

Satellite-based Ocean Color Tools for Coral Reef Management



Erick Geiger, William Hernandez, Brianna Craig, Rob Warner, Alan E. Strong, C. Mark Eakin, Menghua Wang, Jacqueline L. De La Cour, Gang Liu, Kyle Tirak, Scott F. Heron, William J. Skirving



STAR JPSS Annual Team Meeting
August 16, 2017 - NCWCP, College Park, MD



STAR
Ocean Color



UNIVERSITY OF PUERTO RICO
MAYAGÜEZ CAMPUS



UNIVERSITY of HAWAII*
MAUI COLLEGE



NOAA
CORAL REEF
CONSERVATION PROGRAM

Ocean Color

How can it help coral reef managers?

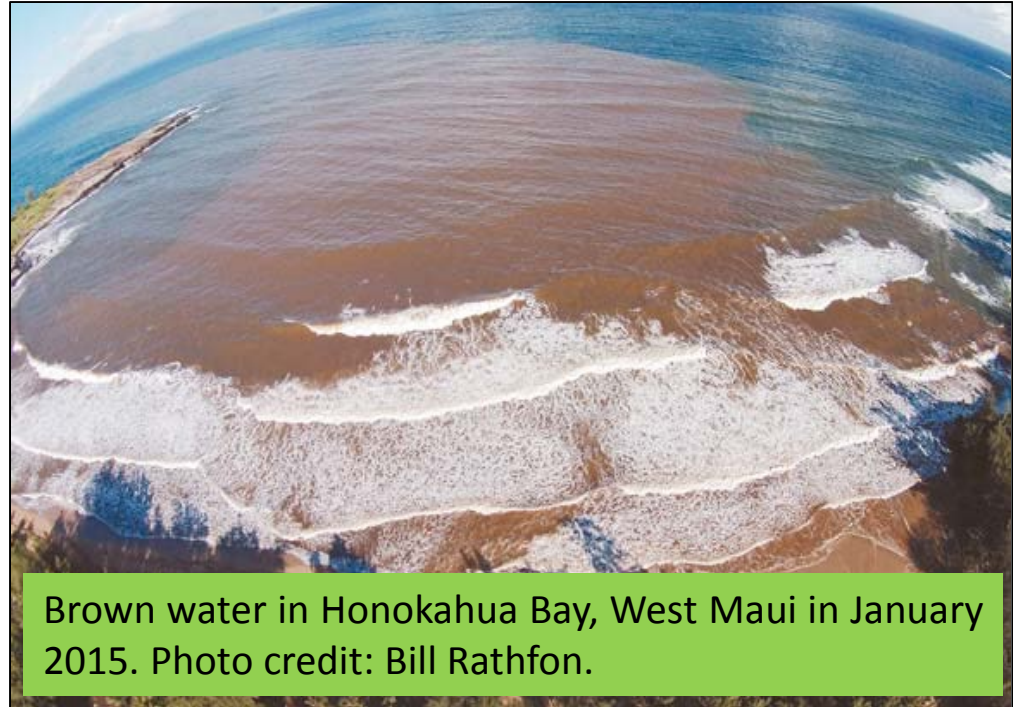
The color of coastal water is related to water quality.

Satellite ocean color data provide a synoptic view of water quality.

Of the many satellite ocean color products, two are most commonly used for monitoring water quality:

Chlorophyll-a

Represents phytoplankton biomass and nutrient status (**productivity**) as an index of water quality.



Brown water in Honokahua Bay, West Maui in January 2015. Photo credit: Bill Rathfon.

$K_d(490)$

The diffuse attenuation coefficient at 490nm (or light blue in the visible spectrum).

Total organic and inorganic matter held in solution and suspension (**turbidity**) within the water column.

Review

Goal:

Provide satellite products for monitoring land-based sources of pollution over coral reef environments tailored to managers' feedback.

FY13/14:

NOAA NESDIS STAR's Ocean Color Team and NOAA Coral Reef Watch conduct "proof of concept" pilot effort using daily ocean color data from the Visible Infrared Imaging Radiometer Suite (VIIRS) matched with large rainfall events. Study areas include Southern Puerto Rico (Guánica) and West Maui (Ka'anapali) watersheds.

FY15/16:

VIIRS data updated to "science quality" and spatial resolution of products enhanced. Begin creating virtual monitoring areas and experimental anomaly products. Cal/Val efforts are advanced with Puerto Rico partners and initiated with West Maui partners.

Review

FY16/17:

Held workshop in West Maui for local watershed manager feedback and to expand user group. Provided student intern with lab equipment for collecting *in situ* water quality data. VIIRS MLS12 v1.21 reprocessing.

Ongoing:

Continue development of virtual monitoring areas. Develop multi-sensor approach with Landsat 8, Sentinel-2. Expand managers' workstation and populate with new VIIRS data, including 375m resolution data.

Study Area

U.S. Coral Reef Task Force priority watershed sites:

- Ka'anapali (West Maui, Hawai'i)
- Faga'alu (American Samoa)
- Guánica Bay (Puerto Rico).

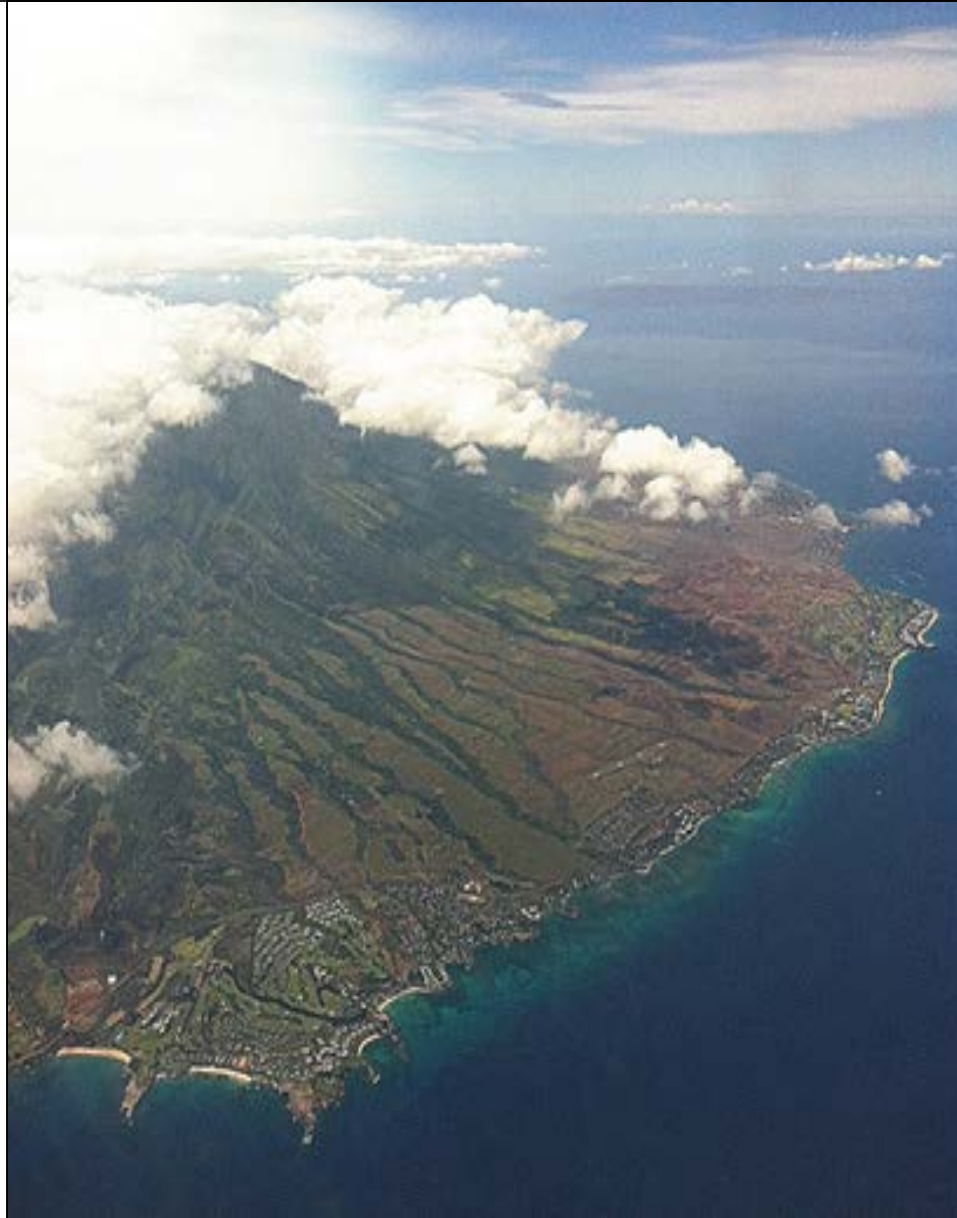
US Coral Reef Task Force Priority Watersheds



Study Site

West Maui – Five Watersheds

- Three distinct management zones: Urban, Agricultural, Conservation
- Anticipating land use change in the next decade



West Maui North Runoff Example - Mid January 2016



Photo credit: Multicopter Maui

West Maui Airport Watershed (Central)

USGS



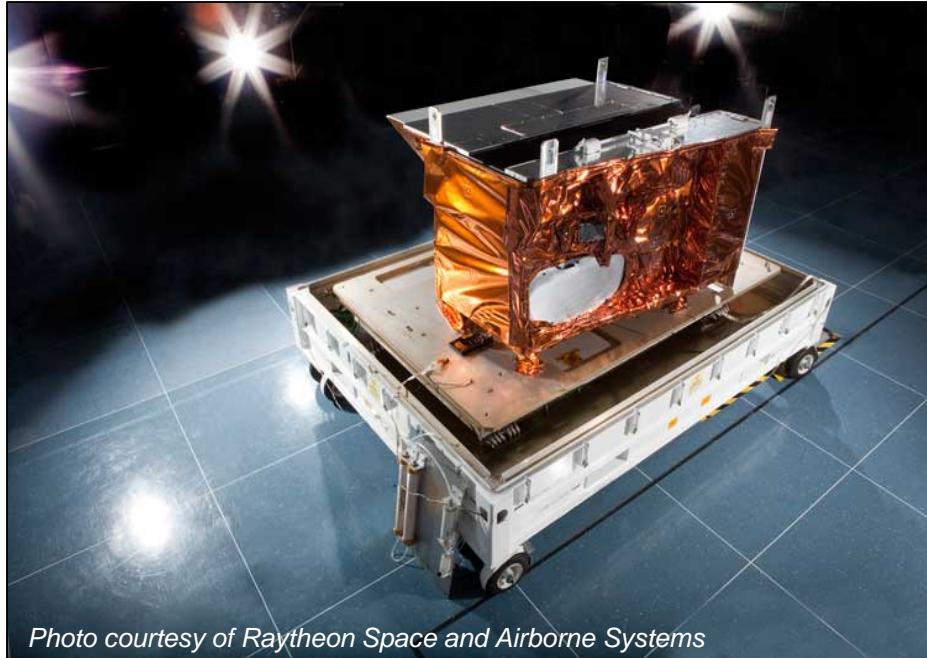
West Maui Hotel Complex (South)



Role for Ocean Color Project

- Which drainages are the biggest source of stressors (nutrient and sediment)?
- How long does sediment persist?
- What are the circulation patterns?
- Which drainages are triggered at what rainfall intensity?
- Can we observe improvements after mitigation on land?

