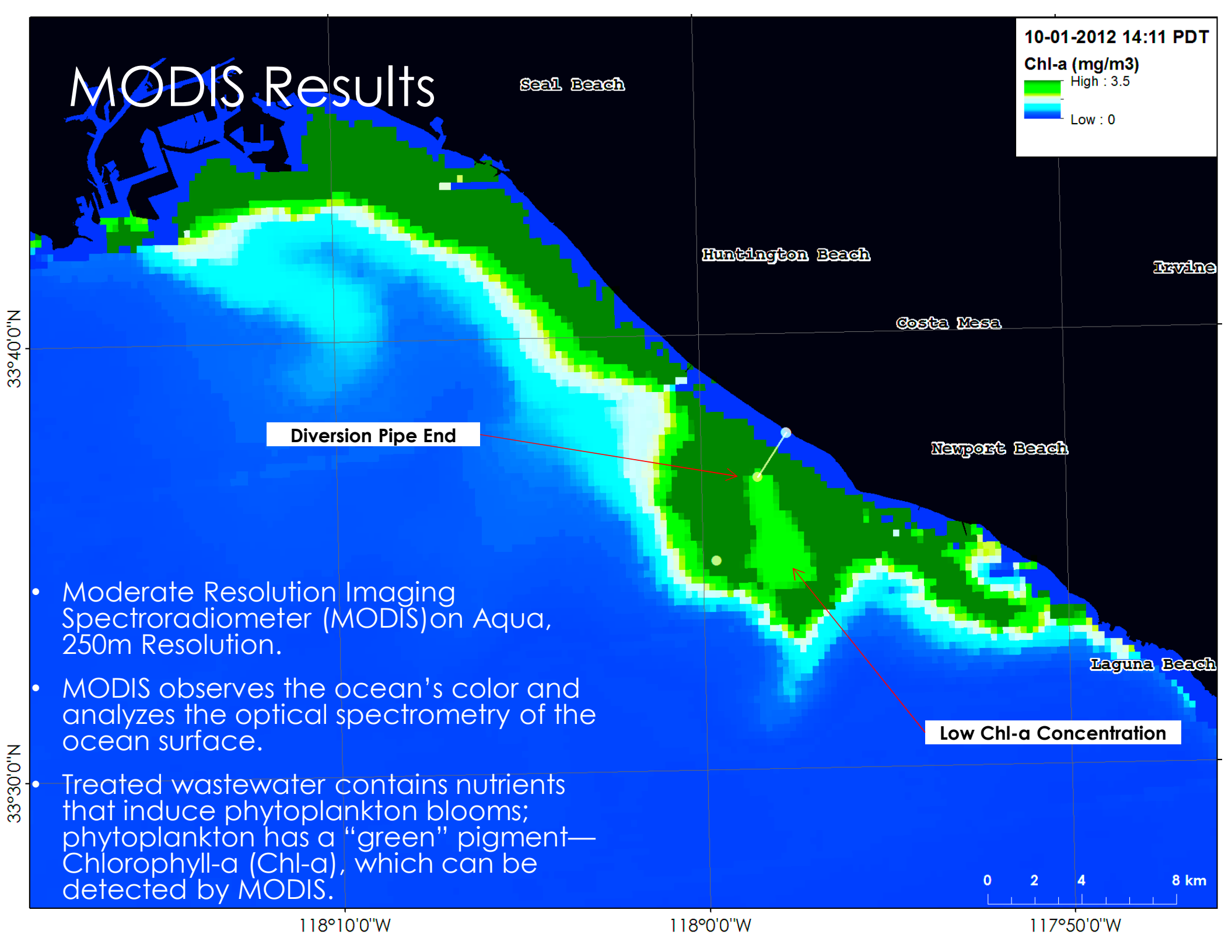




- Moderate Resolution Imaging Spectroradiometer (MODIS)on Aqua, 250m Resolution.
- MODIS observes the ocean's color and analyzes the optical spectrometry of the ocean surface.
- Treated wastewater contains nutrients that induce phytoplankton blooms; phytoplankton has a "green" pigment—Chlorophyll-a (Chl-a), which can be detected by MODIS.

