

The Application of Synthetic Aperture Radar (SAR) to Natural Resource Damage Assessment

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NOAA's Ocean Service, Office of Response & Restoration

April 2nd, 2015

Coastal GeoTools

Charleston, SC

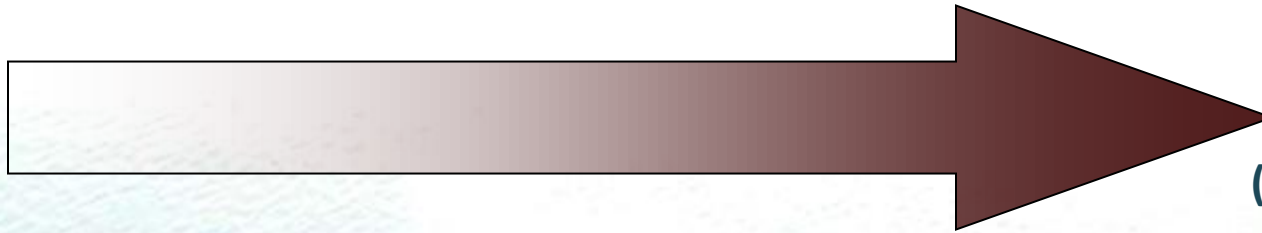


Overview: NRDA and SAR

- OR&R and NRDA
- SAR and TCNNA Processing
- SAR Products
 - Cumulative Composite
 - Cumulative Days of Oiling
 - Shoreline Days of Oiling
 - Time of Oiling
- Summary/Conclusions

Continuum of “Response” Framework for The Office of Response & Restoration

Response
(24 hours)



Recovery or
Restoration
(Years/Decades)

Response

Assessment

Restoration

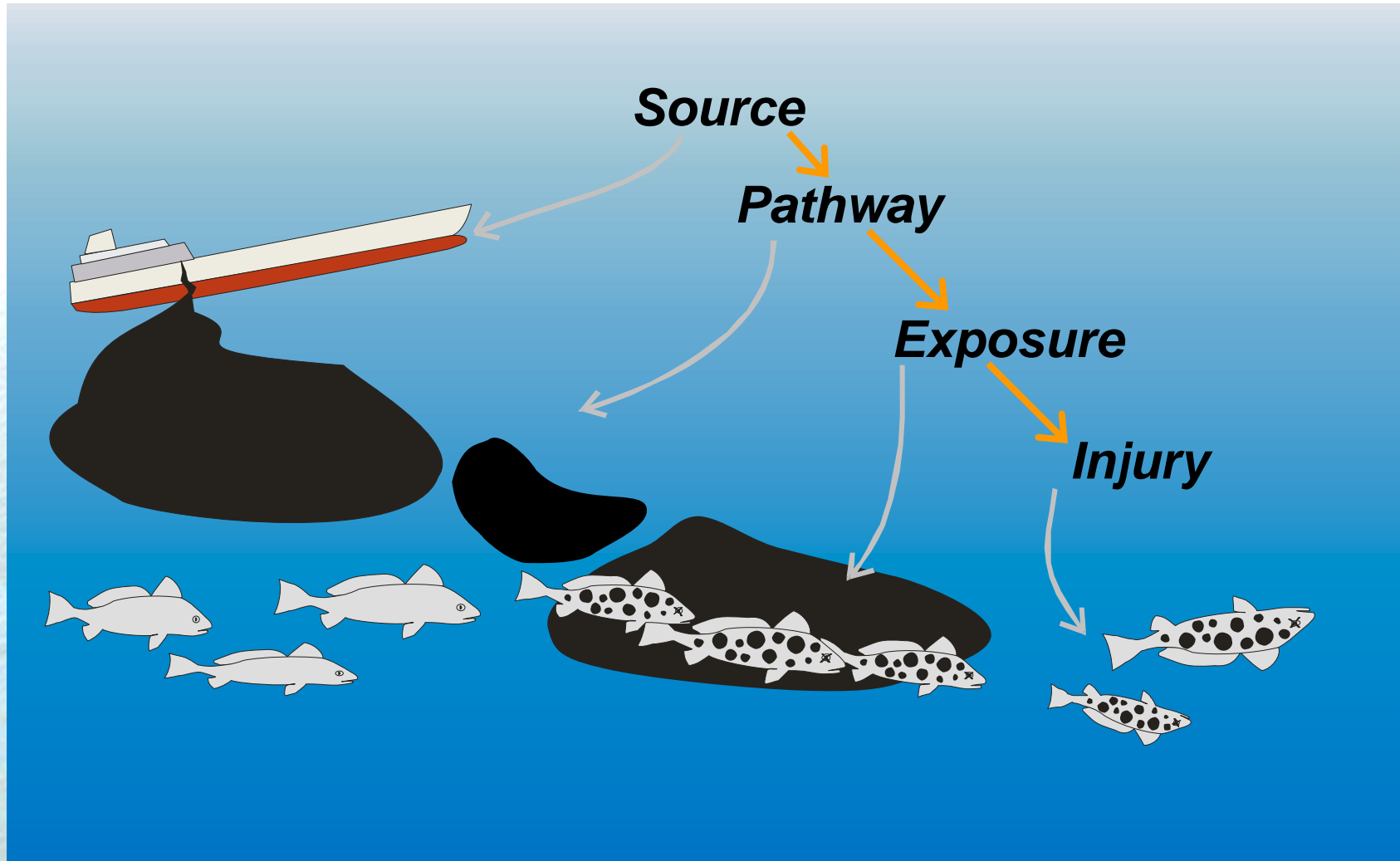


What is NRDA?

- Legal Process
 - OPA 90, CERCLA, CWA
 - Specific steps to follow and things to prove
- Based in Science
- Goal: Public Compensation
 - Determine public loss
 - Recover loss through restoration
- Success = appropriate restoration achieved

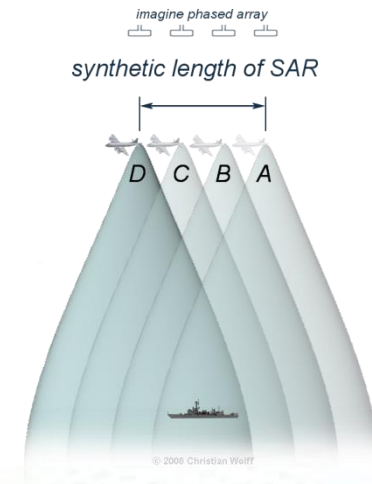


NRDA Requires Demonstration of Causality: Oil causing injury



What is SAR?

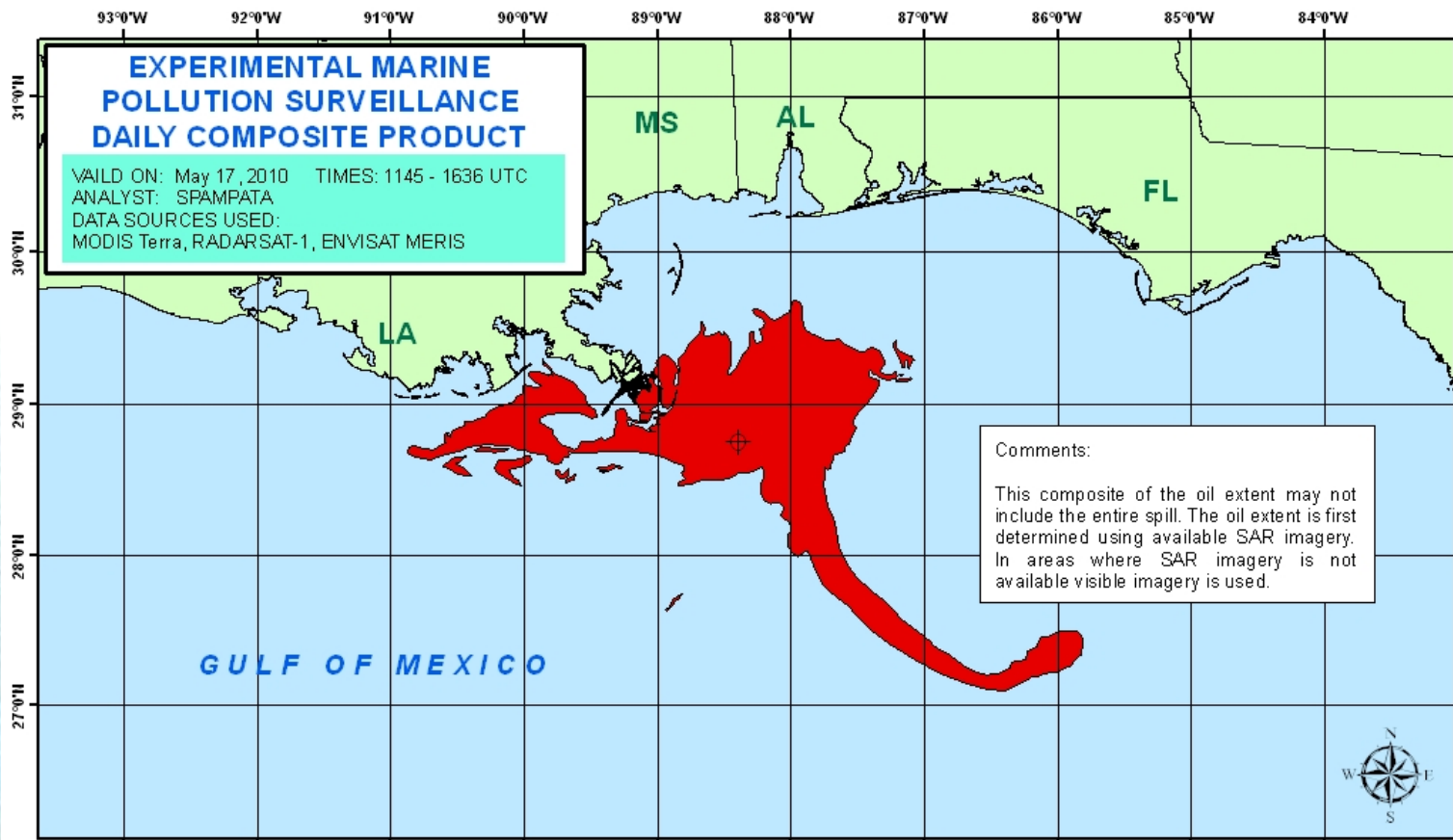
- Synthetic Aperture Radar
- Flight path simulates large antenna
- Magnitude and phase of signal pulse
- Broad area coverage at high resolution
- Penetrates clouds, limited visibility conditions
- NOAA NESDIS uses SAR and a variety of other sensors for response
- NESDIS used many different SAR sensors during Deepwater Horizon



What do we use SAR for?