Visible Infrared Imaging Radiometer Suite (VIIRS)



Provides ocean color data at ~750m resolution.

Daily, afternoon pass. One pass a day (no ocean color at night).

Science quality data delayed 2 weeks. Near real-time data is delayed 1 day.

Geophysical data:

Chlorophyll-a (mg/m^3)

$K_d(490)$ (m^{-1})

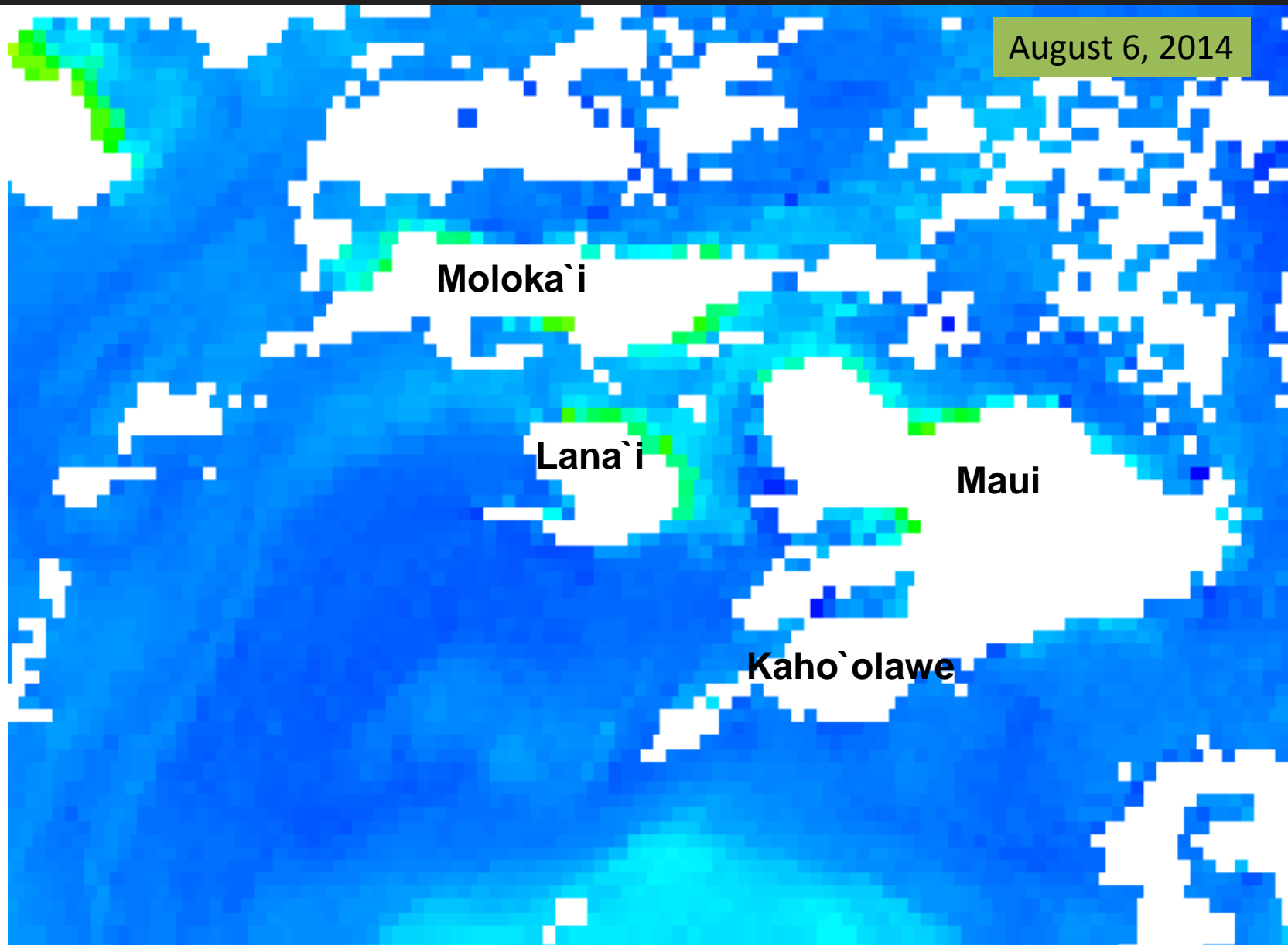
$K_d(\text{PAR})$ (m^{-1})

Normalized water-leaving radiance at:

410, 443, 486, 551, 671nm ($\text{mW}/\text{cm}^2/\text{um}/\text{sr}$)

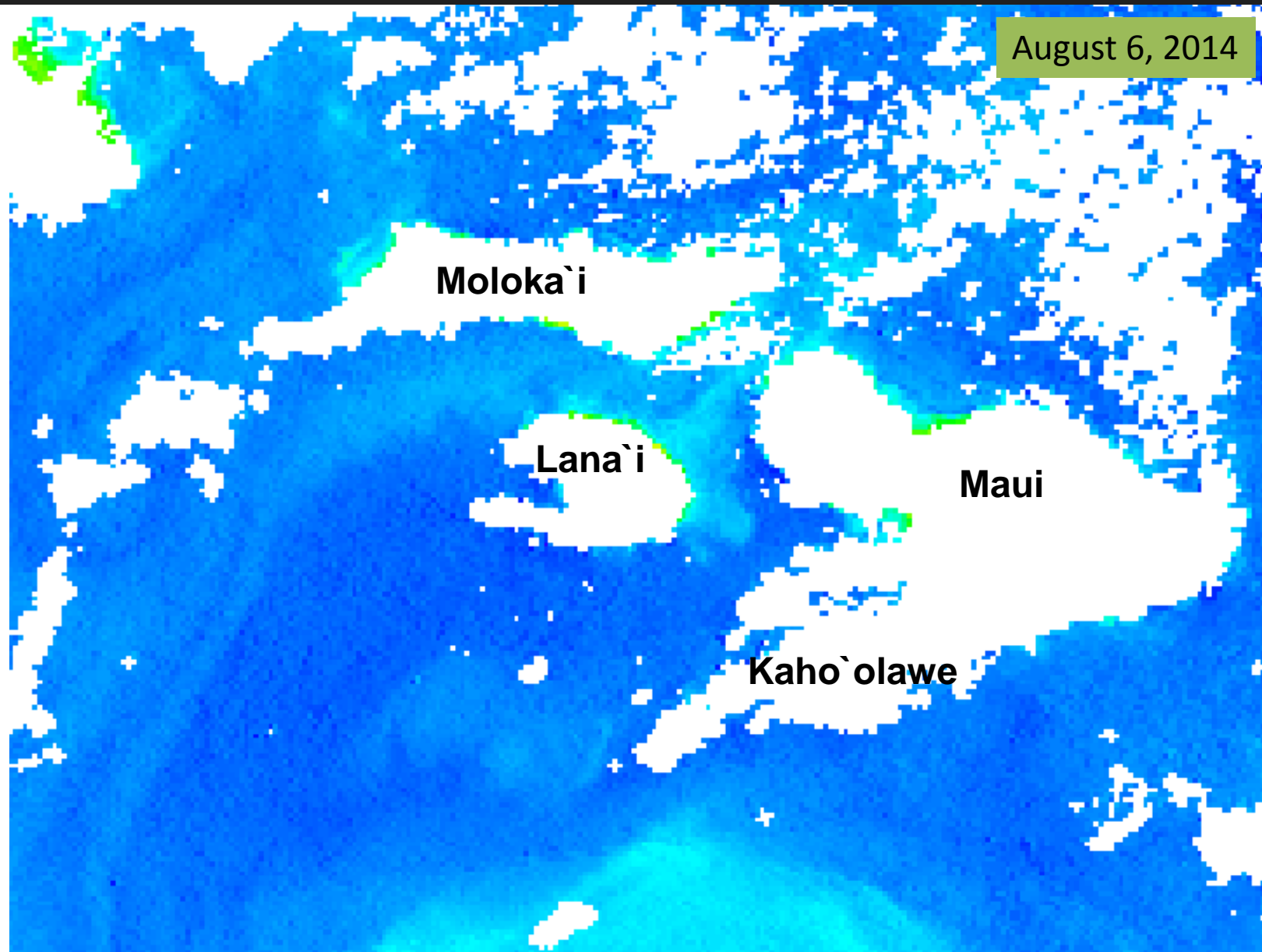
Visible Infrared Imaging Radiometer Suite (VIIRS)