MODIS Confirmation

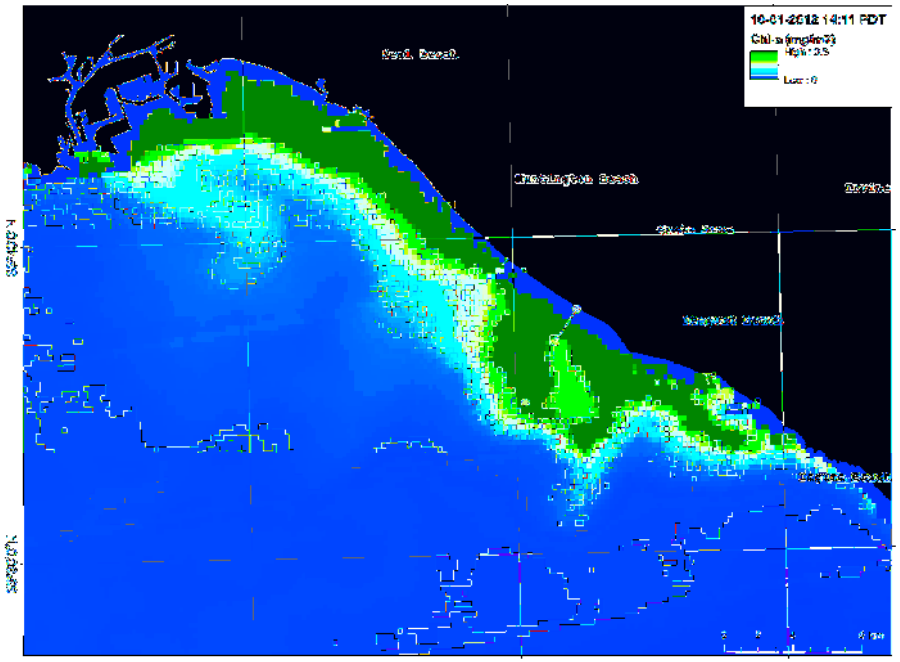
- Newly released treated wastewater disturbs phytoplankton growth despite its nutrient content.
- Chlorine (Cl_2) is added to the sewage towards the end of secondary treatment for terminating pathogens.

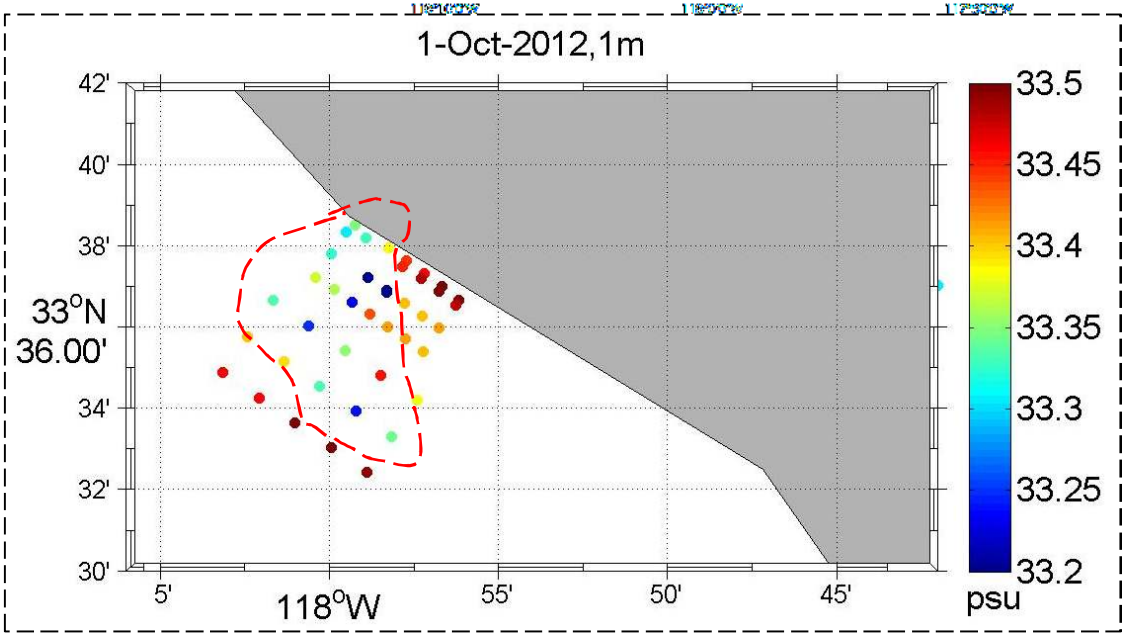
$Cl_2 + H_2O \rightarrow \mathbf{HOCl} + H^+ + Cl^-$