- Analysis of SAR imagery are often used to identify ***surface anomalies***
- These anomalies are used to represent the predicted ***oiling extent***
- In Deepwater Horizon and many medium to large spills SAR imagery have been used to identify ***“actionable” oil***
- The NOAA NESDIS SAR data products were used as the ***search area*** for oil overflight observation for DWH
- These SAR footprints were also used as the ***initialization area*** for OR&R trajectory models
- We use SAR to identify and quantify areas of potential ***resource exposure***

NOAA NESDIS Experimental MPSR – Anomaly Footprint



Analysis Provided by: The National Oceanic and Atmospheric Administration/National Environmental Satellite, Data and Information Service (NOAA/NESDIS)



This is an experimental product of the Satellite Analysis Branch and not operationally maintained. The outline of oil is a daily composite using a variety of satellite images and is based on an experimental pilot product and should be used with caution.

Legend



Anomaly



Location of Deepwater Horizon Platform:
[28°44'12" N / 88°23'14" W]

0 15 30 60 90 120 Miles

0 10 20 40 60 80 Nautical Miles

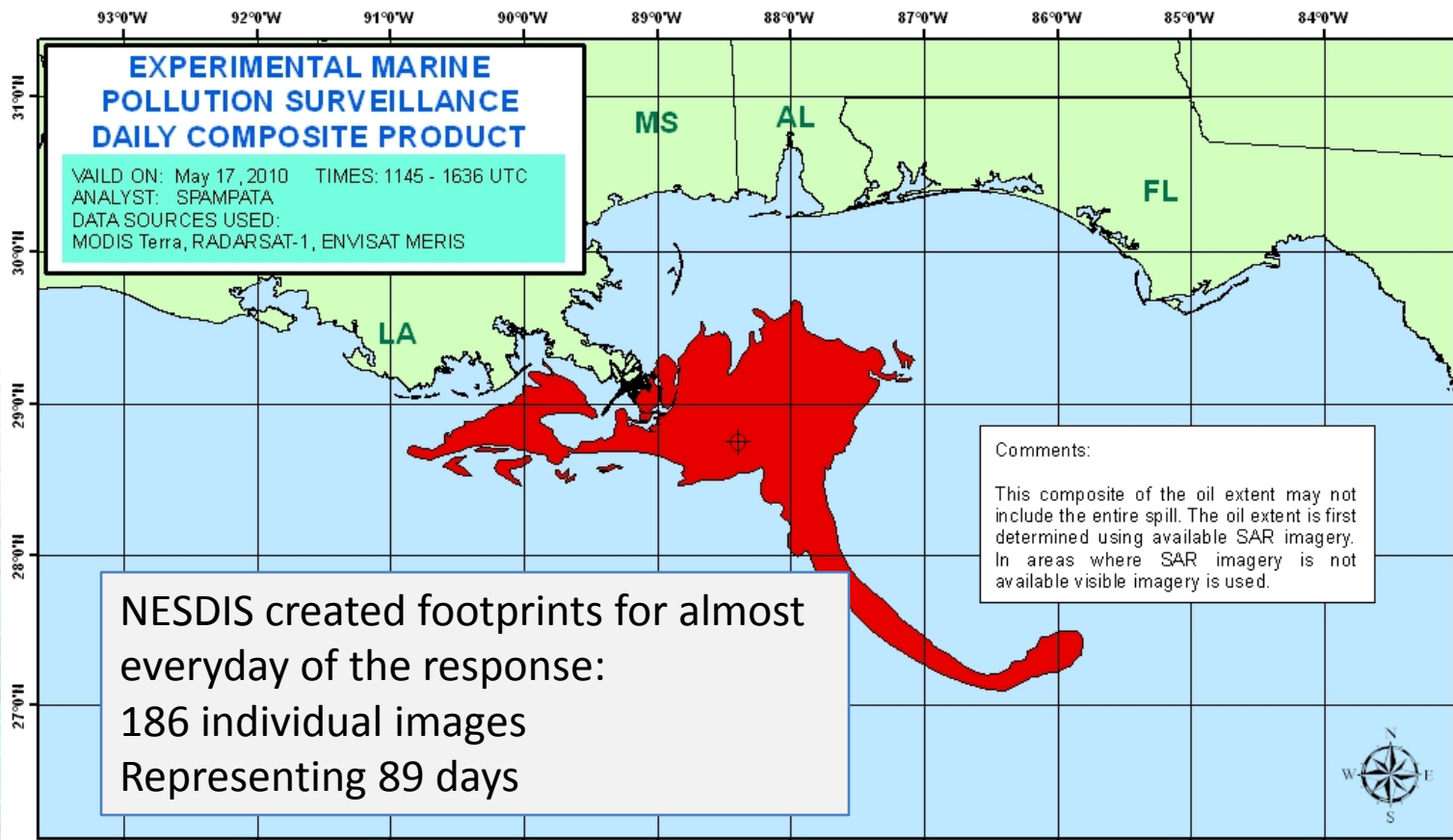
0 20 40 80 120 160 Kilometers

©ESA 2010



© Canadian Space Agency/Agence spatiale canadienne (2010)

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©ESA 2010



© Canadian Space Agency/Agence spatiale canadienne (2010)

SAR Oiling Extent Analysis

- SAR Anomaly Classification Methods
 - *NESDIS SAR analysis* (analyst specific, manual)
 - *TCNNA algorithm* (semi-automated)
- TCNNA (texture classifying neural network algorithm) developed jointly between NESDIS and FSU
- Methodology published in 2009

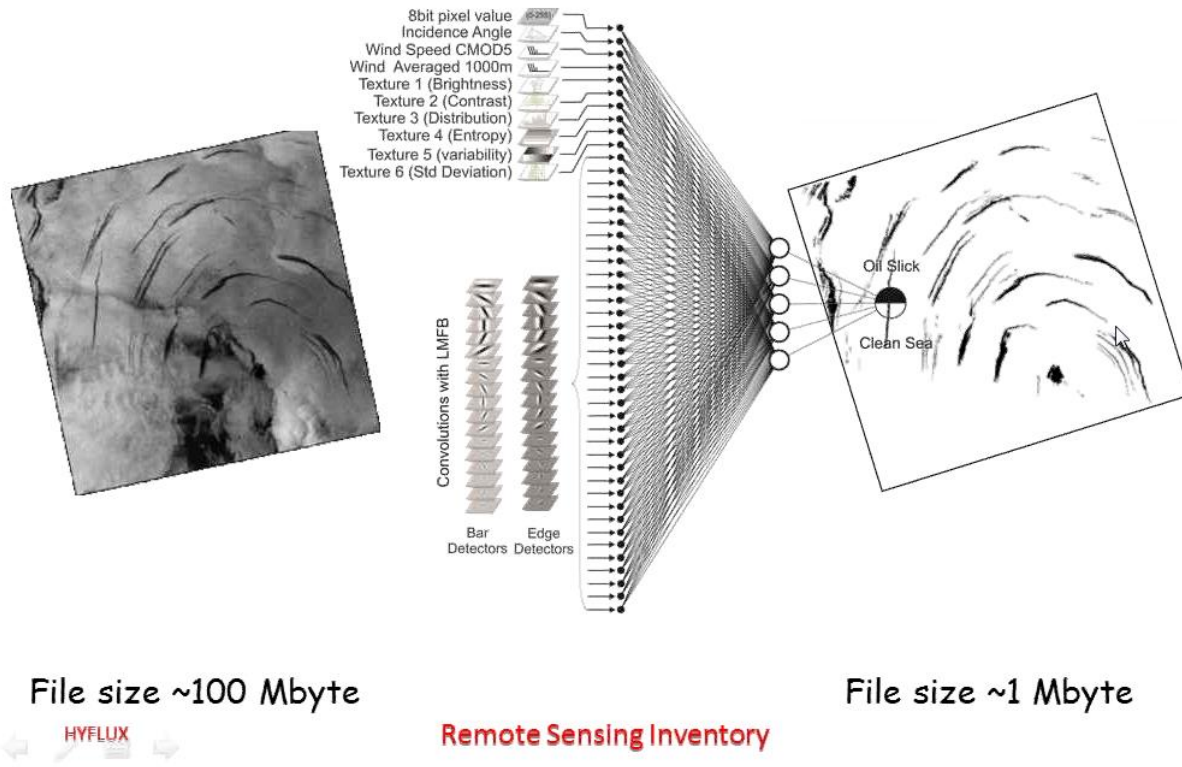
Can. J. Remote Sensing, Vol. 35, No. 5, pp. 411–421, 2009

Using SAR images to delineate ocean oil slicks with a texture-classifying neural network algorithm (TCNNA)¹