Chlorophyll-a prototype 2km resolution



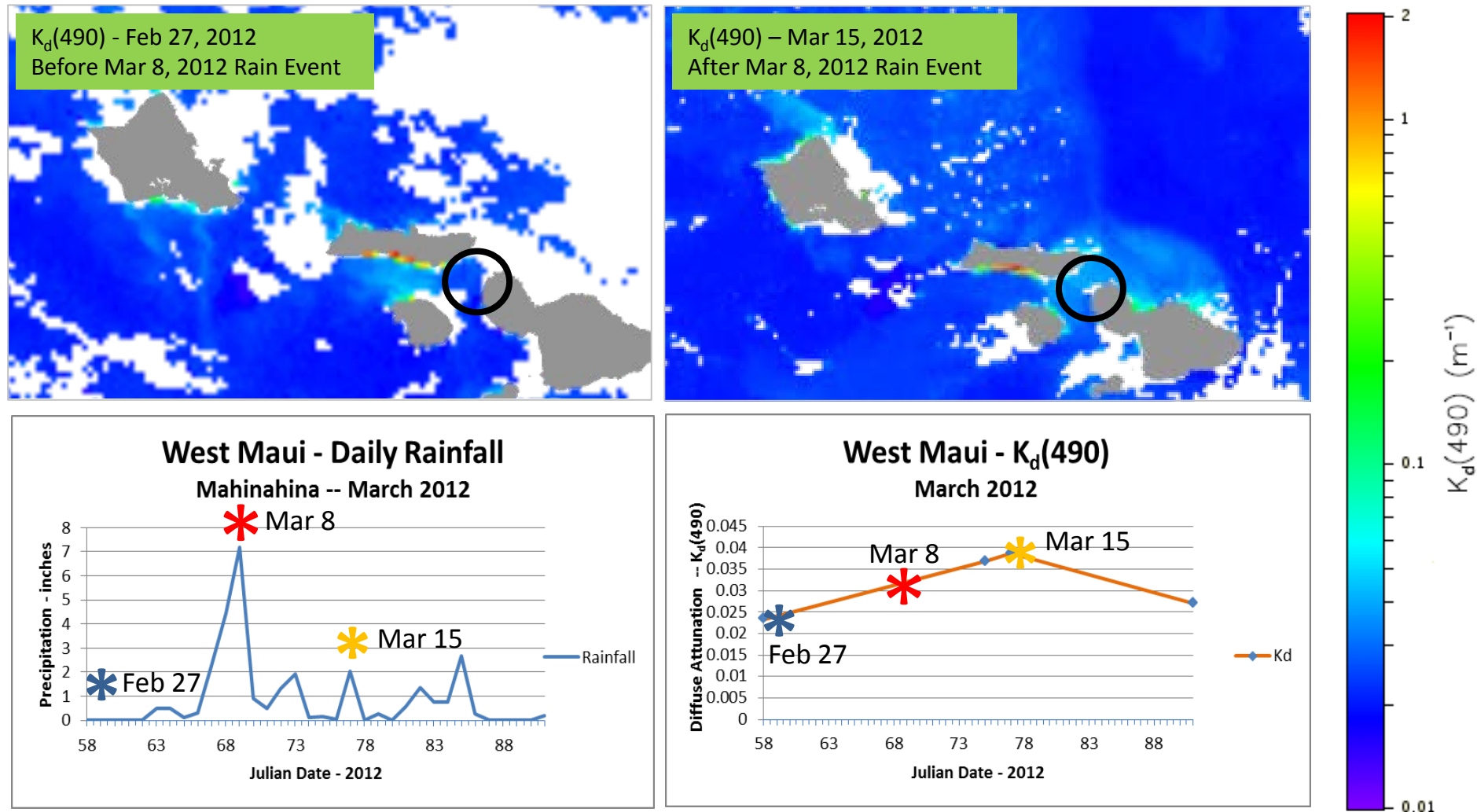
Visible Infrared Imaging Radiometer Suite (VIIRS)

Chlorophyll-a prototype 750m resolution



Proof of Concept

Matching with Precipitation Events

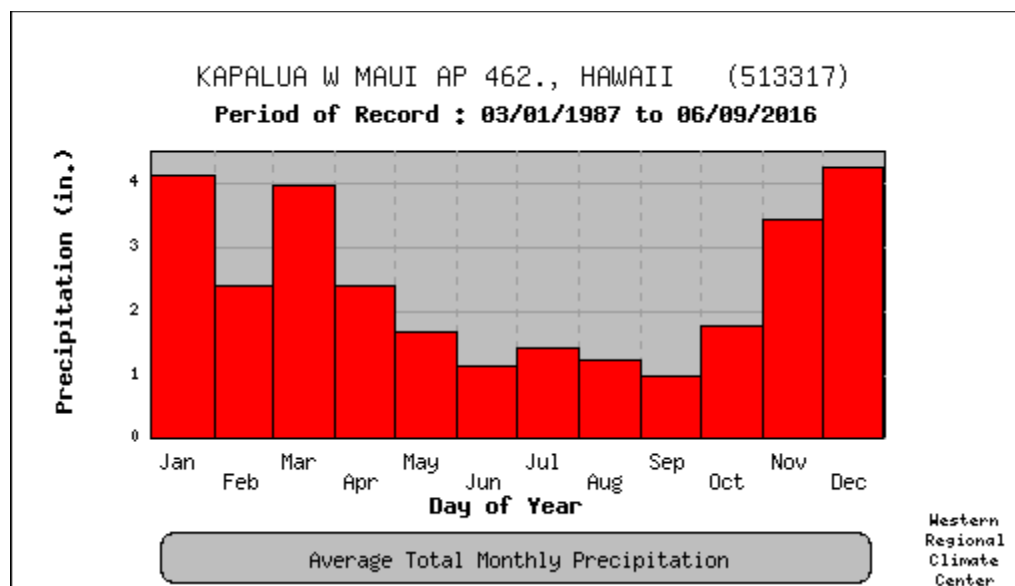


Top left and right: VIIRS $K_d(490)$ images for February 27 and March 15, 2012. Black circles indicate the West Maui watershed. **Bottom left:** Daily rainfall amounts in Mahinahina from February 27 to March 31, 2012. **Bottom right:** $K_d(490)$ values near West Maui watershed for the same time period. The large rainfall event is associated with a local rise in $K_d(490)$ or turbidity.

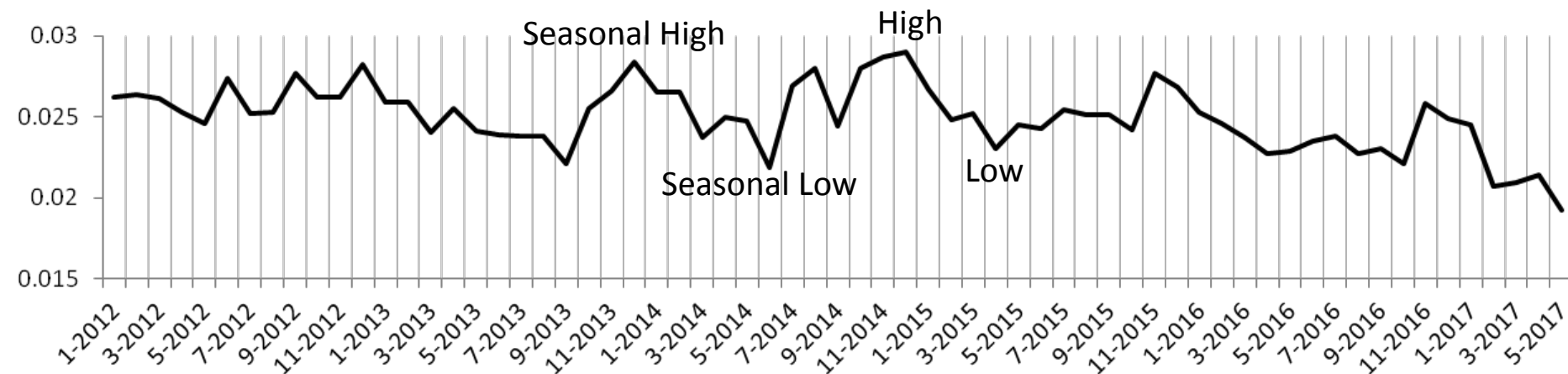


Western Regional Climate Center

PROVIDING CLIMATE SERVICES SINCE 1986

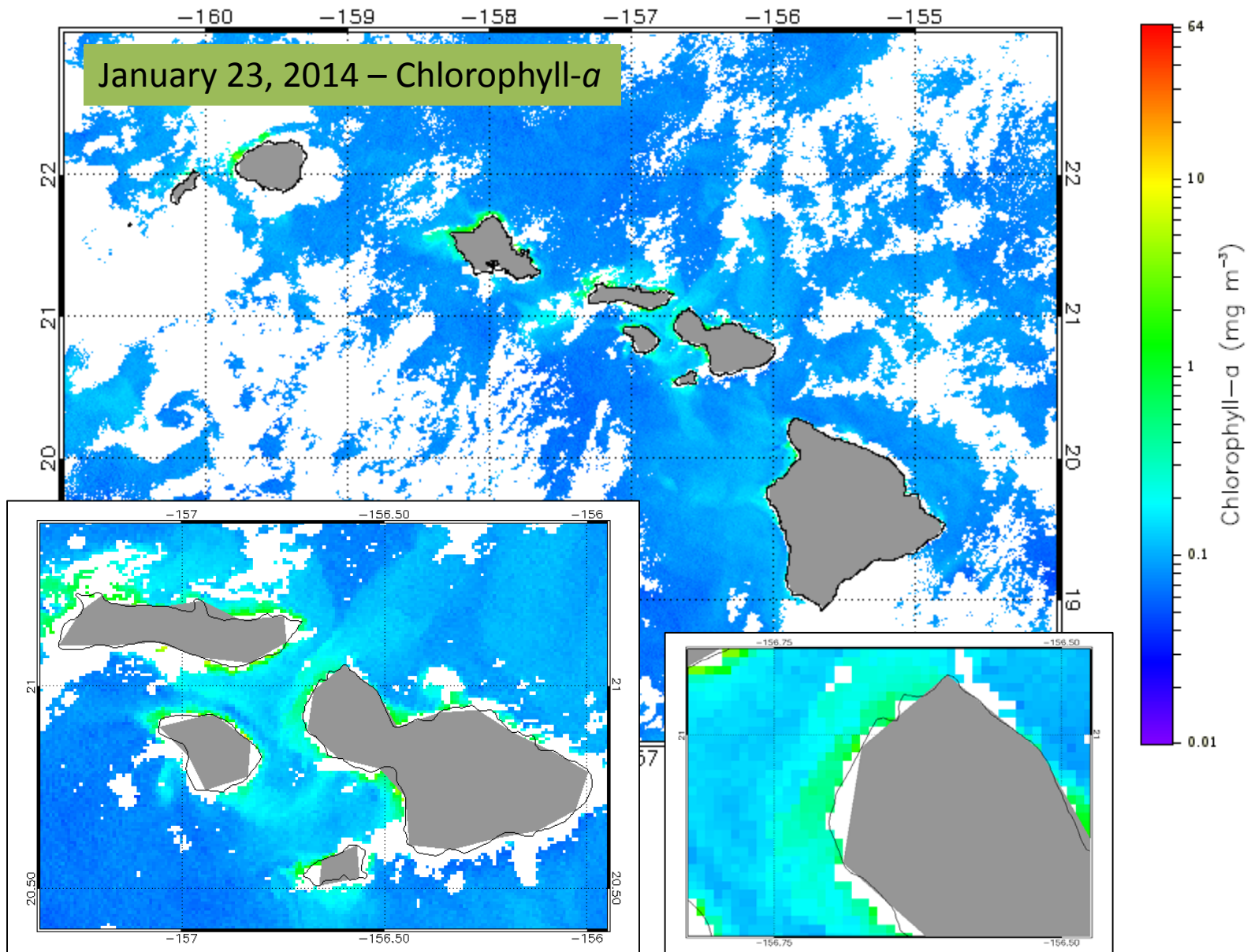


VIIRS Monthly Mean $K_d(490)$ for West Maui Region (2012 – mid 2017)