Depends on the pH:
$Cl_2 + 2H_2O \rightarrow HOCl + H3O + Cl^-$
$HOCl + H_2O \rightarrow H_3O^+ + \mathbf{OCl^-}$

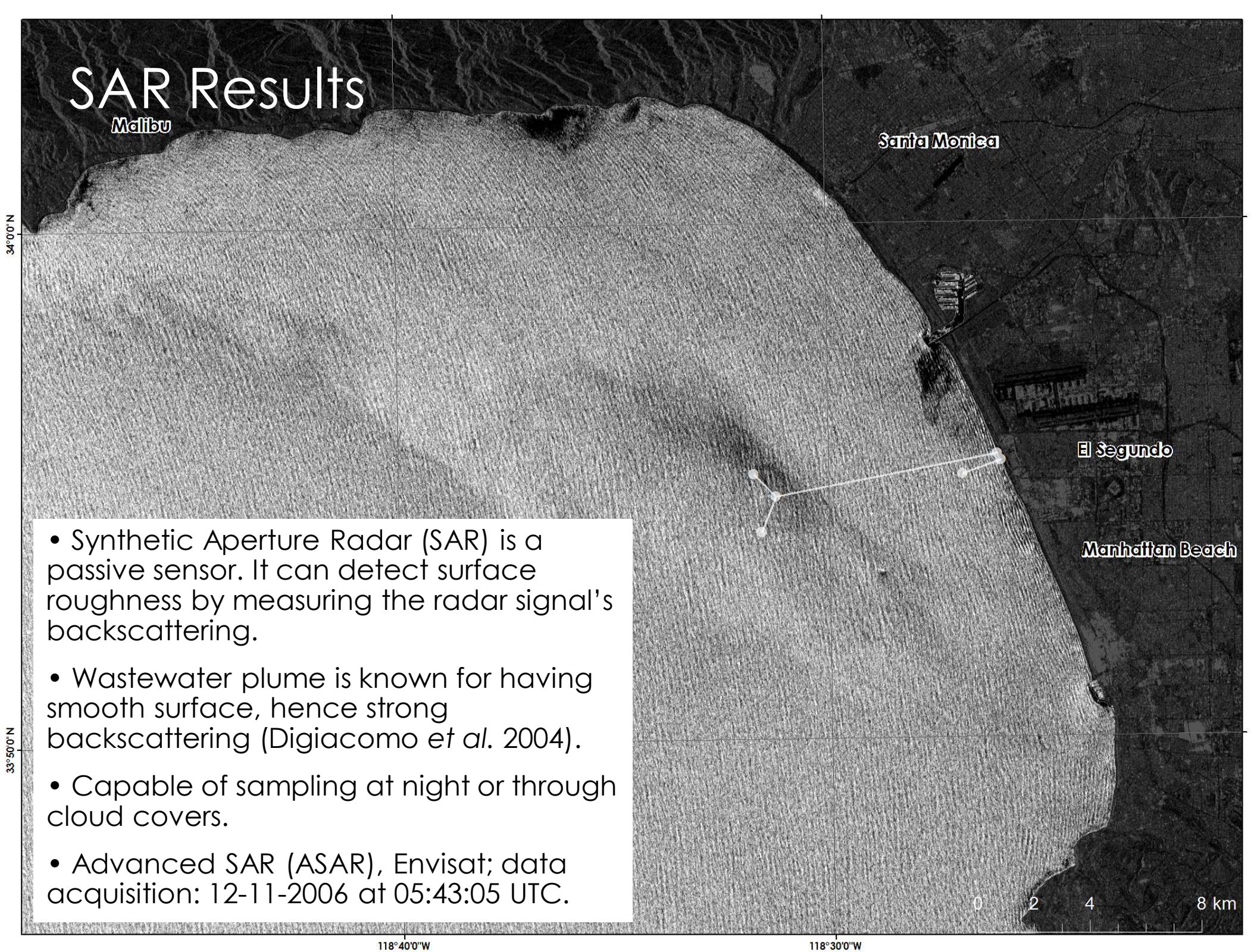
$OCl^- \rightarrow Cl^- + O$

- Underchloric acid (HOCl) and hypochlorite ions (OCl^-) are very powerful disinfectants. They can effectively kill bacteria and fungi, but suppressing phytoplankton growth in the process.
- Furthermore, in-situ salinity samples display a freshwater patch, which confirm the surfacing of treated wastewater.