Oscar Garcia-Pineda, Beate Zimmer, Matt Howard, William Pichel, Xiaofeng Li, and Ian R. MacDonald

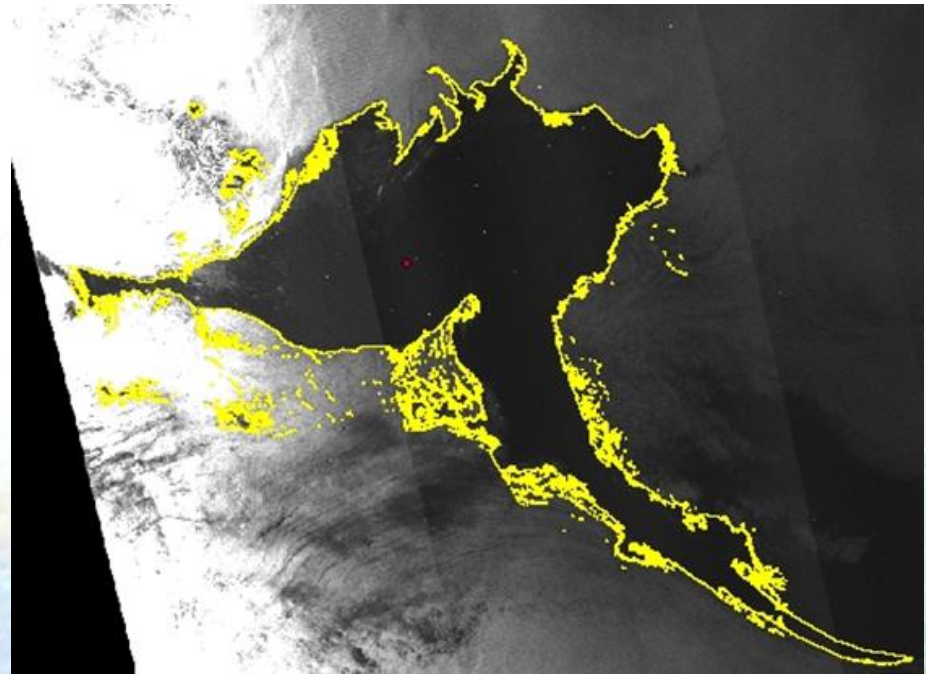
Texture Classifying Neural Network – (TCNNA) SAR Oil Footprint

Texture Classifying Neural Network Algorithm
Garcia et al DSR-II 2010



SAR TCNNA Oiling Footprint

- Semi-automated process
- Detailed examination of environmental conditions
- Use data to map low wind features, false positives
- Help eliminate subjectivity of individual analyst
- Expedite delivery
- Oil not anomaly



SAR TCNNA Products

- SAR Products and Model Builder
 - Daily Composites
 - Cumulative Composite
 - Cumulative Days of Oiling
 - Shoreline Days of Oiling
 - Time of Oiling

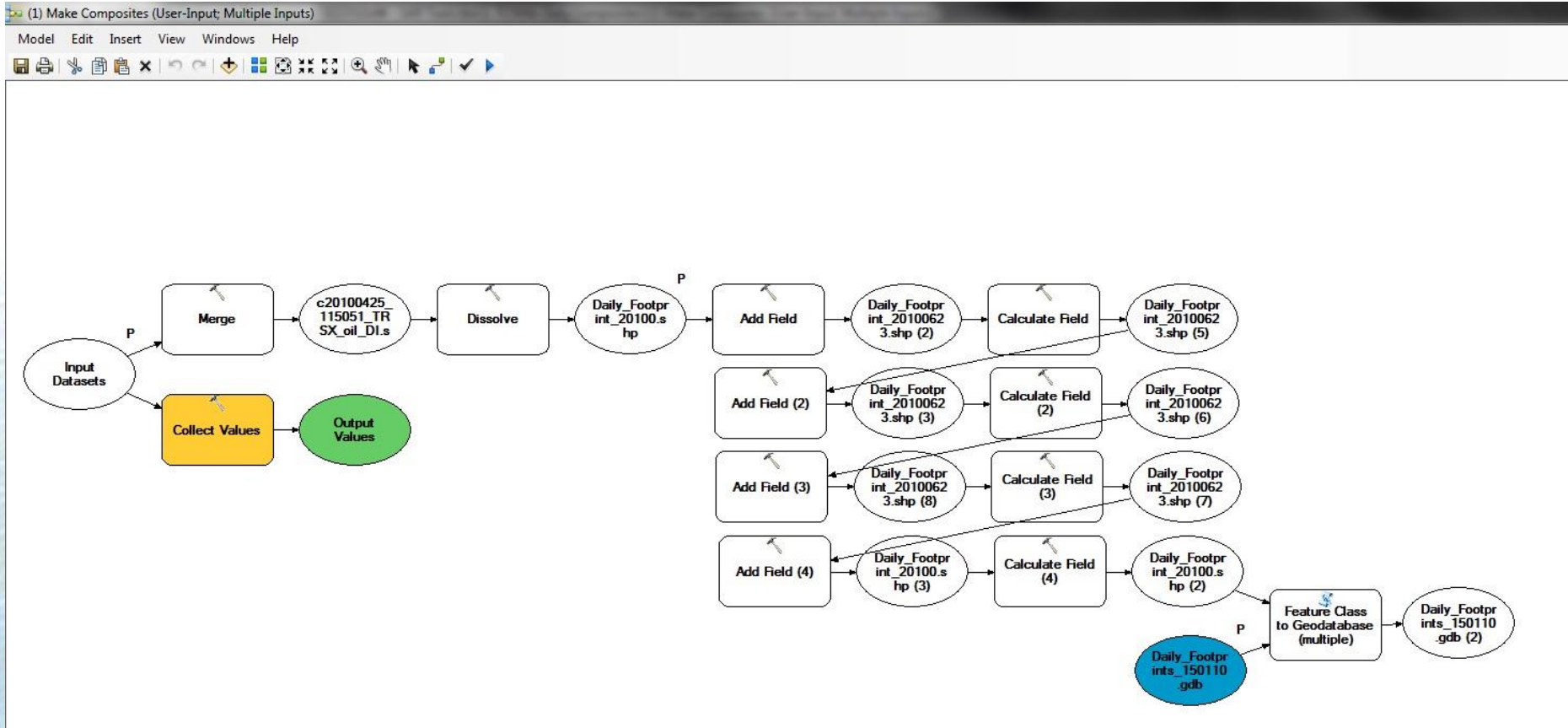
SAR TCNNA Tools

Process required preparation for multiple iterations of data and reprocessing these large complex datasets multiple times....

ArcGIS Model Builder OoW – SAR Tools.tbx

In-line Ref.	Model Name	Toolset Application
• 1A	(1) Make Composites (Single/Multiple)	1. TCNNA Daily Comp.
• 1B	(2) Add Date Fields	1. TCNNA Daily Comp.
• 1C	(3) Add 'Day' Count Field	1. TCNNA Daily Comp.
• 2A	(1) Add Julian Date to Daily Composites	2. TCNNA Shoreline Int.
• 2B	(2) Add Julian Date to Shoreline	2. TCNNA Shoreline Int.
• 2C	(3) Calculate Intersections	2. TCNNA Shoreline Int.
• 3A	(1) Convert Daily Footprints to Rasters	3. TCNNA Days of Oiling

SAR – Daily Composites



SAR – Daily Composites

(1) Make Composites (User-Input; Multiple Inputs)

Model Edit Insert View Windows Help



Build TCNNA Daily Composites:

- Import multiple footprints from the same day
- Merge and Dissolve to form single polygon
- Add and calculate geometry for fields SQ_MI, SQ_KM, and ACRES
- Add lineage field which captures input filenames
- Export to GDB

Input
Datasets

ints_150110
.gdb

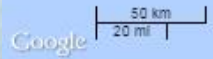
SAR TCNNA Shoreline Analysis Products

Daily Composite/Cumulative Composite

The screenshot displays the ERMA Deepwater Gulf Response web application. The main map area shows the Gulf of Mexico coastline from New Orleans to Santa Rosa Beach, with SAR TCNNA oiling footprints overlaid in shades of green and blue. The interface includes a top navigation bar with 'Information', 'Help', and 'Recent Data' tabs, and a search box. A right-hand sidebar contains a 'Layers' panel with the following structure:

- Active View: TCNNA SAR Footprints (info)
- Background
- BP Deepwater Horizon Oil Spill
 - Satellite, Radar, and Aerial Images of the Spill
 - TCNNA SAR Potential Oiling Footprints
 - August 2010
 - NESDIS Re-Analysis 11-August-10
 - NESDIS Re-Analysis 10-August-10
 - NESDIS Re-Analysis 09-August-10
 - NESDIS Re-Analysis 08-August-10
 - NESDIS Re-Analysis 05-August-10
 - NESDIS Re-Analysis 04-August-10
 - NESDIS Re-Analysis 02-August-10
 - NESDIS Re-Analysis 01-August-10
 - July 2010
 - NESDIS Re-Analysis 30-July-10
 - NESDIS Re-Analysis 27-July-10
 - NESDIS Re-Analysis 26-July-10
 - NESDIS Re-Analysis 25-July-10
 - NESDIS Re-Analysis 24-July-10
 - NESDIS Re-Analysis 21-July-10
 - NESDIS Re-Analysis 20-July-10
 - NESDIS Re-Analysis 19-July-10
 - NESDIS Re-Analysis 18-July-10
 - NESDIS Re-Analysis 17-July-10
 - NESDIS Re-Analysis 16-July-10
 - NESDIS Re-Analysis 14-July-10
 - NESDIS Re-Analysis 12-July-10
 - NESDIS Re-Analysis 11-July-10
 - NESDIS Re-Analysis 10-July-10
 - NESDIS Re-Analysis 09-July-10
 - NESDIS Re-Analysis 08-July-10
 - NESDIS Re-Analysis 07-July-10
 - NESDIS Re-Analysis 06-July-10