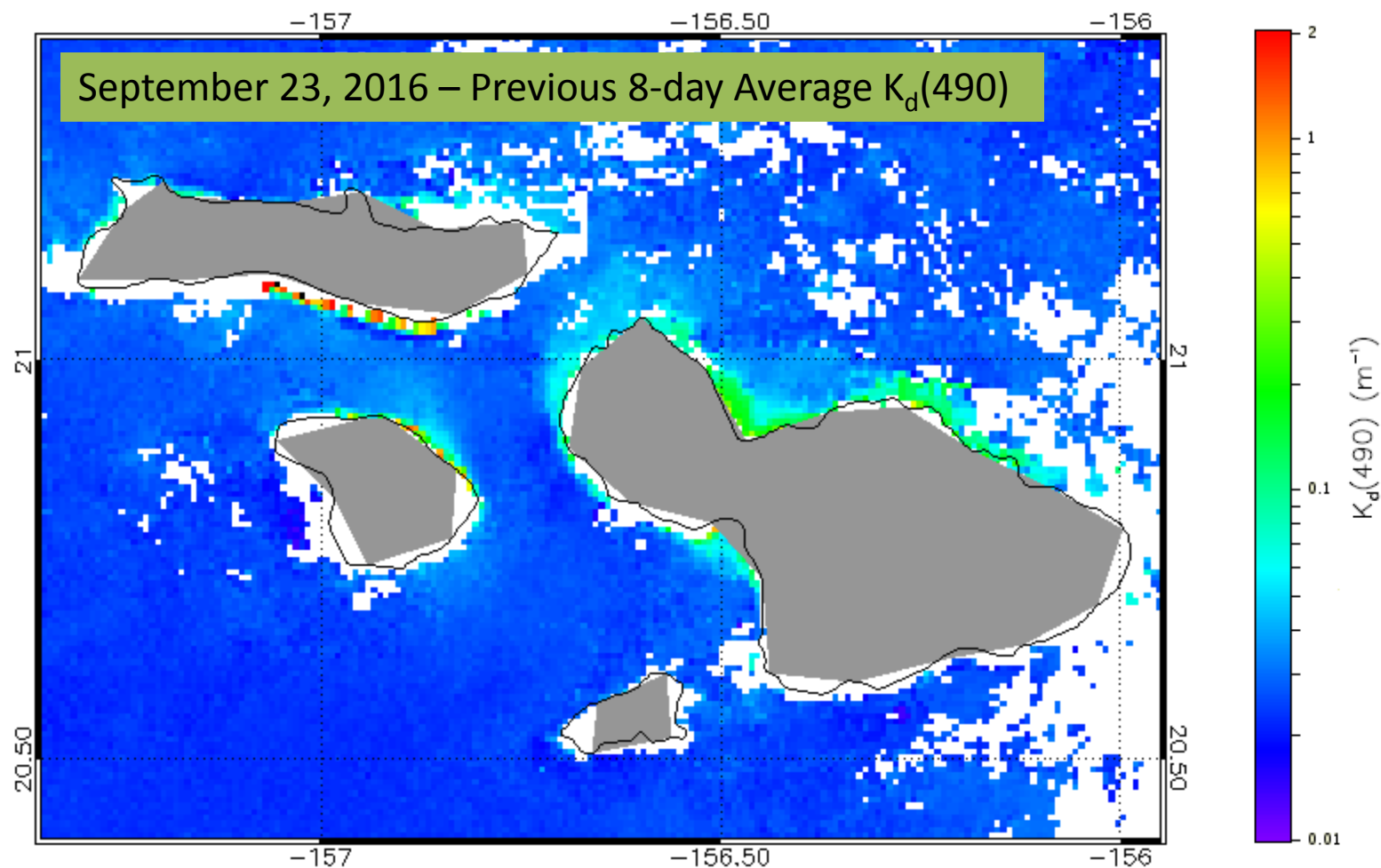
Coral Reef Watch Tools

Daily Mapped Ocean Color Images – 750m



Coral Reef Watch Tools

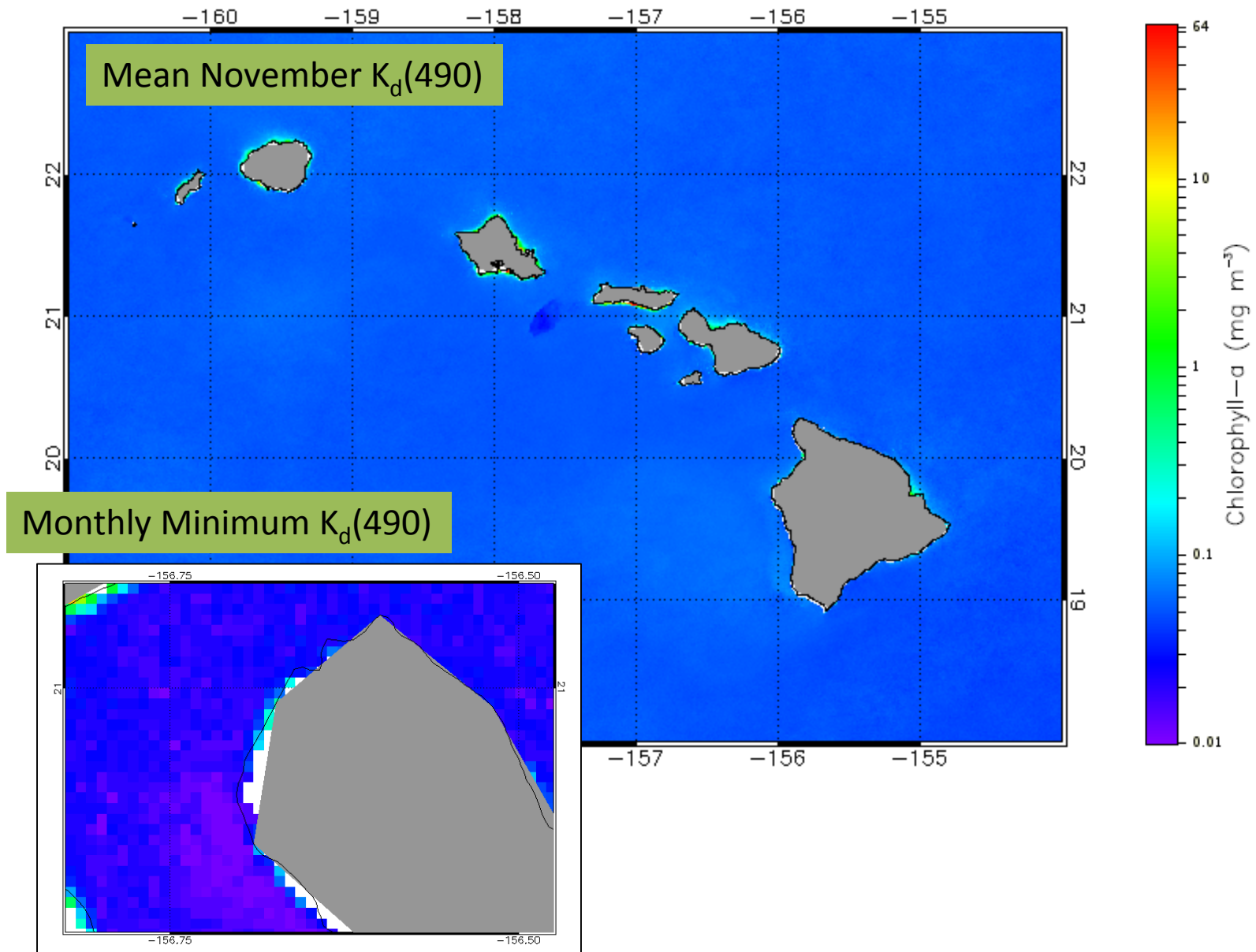
3- and 8-Day Average Ocean Color Images – 750m