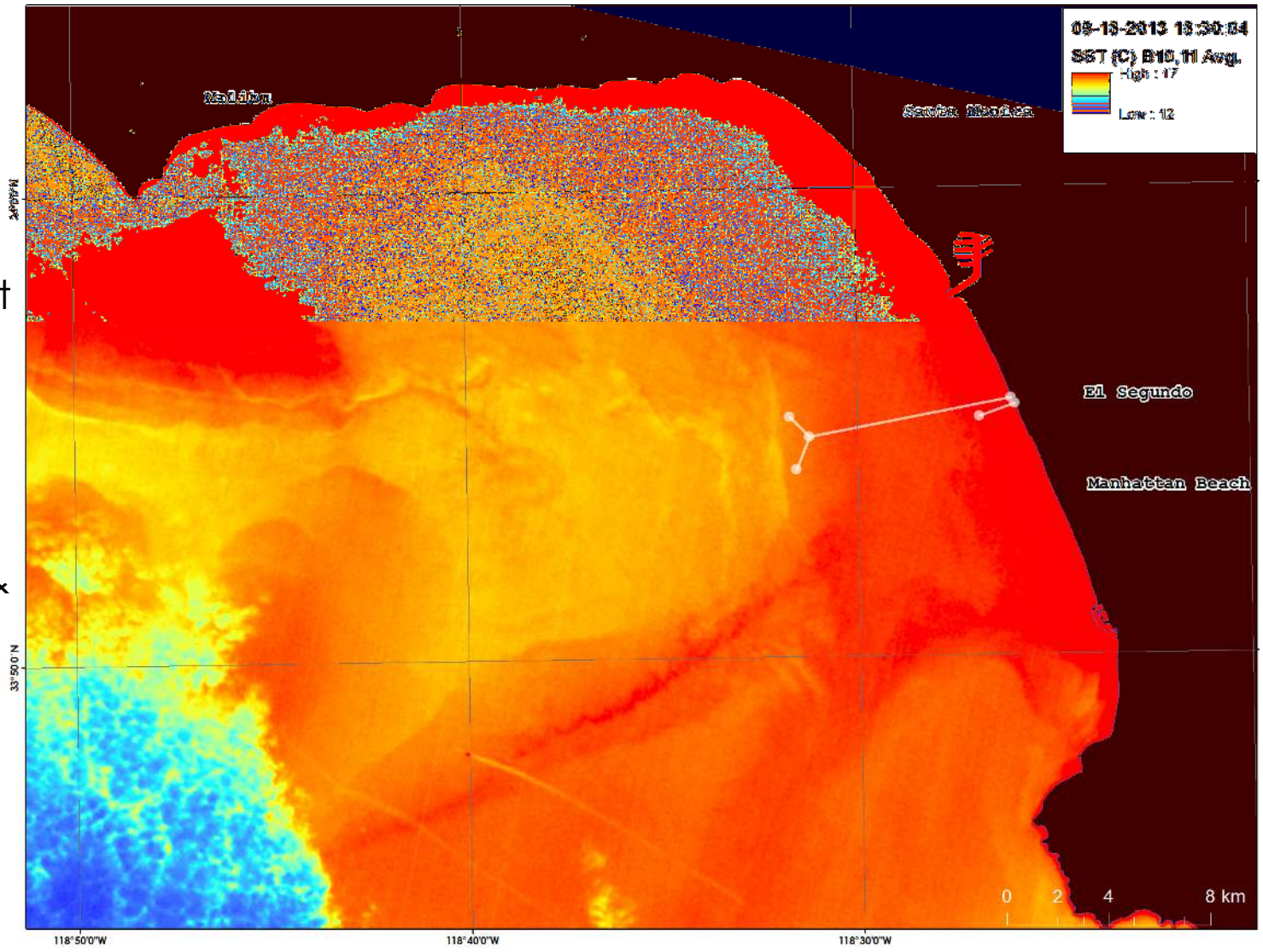
SAR Results



- Synthetic Aperture Radar (SAR) is a passive sensor. It can detect surface roughness by measuring the radar signal's backscattering.
- Wastewater plume is known for having smooth surface, hence strong backscattering (Digiacomo *et al.* 2004).
- Capable of sampling at night or through cloud covers.
- Advanced SAR (ASAR), Envisat; data acquisition: 12-11-2006 at 05:43:05 UTC.