89 Daily composite oiling footprints created from multiple images a day



Cumulative SAR TCNNA Footprint

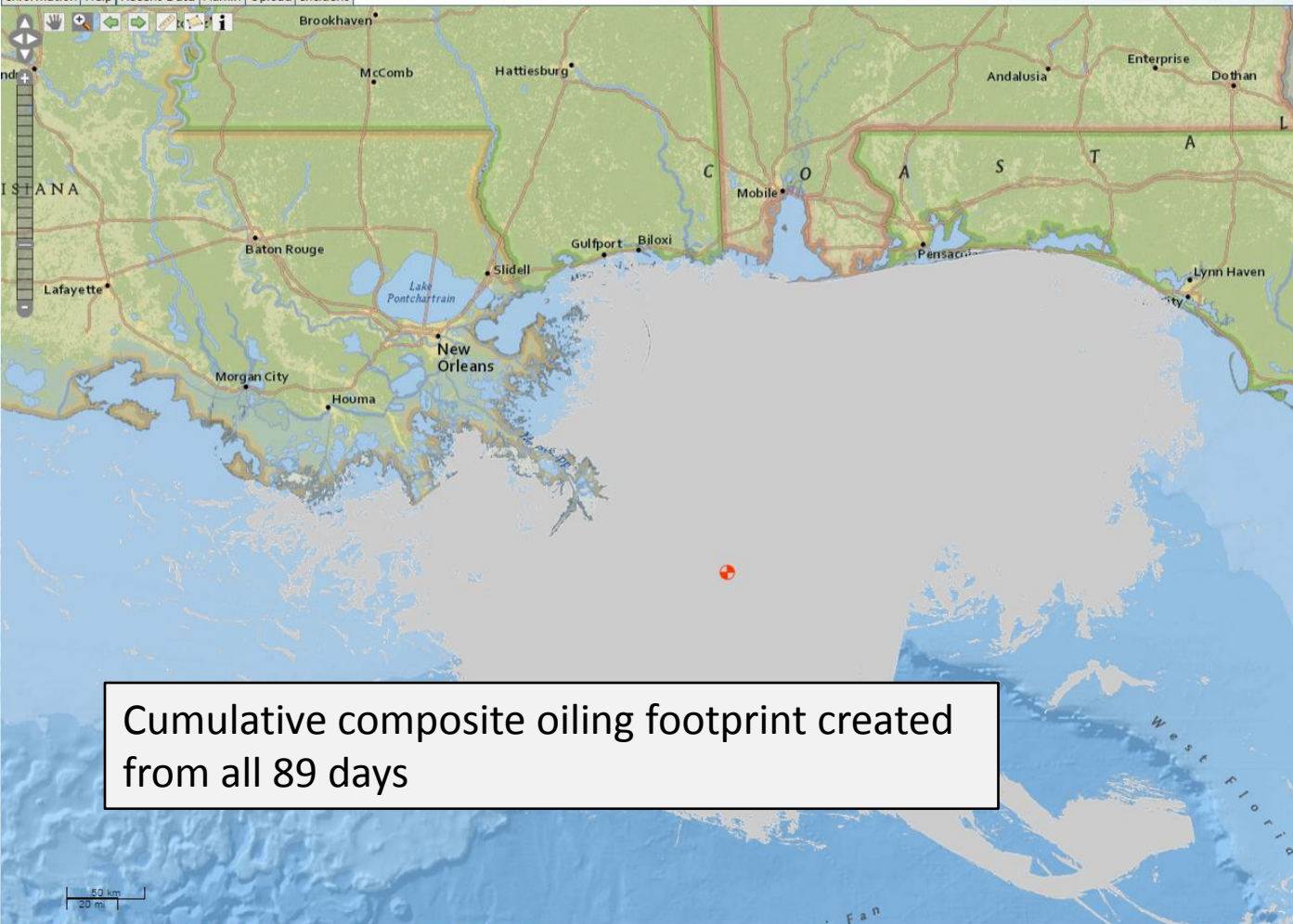
ERMA | Environmental Response Management Application
Deepwater Horizon MC252

Information | Help | Recent Data | Admin | Upload | Incident

Search Layers, Folders, and Bookmarks

Geographic Search

Change Password | Logout



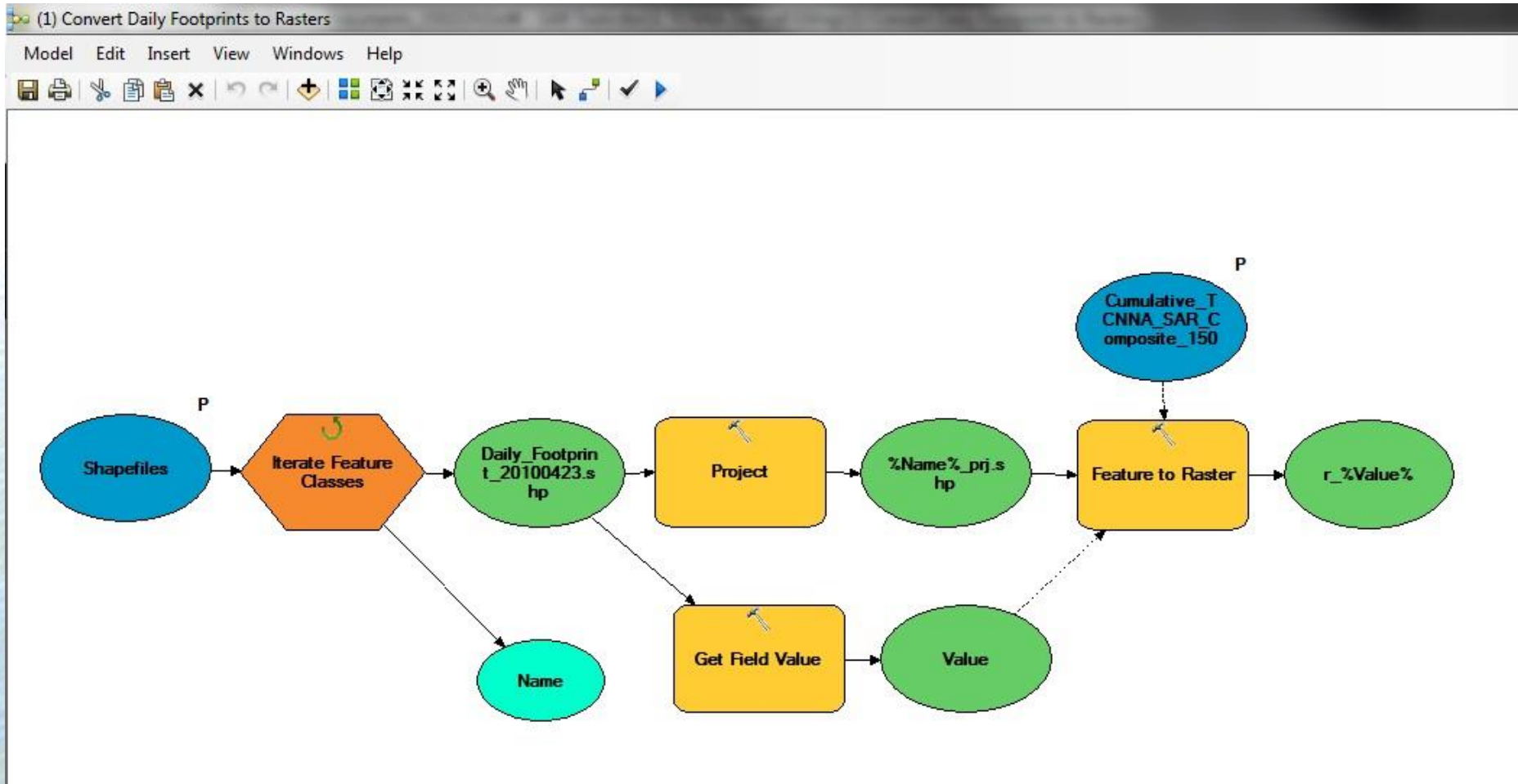
Layers Legend Query Tools AOI Labels Zoom Download Print

- Deepwater Horizon MC 252 Incident
 - Deepwater Horizon Wreckage
 - Deepwater Horizon Wreckage
- Cumulative Oiling
 - Cumulative TCNNA SAR Composite
 - Oiling footprint

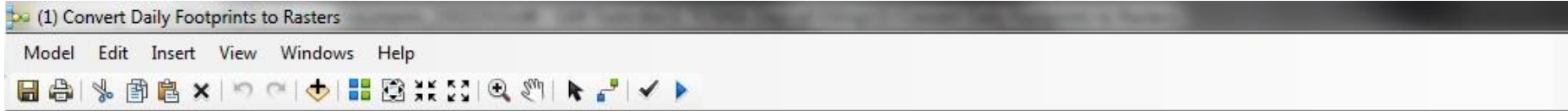
Cumulative composite oiling footprint created from all 89 days