September 22-30, 2016: Brown water events captured by drones

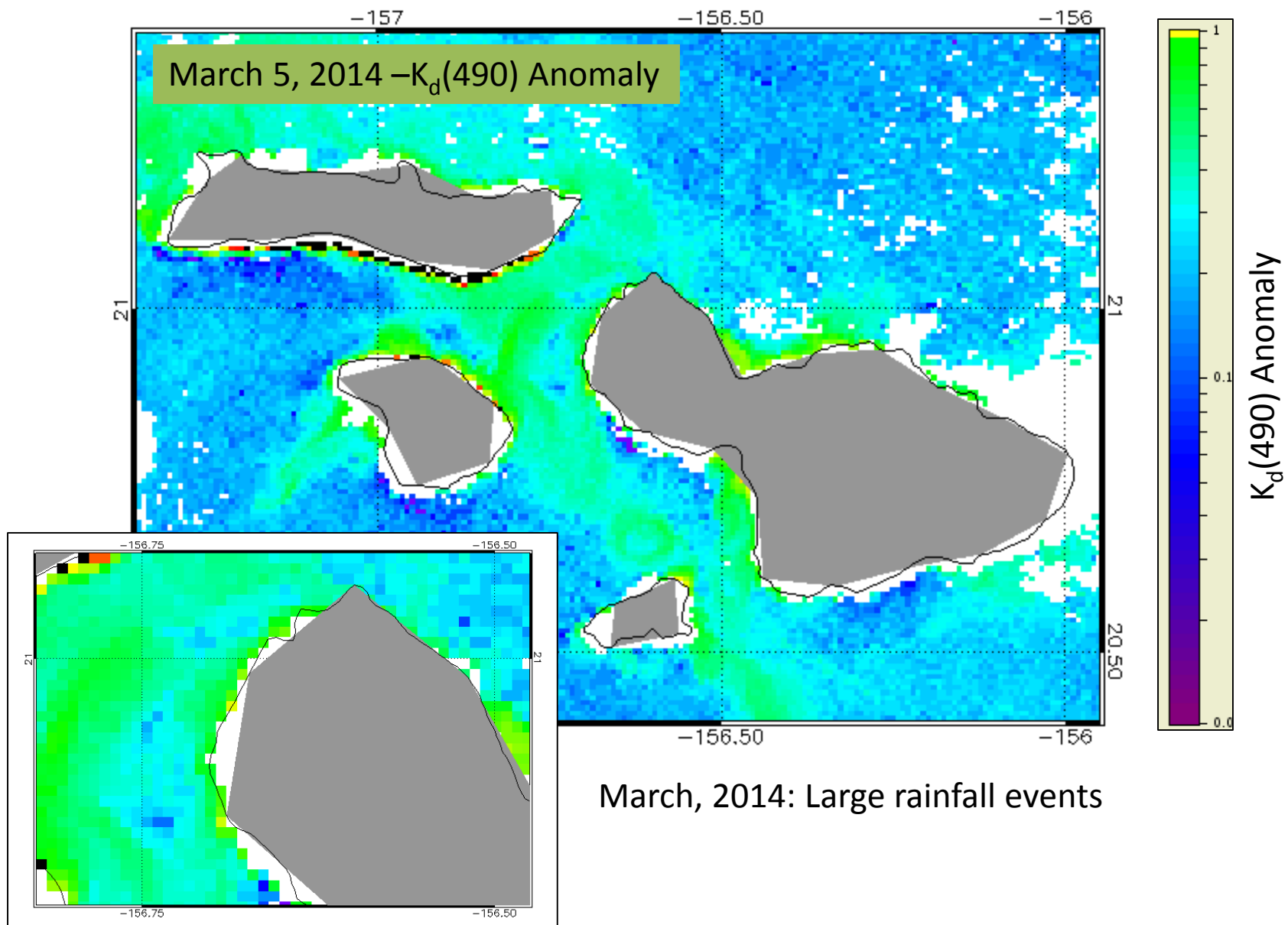
Coral Reef Watch Tools

Climatological Means and Minimums



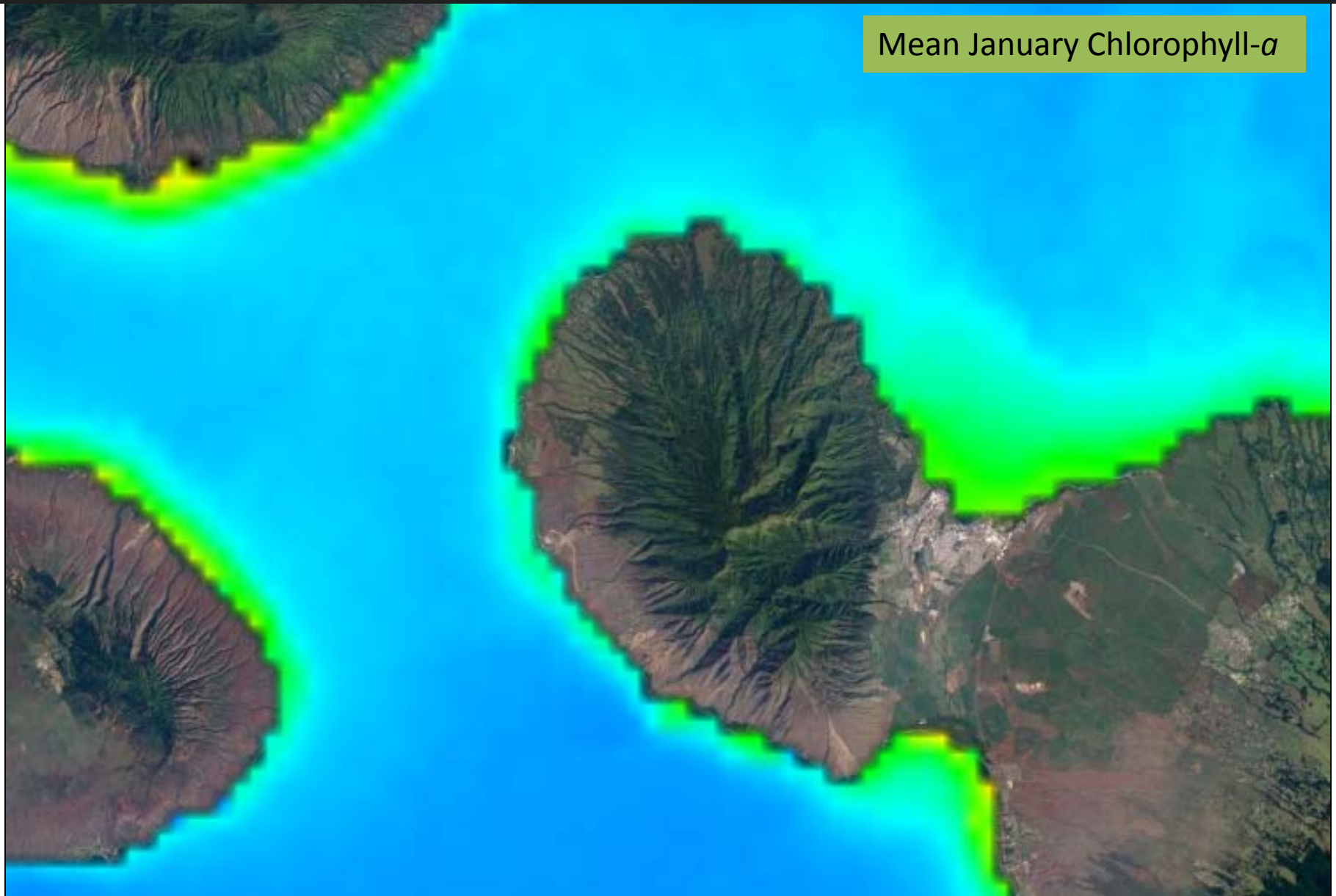
Coral Reef Watch Tools

Anomalies



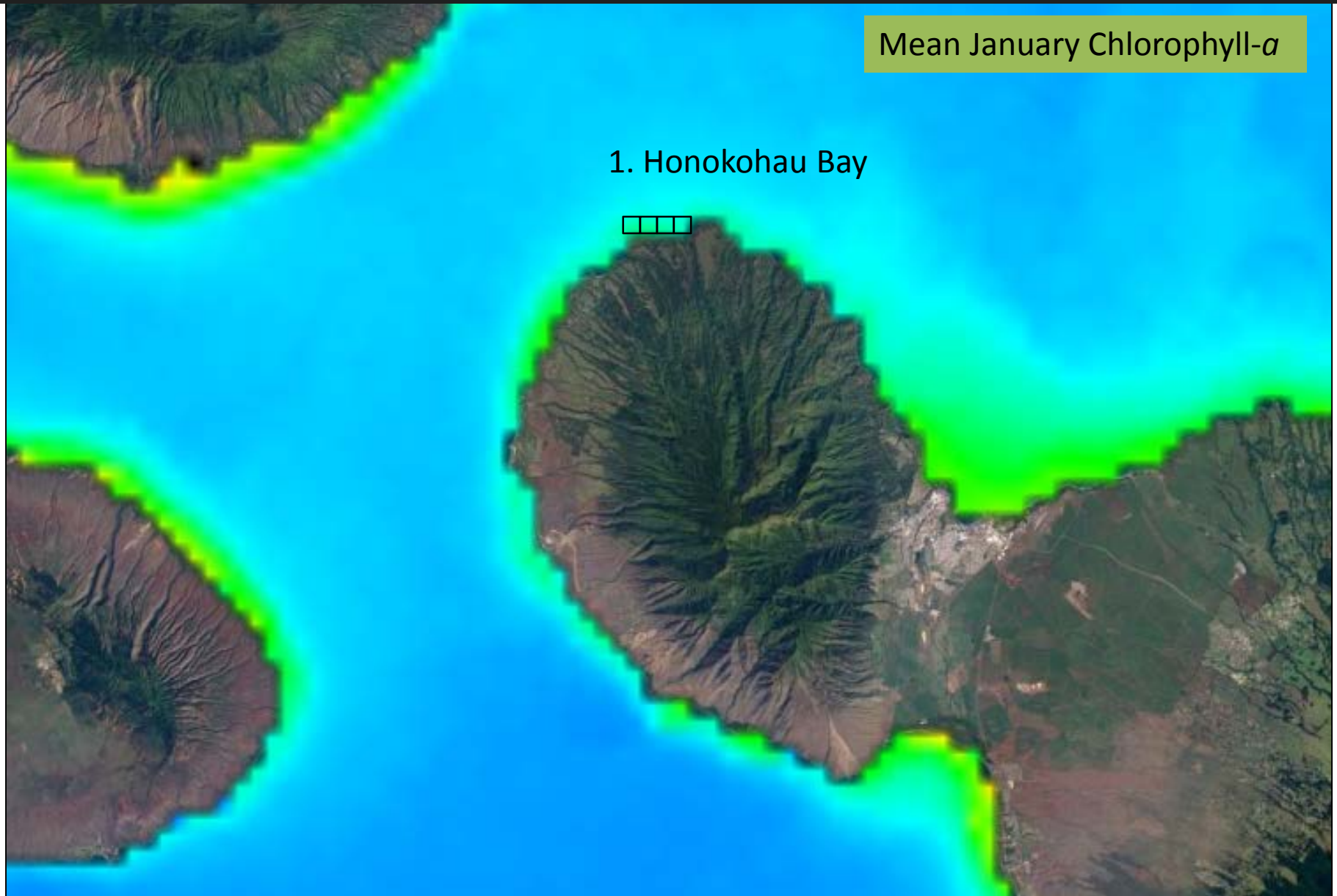
Coral Reef Watch Tools

Virtual Monitoring Areas



Coral Reef Watch Tools

Virtual Monitoring Areas



Coral Reef Watch Tools

Virtual Monitoring Areas

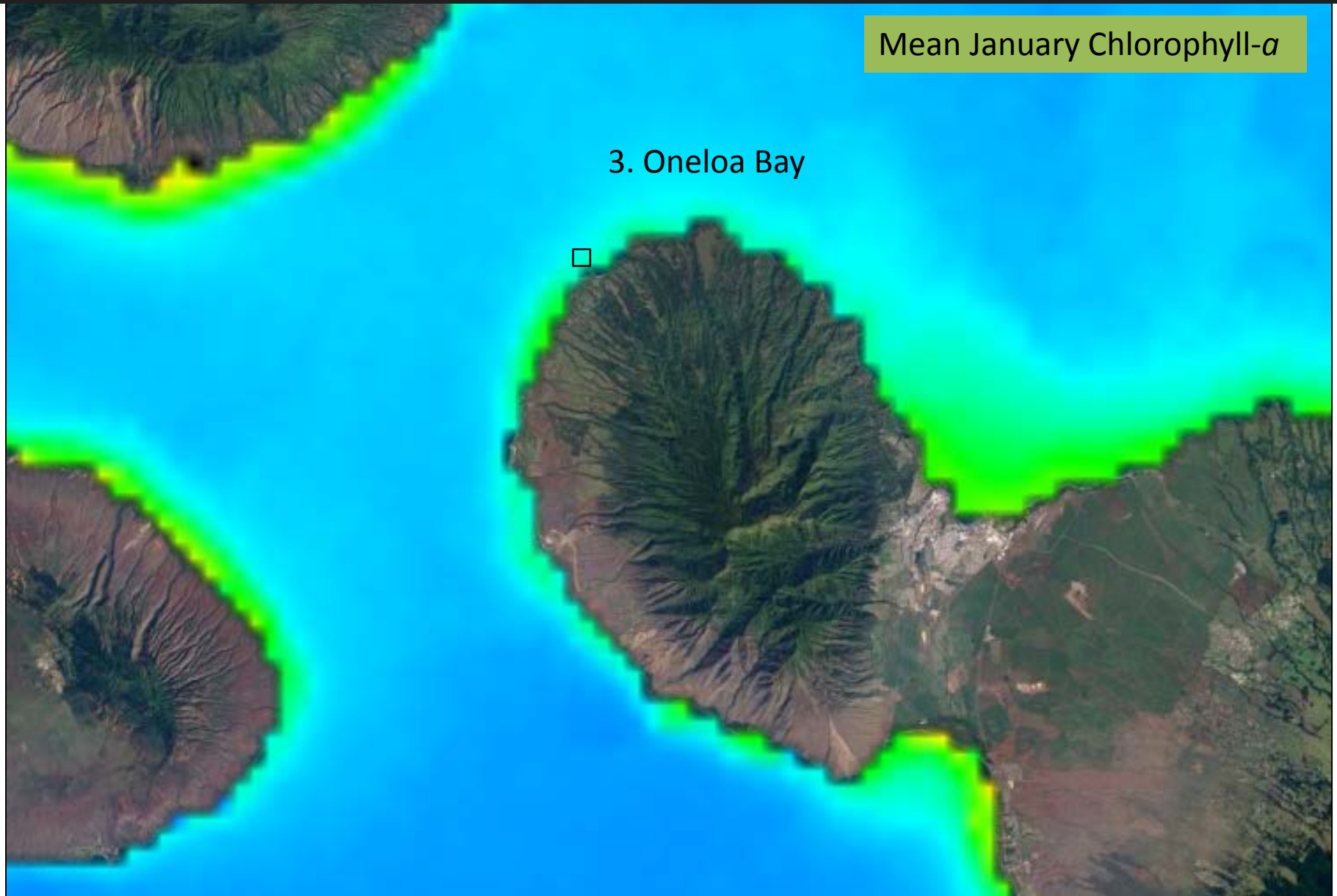