Landsat 8 Results

- Landsat 8 launched on February 11, 2013; Thermal Infrared Sensor (TIRS) is on board.
- Band 10 & 11 (100m resolution) can detect surface thermal infrared, hence can be used to derive SST data.
- Imagery on the right: 09-18-2013, band 10 & 11 average.
- Landsat 8 and other satellite missions can assist future diversion events.
- A 7- week diversion is scheduled for 2015 at HWTP.



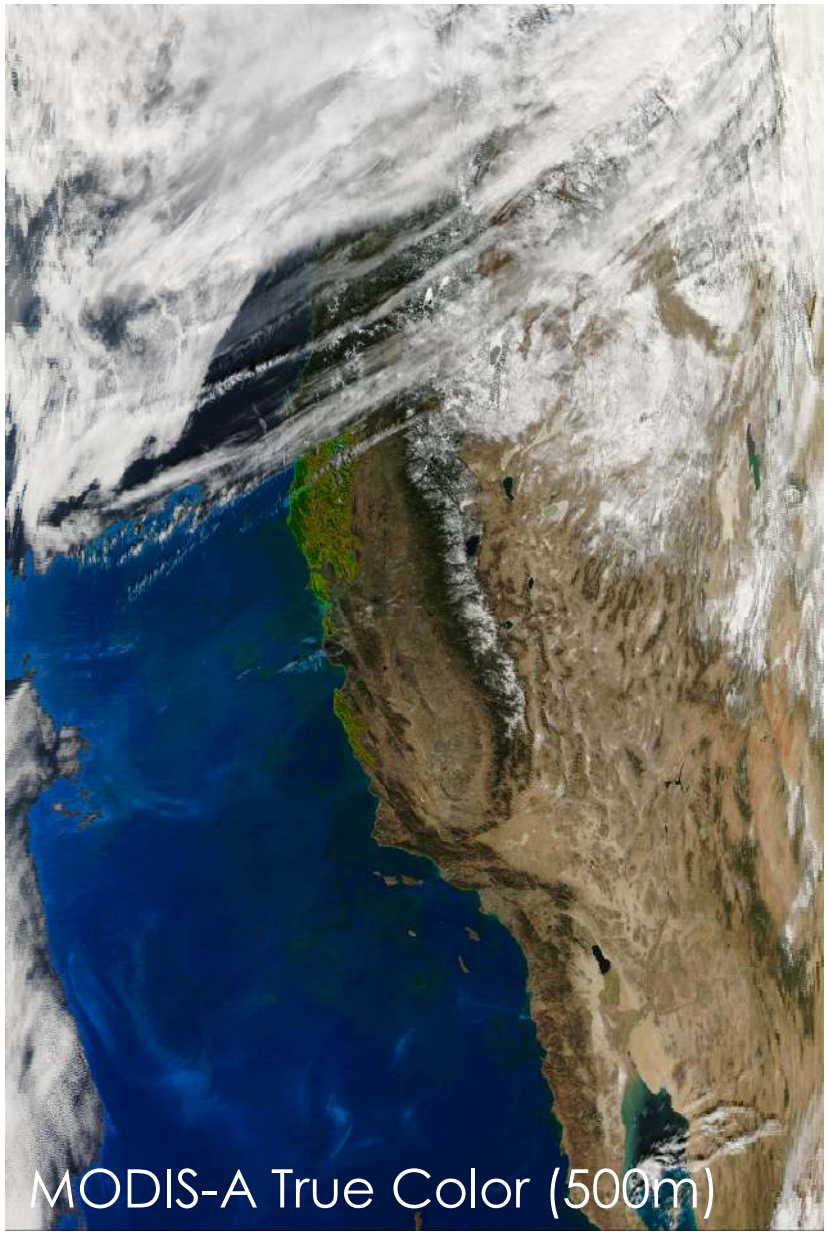
Acknowledgements

I would like to acknowledge other SoCal Oceans Team members: **Christine Rains** and **Rebecca Trinh**.

The SoCal Oceans Team would like to thank our science advisors—**Ben Holt** (JPL) and **Michelle Gierach** (JPL) for data retrieval and assisting us in data analysis.

We would also like to acknowledge our project partners: **Curtis Cash** and **Mas Dojiri** at the HWTP, **George Robertson** at OCSD, and **Meredith Howard** at SCCWRP.

Their contributions along with the **NASA DEVELOP Program** have made this project possible.



MODIS-A True Color (500m)