Scale: 1: 2M Zoom Level: 8 Location: 29.35029°,-88.81600°

SAR – Days of Oiling



SAR – Days of Oiling

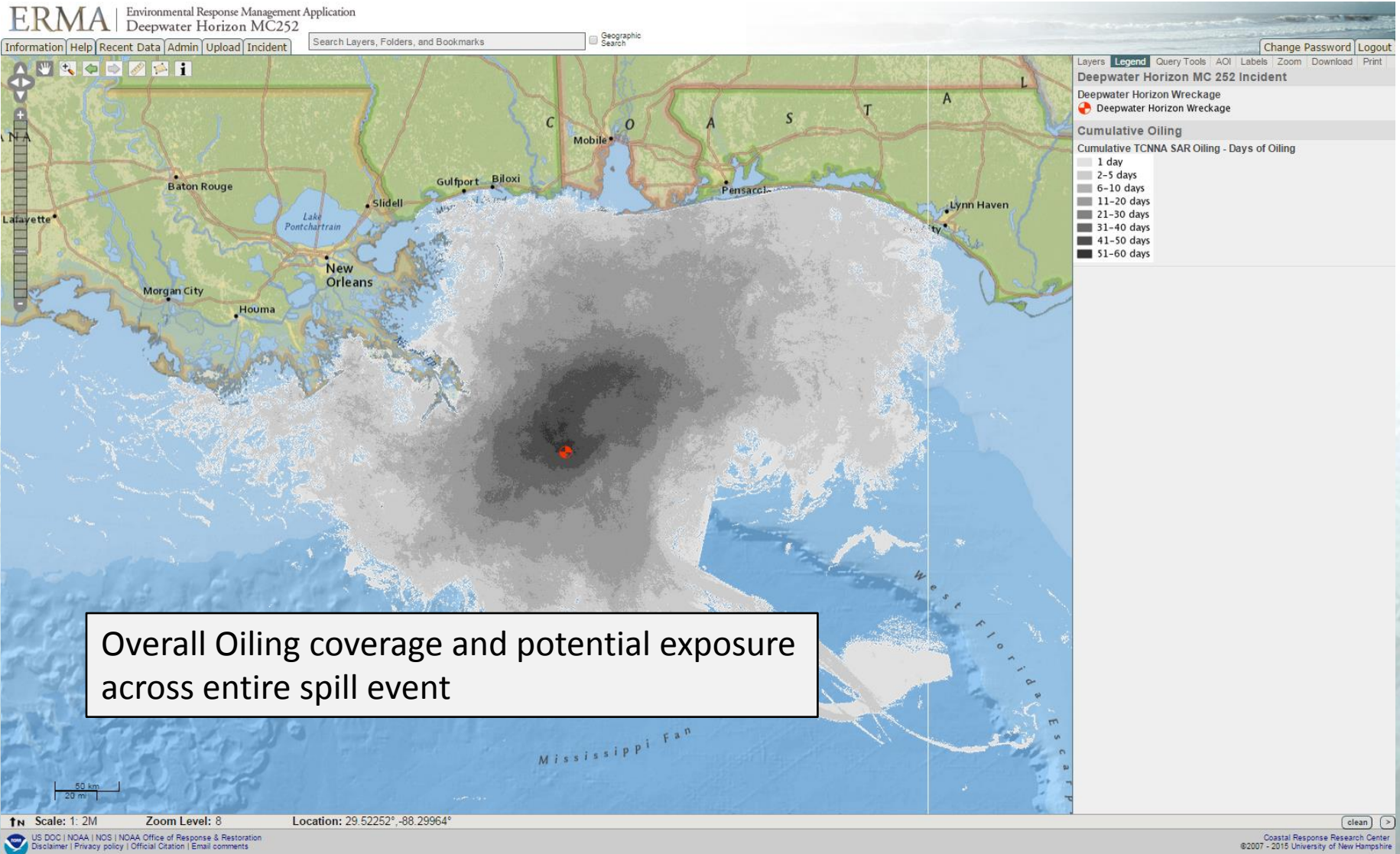


Days of Oiling - Convert to Raster

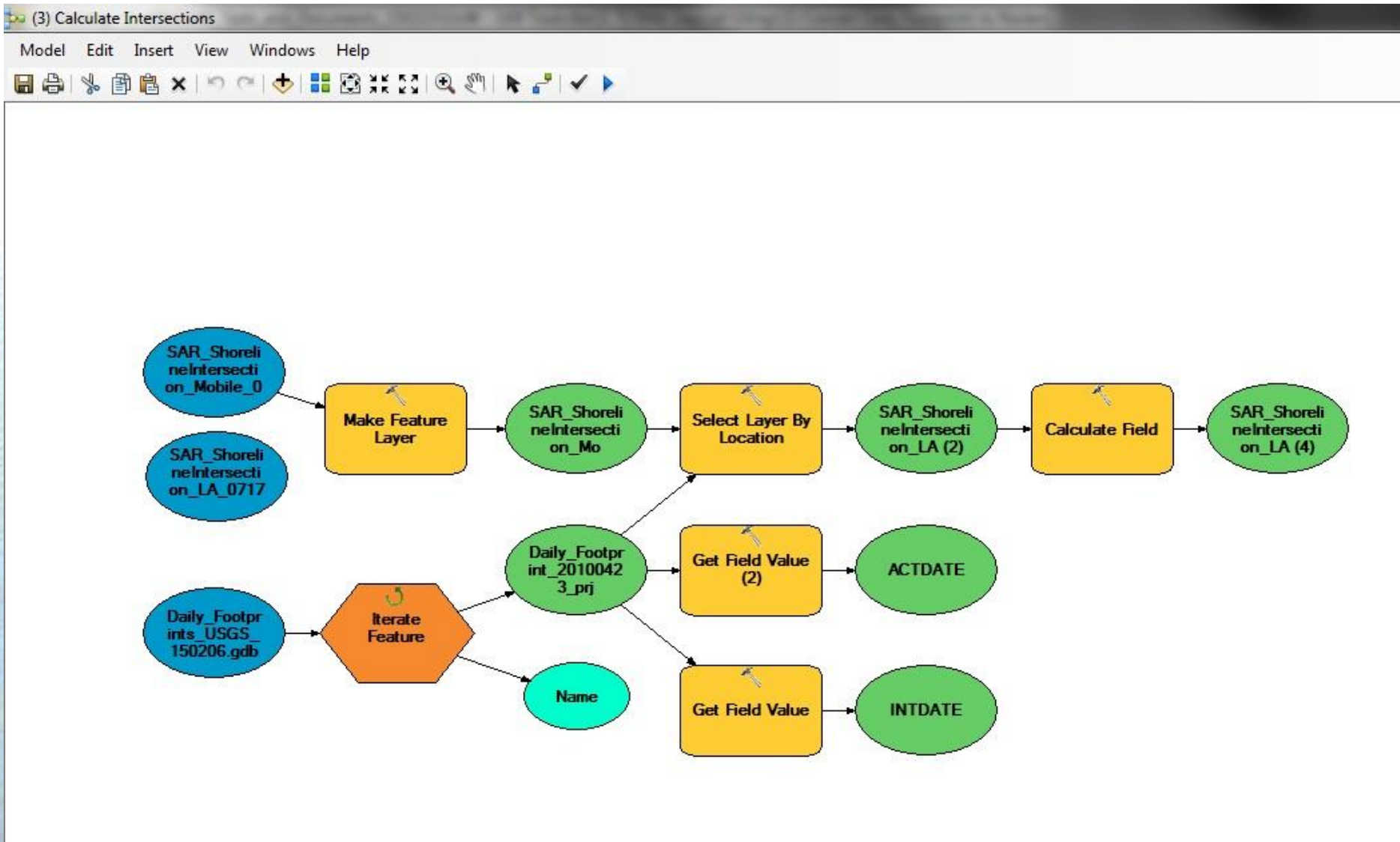
- Iterate across TCNNA Daily Composites
- Re-project data
- Convert Daily Composite to Raster using Cumulative Composite as extent
- Tally days of oil
- Create binned geotif