Mean January Chlorophyll-*a*

2. Honolua, Mokuleia, Honokahua Bay



Coral Reef Watch Tools

Virtual Monitoring Areas



Coral Reef Watch Tools

Virtual Monitoring Areas

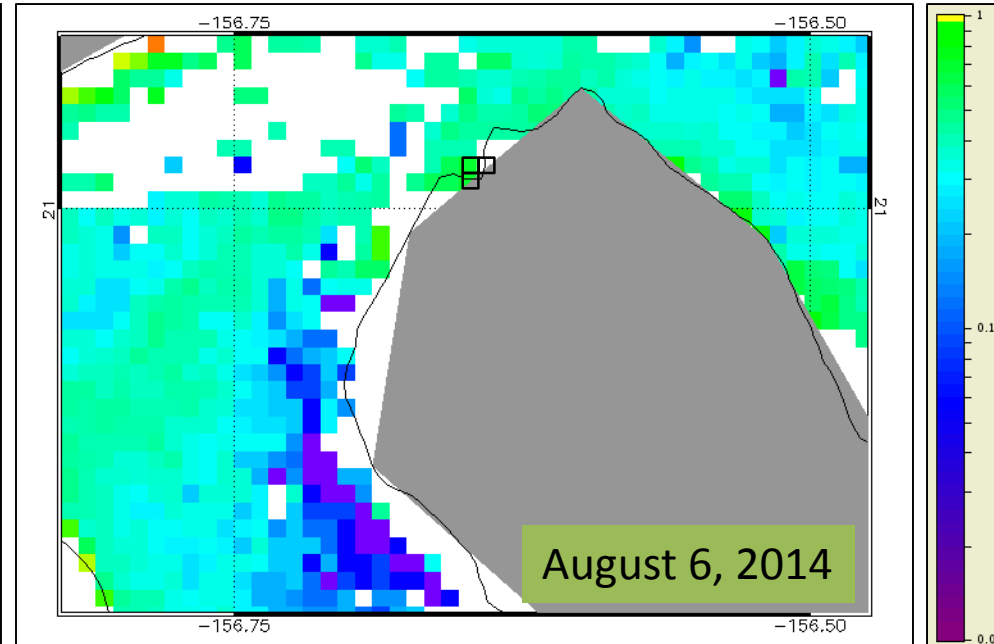
1. Honokohau Bay
2. Honolulu, mokuleia, Honokahua Bay
3. Oneloa Bay
4. Namalu Bay
5. Napili, Honokeana Bay
6. Airport North
7. Airport South
8. Kaanapali North
9. Kaanapali South
10. Lahaina North
11. Lahaina South
12. Maalaea Bay
13. Kahului
14. West Maui Total Area
15. ...