SAR TCNNA Shoreline Analysis Products

Days of Oiling



SAR – Shoreline Intersections



SAR – Shoreline Intersections

(3) Calculate Intersections

Model Edit Insert View Windows Help

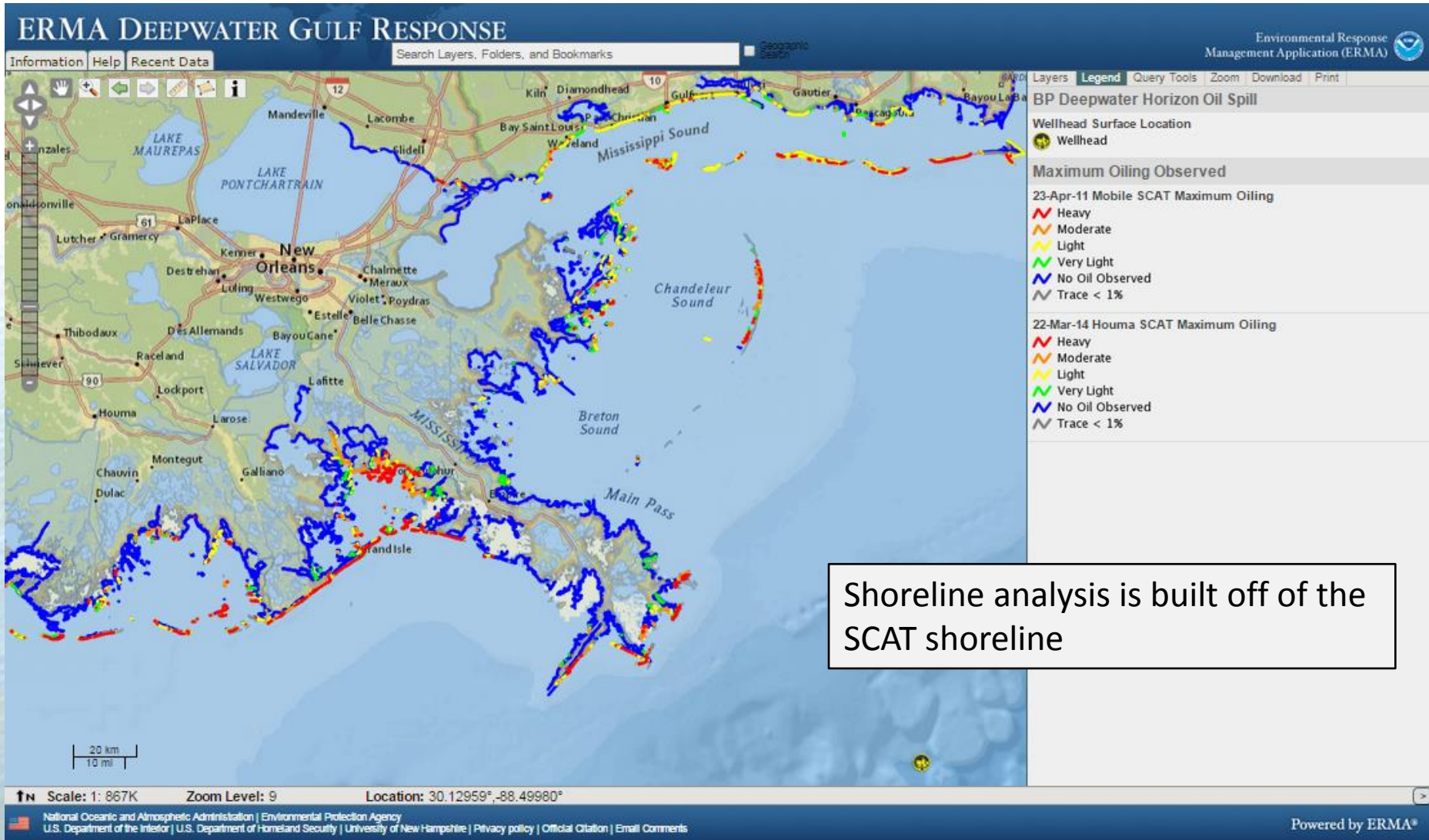


Calculate TCNNA Daily Shoreline Intersections:

- Iterate across TCNNA Daily Composites
- Select shoreline segments ≤ 3 km from a given Daily Composite
- Calculate the appropriate date field with the day being assessed
- Create Days of shoreline oiling

SAR TCNNA Shoreline Analysis Products

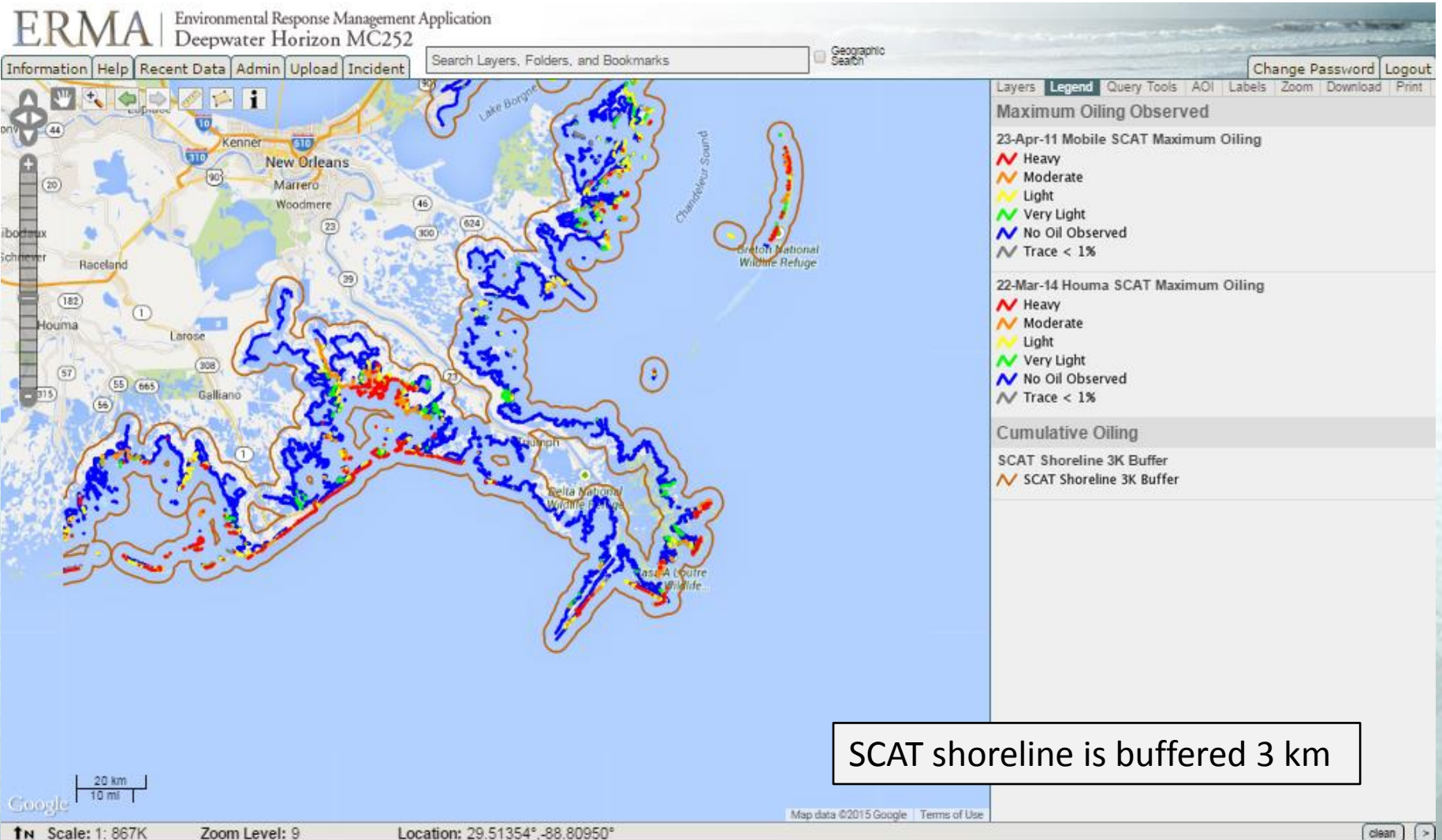
Days of Shoreline Oiling



Shoreline analysis is built off of the SCAT shoreline

SAR TCNNA Shoreline Analysis Products

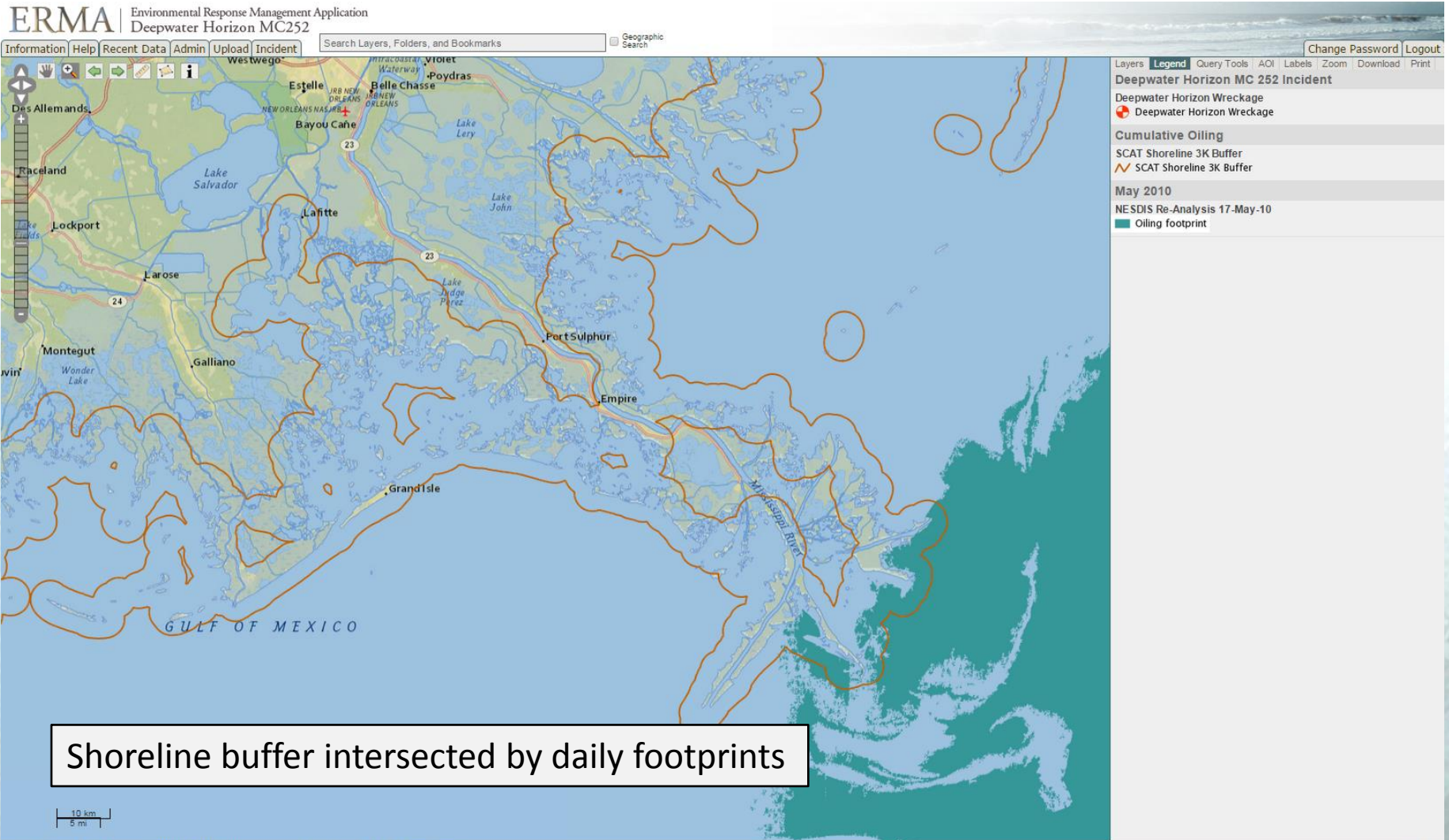
Days of Shoreline Oiling



SCAT shoreline is buffered 3 km

SAR TCNNA Shoreline Analysis Products

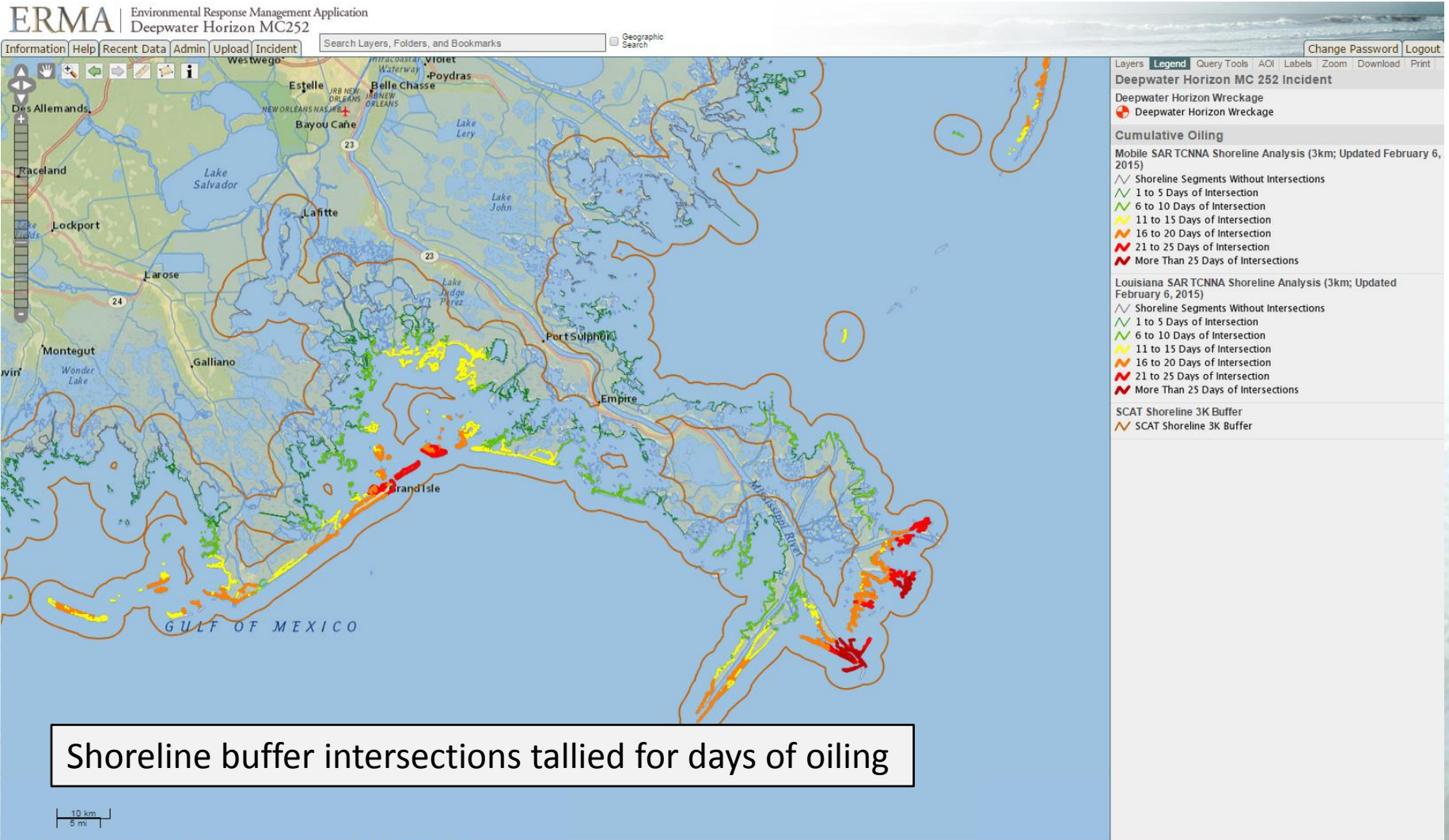
Days of Shoreline Oiling



Shoreline buffer intersected by daily footprints

SAR TCNNA Shoreline Analysis Products

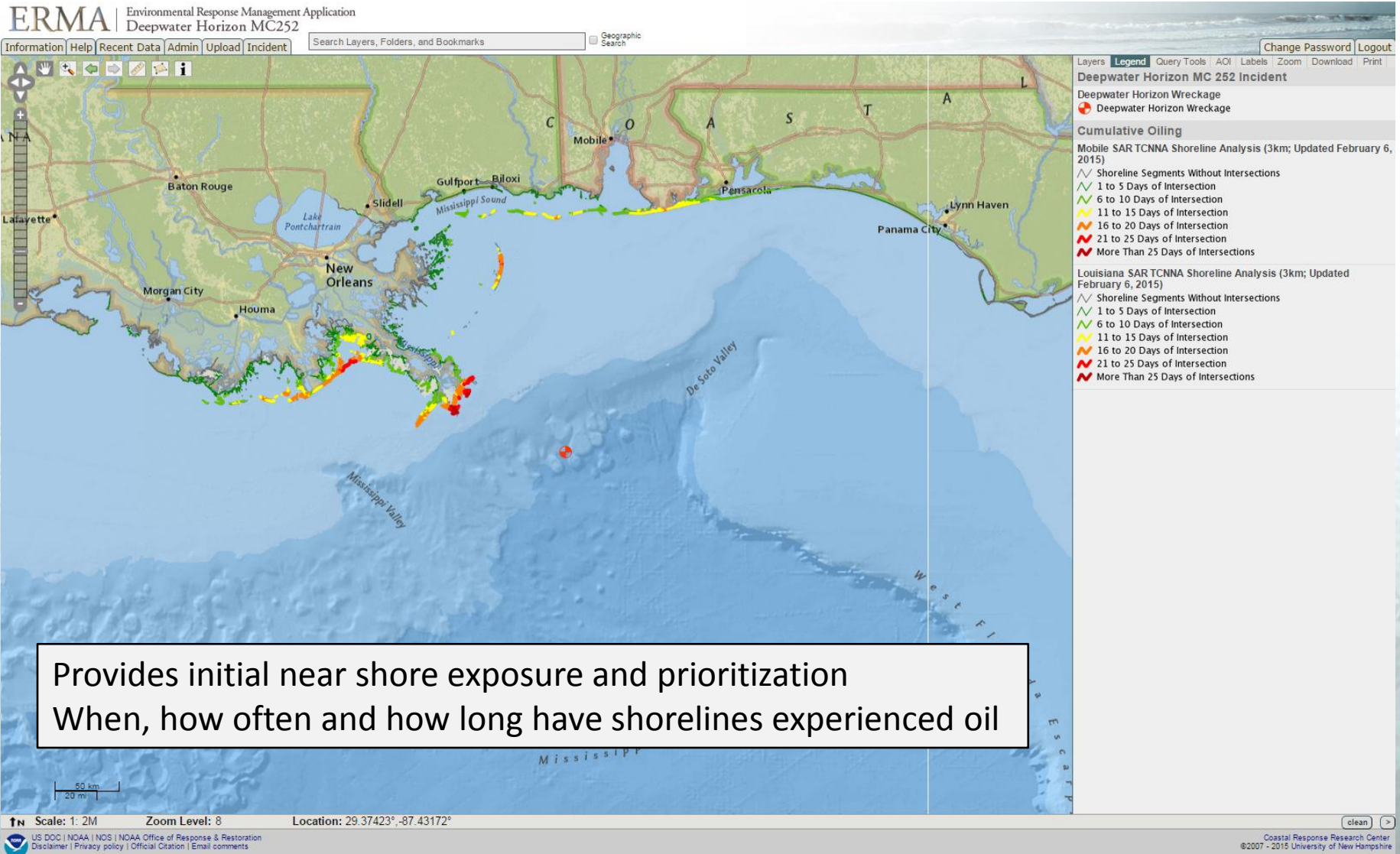
Days of Shoreline Oiling



Shoreline buffer intersections tallied for days of oiling

SAR TCNNA Shoreline Analysis Products

Days of Shoreline Oiling



Provides initial near shore exposure and prioritization
When, how often and how long have shorelines experienced oil