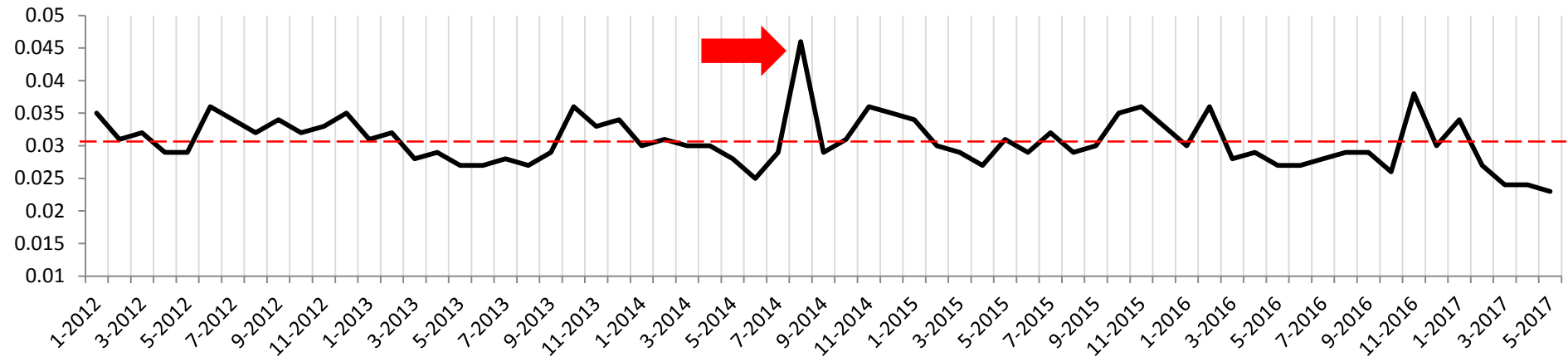
Coral Reef Watch Tools

Virtual Monitoring Areas

2. Honolulu, Mokuleia, Honokahua Bay



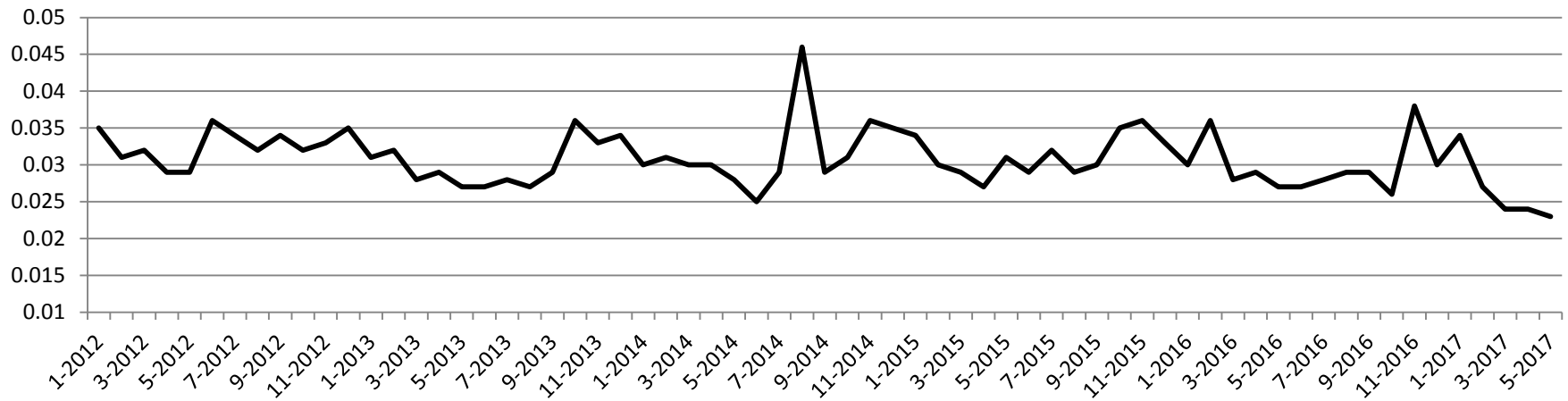
Monthly Maximum $K_d(490)$



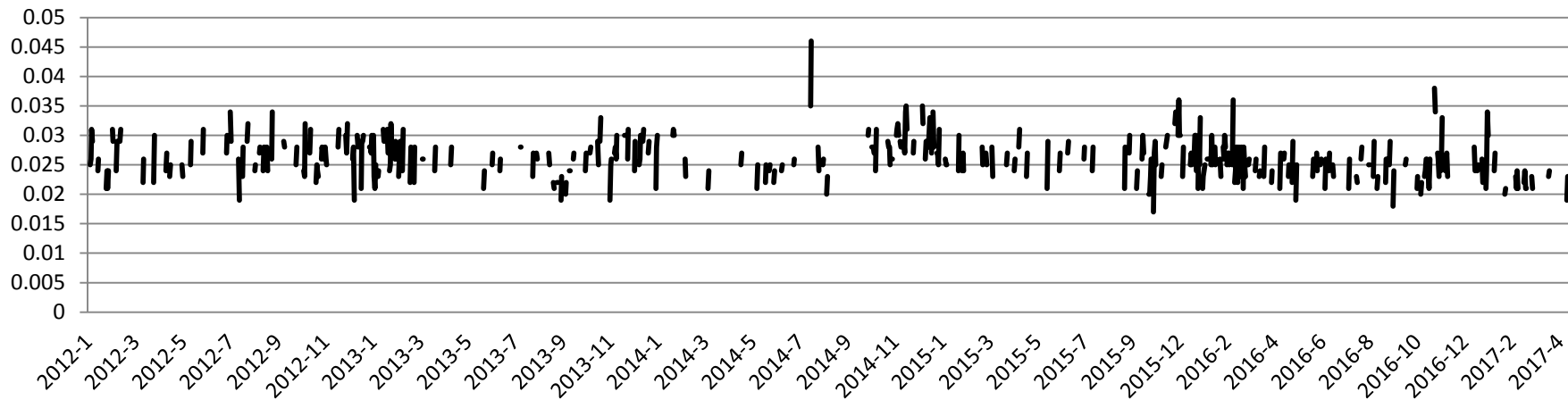
Coral Reef Watch Tools

Virtual Monitoring Areas

Monthly Maximum $K_d(490)$

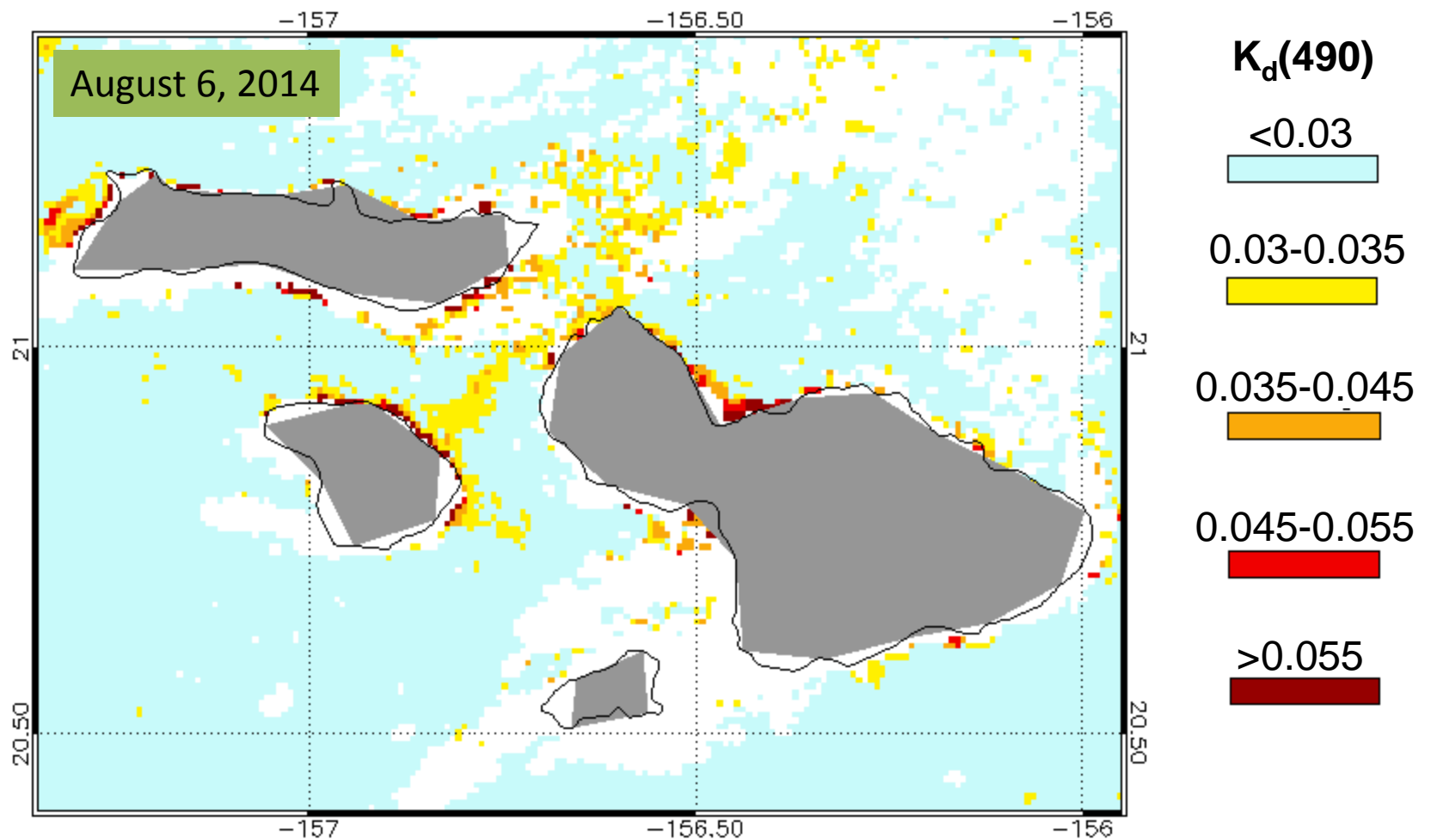


Daily Maximum $K_d(490)$



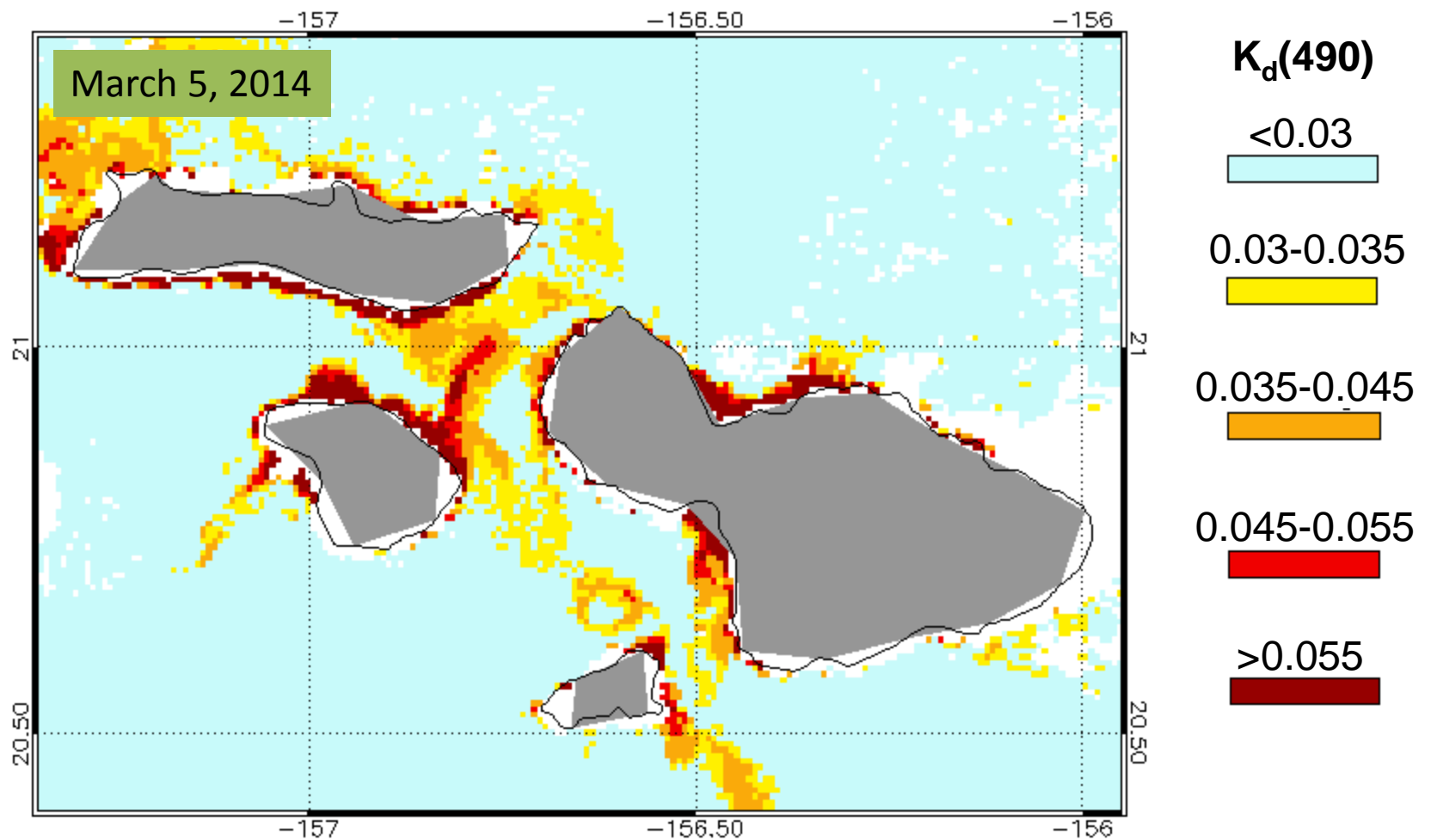
Coral Reef Watch Tools

Alert Products



Coral Reef Watch Tools

Alert Products



Coral Reef Watch Tools Manager's Portal



NOAA Satellite and Information Service
National Environmental Satellite, Data, and Information Service (NESDIS)



[DOC](#) > [NOAA](#) > [NESDIS](#) > [STAR](#) > [CRW](#)