SAR TCNNA SAR Analysis Products

Time of Oiling

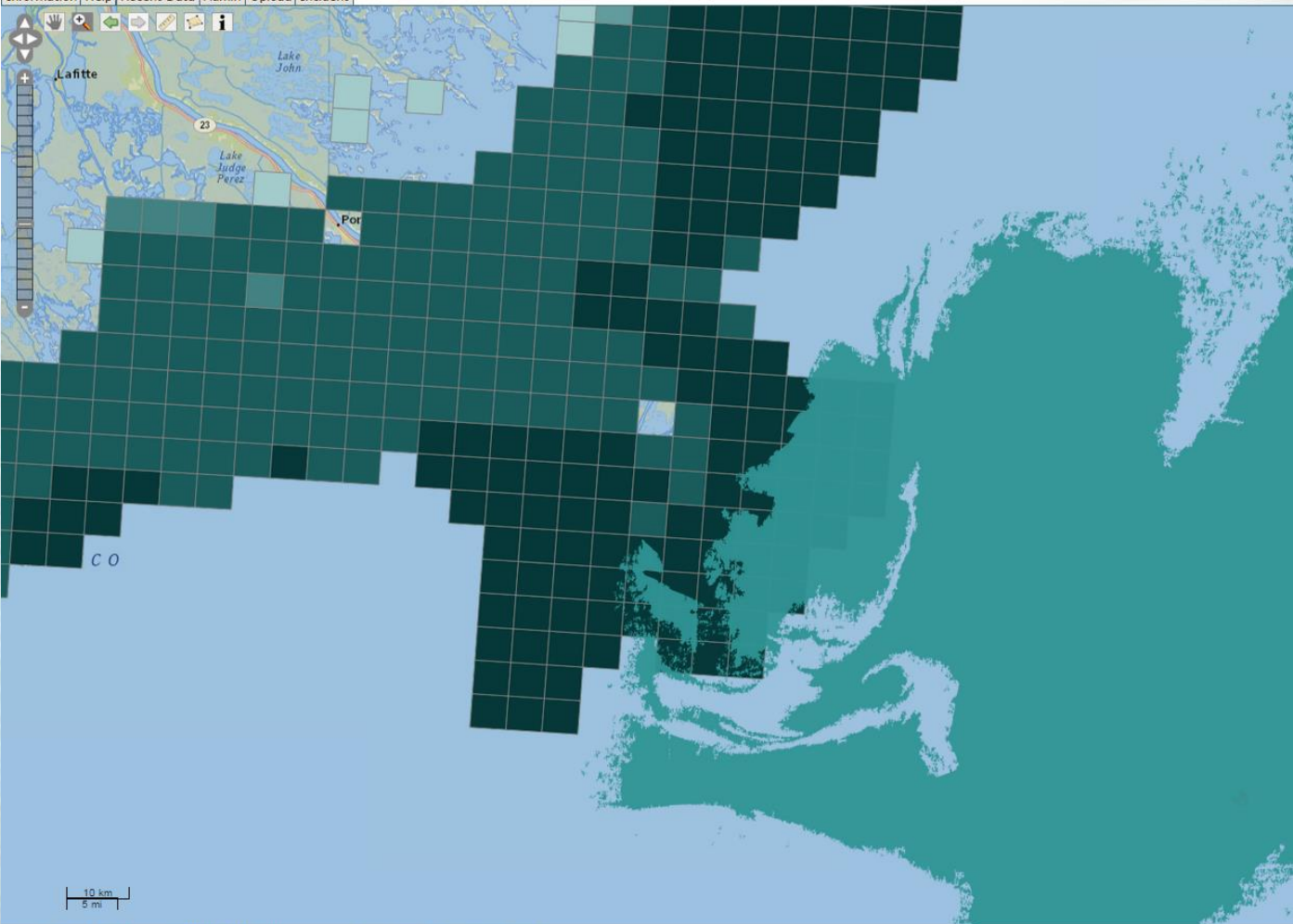
ERMA | Environmental Response Management Application
Deepwater Horizon MC252

Information | Help | Recent Data | Admin | Upload | Incident

Search Layers, Folders, and Bookmarks

Geographic Search

Change Password | Logout



Layers | Legend | Query Tools | AOI | Labels | Zoom | Download | Print

Deepwater Horizon MC 252 Incident

Deepwater Horizon Wreckage

Deepwater Horizon Wreckage

Cumulative Oiling

Initial Oiling Date Grid (5 Km) in Nearshore Areas (updated February 10, 2015)

- Initially oiled April 29 - May 19, 2010
- Initially oiled May 20 - June 5, 2010
- Initially oiled June 6 - June 21, 2010
- Initially oiled June 26 - July 12, 2010
- Initially oiled July 14 - August 11, 2010
- No oiling observed

May 2010

NESDIS Re-Analysis 17-May-10

Oiling footprint

Scale: 1: 433K | Zoom Level: 10 | Location: 29.26766°, -88.58940°

SAR TCNNA SAR Analysis Products

Time of Oiling

ERMA | Environmental Response Management Application
Deepwater Horizon MC252

Information | Help | Recent Data | Admin | Upload | Incident | Search Layers, Folders, and Bookmarks | Geographic Search

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Deepwater Horizon MC 252 Incident
Deepwater Horizon Wreckage
Deepwater Horizon Wreckage

Cumulative Oiling
Initial Oiling Date Grid (5 Km) in Nearshore Areas (updated February 10, 2015)

- Initially oiled April 29 - May 19, 2010
- Initially oiled May 20 - June 5, 2010
- Initially oiled June 6 - June 21, 2010

Calculate Time of Oiling:

- Iterate across TCNNA Daily Composites
- Select shoreline grids for every given Daily Composite
- Calculate date for every day of intersection

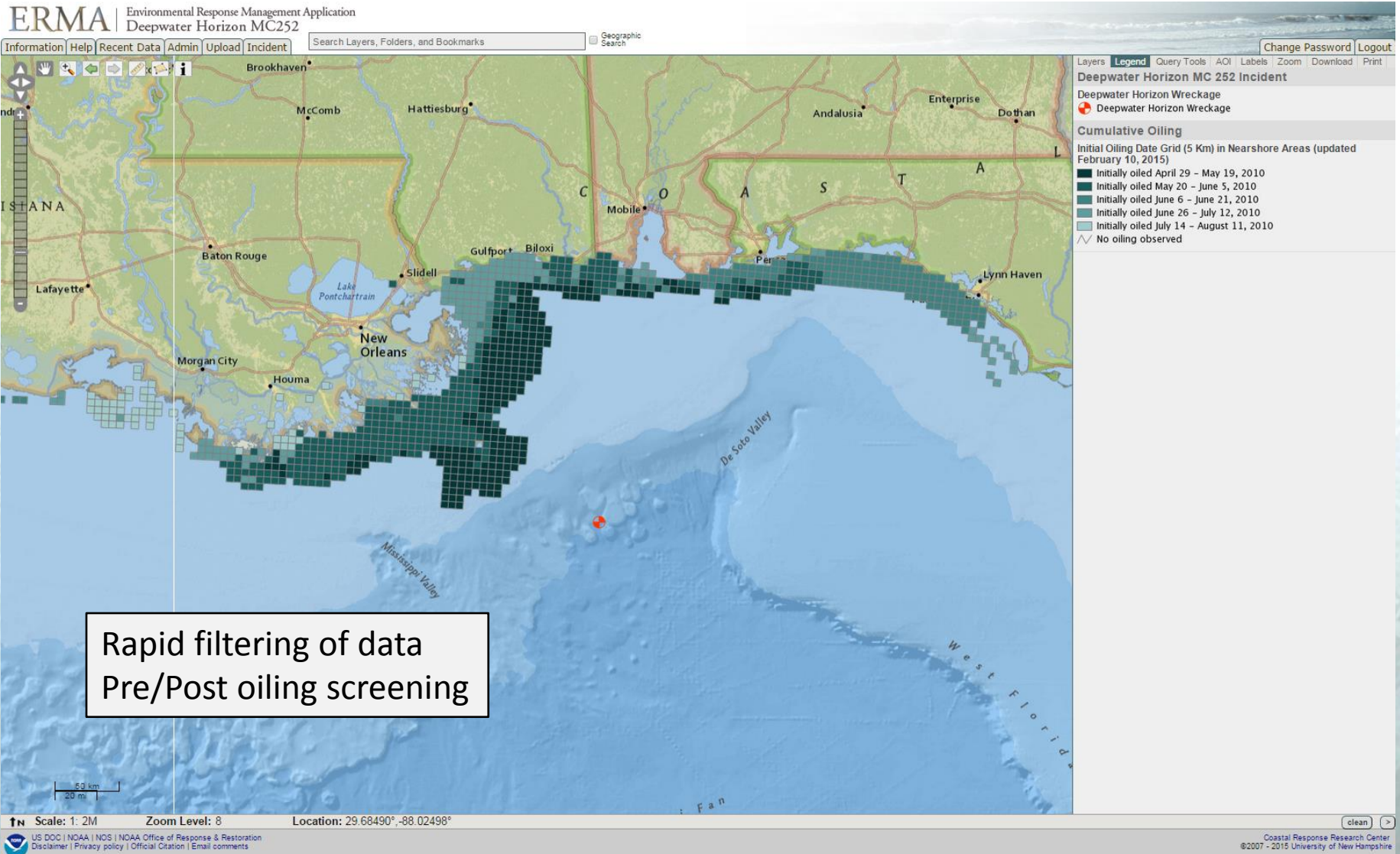
Scale: 1: 433K | Zoom Level: 10 | Location: 29.26766°, -88.58940°

US DOC | NOAA | NOS | NOAA Office of Response & Restoration
Disclaimer | Privacy policy | Official Citation | Email comments

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SAR TCNNA SAR Analysis Products

Time of Oiling



Rapid filtering of data
Pre/Post oiling screening

SAR use in NRDA

- Data provide tools for filtering and focusing allowing prioritization
- SAR data provide an effective screening tool
- Allows us to focus assessment efforts to habitats and species assemblages at the greatest risk of exposure



SAR and NRDA

- SAR data allow us to look at overall extent and duration of potential exposure
- Open water and shoreline conditions are informed by SAR analysis
- Satellite analysis supplements in situ observations and sampling
- SAR data are a useful as an indication of exposure, but not injury



SAR and Future Assessments

- Unmanned Aerial Systems (UAS) are beginning to support the use of traditional satellite sensors such as IR, Thermal and Radar
- New technology in SAR technology provides real promise for enhanced response and damage assessment
- SAR and other remote sensing resources will be part of future assessments

Thank-you!

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Questions?