Coral Reef Watch

[CRTF](#) | [CRCP](#) | [CREIOS](#) | [CoRIS](#)



[CRW Home](#)

[Product Overview](#)

[Near-Real-Time Data](#)

[5-km Resolution](#)

[50-km Resolution](#)

[Experimental Products](#)

[Research Activities](#)

[Bleaching Obs Reporting](#)

[Ocean Color](#)

[Projections: OA/Bleaching](#)

[Projections: Bleaching 4km](#)

[Ocean Acidification](#)

[Hydrodynamic Modeling](#)

[Paleoclimatology](#)

[High-resolution SST](#)

[Decision Support System](#)

[QCed Bleaching Obs](#)

[Outreach/Education](#)

[Research Partnerships](#)

[Publication List](#)

[Cite CRW Data & Products](#)

[Report Bleaching](#)

West Maui Ocean Color Monitoring

Product:

[Chl-*a*](#)

[K_d\(490\)](#)

[Anomaly](#)

[Alert](#)

Map Extent:

▼ [Maui](#)

Aggregation:

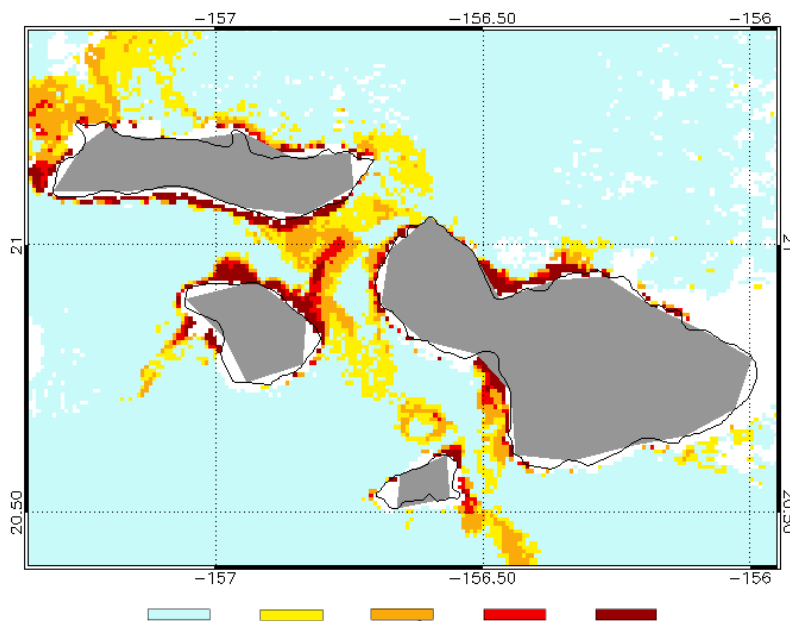
▼ [Daily](#)

Virtual Area:

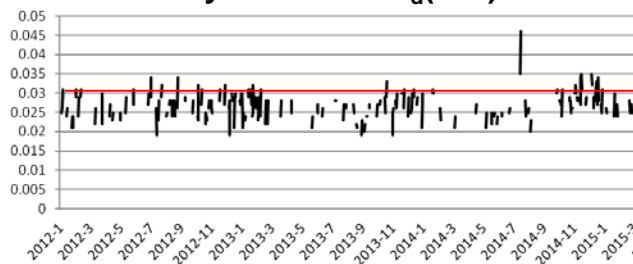
▼ [Namalu Bay](#)

Time Series:

▼ [Max k_d\(490\)](#)



Daily Maximum K_d(490)



High Resolution True Color:

[Sentinel-2](#)

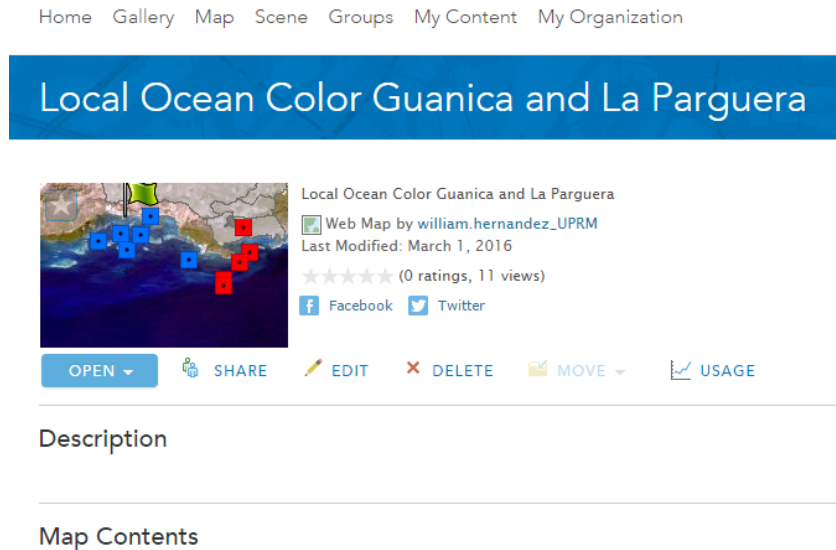
[Landsat](#)



Local Ocean Color in ArcGIS Web Map

- Proposed information platform using GIS for HI and PR.
- Information can be compiled in a web mapping application for watershed managers that can include:
 - Watershed layers
 - Benthic habitat/land cover maps.
 - Water quality from satellites (VIIRS, Landsat/Sentinel).
 - *In situ* water samples results.
 - Layers from watershed managers.

UPRM Sample



<http://arcg.is/1QpyIL7>



NOAA Satellite and Information Service
National Environmental Satellite, Data, and Information Service (NESDIS)



[DOC](#) > [NOAA](#) > [NESDIS](#) > [STAR](#) > [CRW](#)



Coral Reef Watch

[CRTF](#) | [CRCP](#) | [CREIOS](#) | [CoRIS](#)



[CRW Home](#)

[Product Overview](#)

[Near-Real-Time Data](#)

[5-km Resolution](#)
[50-km Resolution](#)

[Experimental Products](#)

[Research Activities](#)

[Bleaching Obs Reporting](#)
[Ocean Color](#)
[Projections: OA/Bleaching](#)
[Projections: Bleaching 4km](#)
[Ocean Acidification](#)
[Hydrodynamic Modeling](#)
[Paleoclimatology](#)
[High-resolution SST](#)
[Decision Support System](#)
[QCed Bleaching Obs](#)

[Outreach/Education](#)

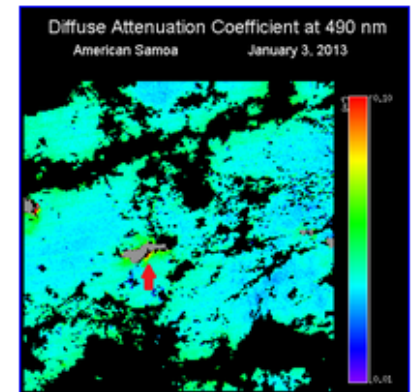
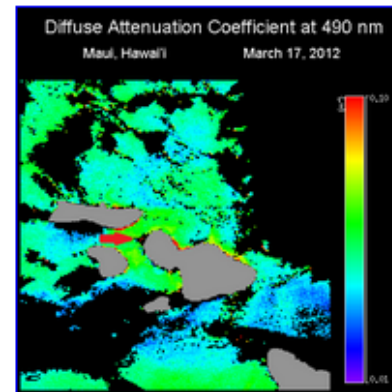
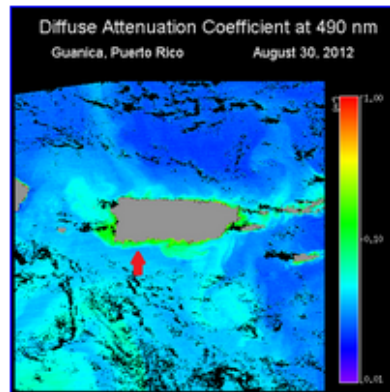
[Research Partnerships](#)

[Publication List](#)

[Cite CRW Data & Products](#)

[Report Bleaching](#)

Satellite Ocean Color Product Development



Preliminary Results (event-driven variations in $K_d(490)$ and Chl-*a*):

- Click [here](#) for preliminary time series results for Puerto Rico.
- Click [here](#) for preliminary time series results for West Maui.

Presentations:

- Click [here](#) for a poster presented at the 2015 NOAA Satellite Conference.
- Click [here](#) for a poster presented at the 2016 Ocean Sciences Meeting in New Orleans.

[NOAA Coral Reef Watch](#) and [NOAA/NESDIS' Ocean Color Team](#) are working closely with partners in the U.S. Coral Reef Task Force (USCRTF) Watershed Working Group (WWG) to develop pilot satellite ocean color products using data from the [Visible Infrared Imaging Radiometer Suite \(VIIRS\)](#) aboard the [Suomi National Polar-orbiting Partnership \(S-NPP\)](#) satellite operated by the [NOAA Joint Polar Satellite System \(JPSS\)](#).

The pilot satellite ocean color products are designed to help coral reef ecosystem managers monitor variable water

University of Hawaii – Maui College

Professor Brown's Student Exploratory Team



Bio-Optical Oceanography Laboratory

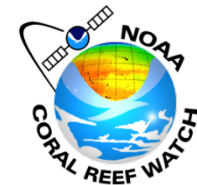
Team Members

- Dr. Roy Armstrong -Director
- Dr. Yasmin Detres - Researcher
- Suhey Ortiz, Maria Cardona, Myrna Santiago, Jenniffer Perez, Omar Lopez -Graduate Students
- Luis Lugo - Staff





Thank you from the NOAA Coral Reef Watch Team!!



Mark Eakin



Jacquie De La Cour (GST)



Gang Liu (GST)



Erick Geiger (GST)



**Ben Marsh
(GST & ReefSense)**



Kyle Tirak (GST)



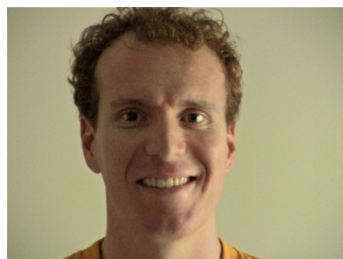
**Andrea Gomez
(CCNY & NOAA-CREST)**



**William Hernandez Lopez
(CCNY & NOAA-CREST)**



**William Skirving
(GST & ReefSense)**



Scott Heron (GST & ReefSense)



Rob Warner (NOAA/NOS)



Al Strong (GST & SR)

