

EPA Tools and Resources Webinar: Tracking Nutrient Trends to Emerging Harmful Algal Blooms via the Estuary Data Mapper

Naomi Detenbeck and Steve Rego
Tori Wolters (ORISE)
US EPA Office of Research and Development

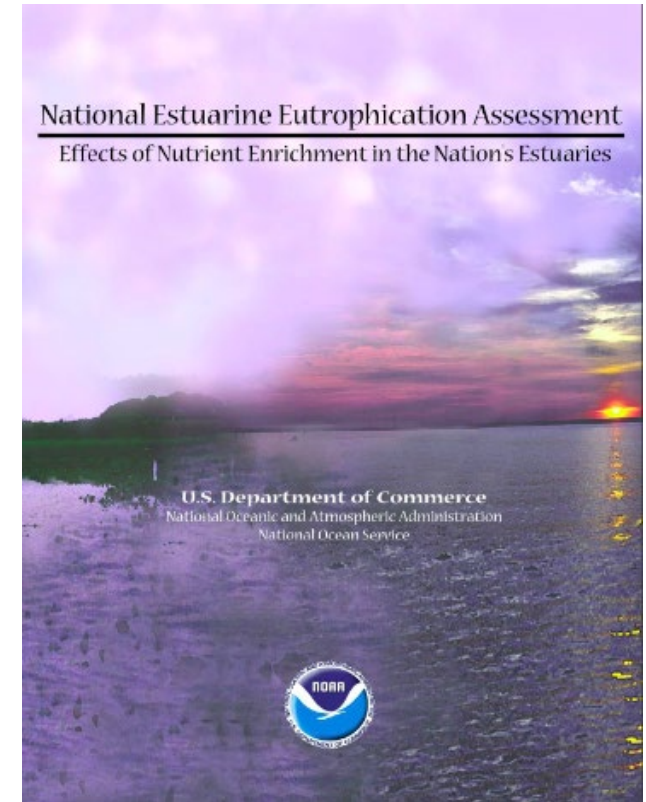
July 19, 2023

Presentation Outline

- Historic and emerging coastal issues
- Estuary Data Mapper
 - Purpose/scope
 - Demo
 - Types of data included
- Chlorophyll and Harmful Algal Bloom (HAB) mapping
 - Approach
 - Tools for use of Sentinel 2 imagery
- Impact and Conclusions

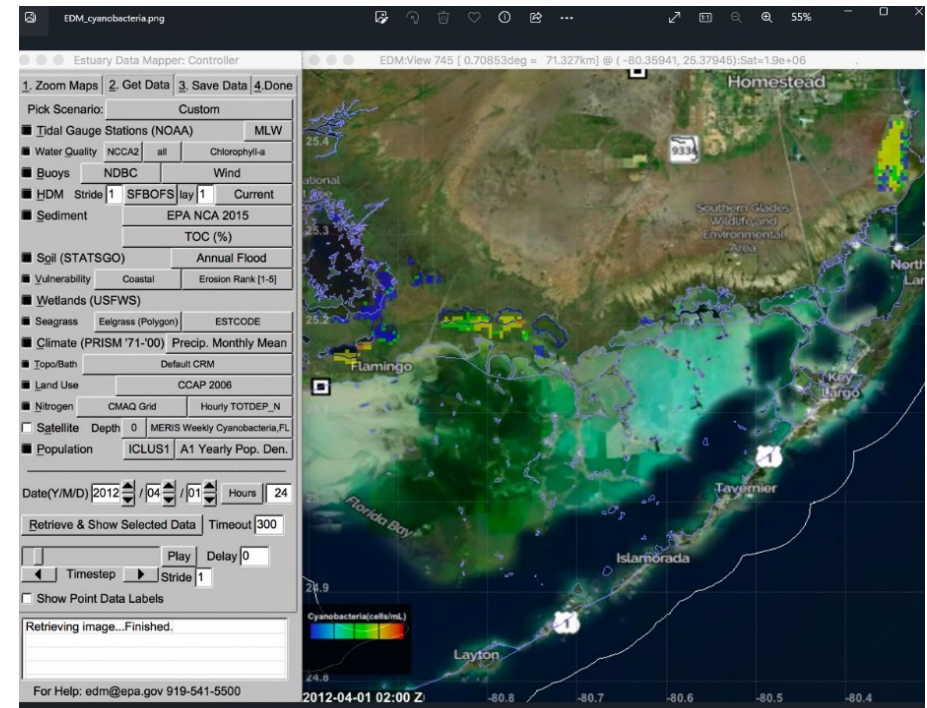
Problem

- NOAA's 1999 comprehensive assessment of the scale, scope and characteristics of nutrient enrichment and eutrophic conditions—in 139 US estuaries using best available information and expert opinion— was largely qualitative; more detailed information is needed to establish loading targets
- Excess nutrient loading in estuaries can cause loss of critical habitat for fish and shellfish, phytoplankton, and HABs and hypoxia
- The 2014 Harmful Algal Bloom Hypoxia Recovery and Control Act (HABHRCA) specifies EPA "*shall include research on the ecology and impacts of freshwater harmful algal blooms; and forecasting and monitoring of and event response to freshwater harmful algal blooms in lakes, rivers, **estuaries (including their tributaries)**, and reservoirs.*"



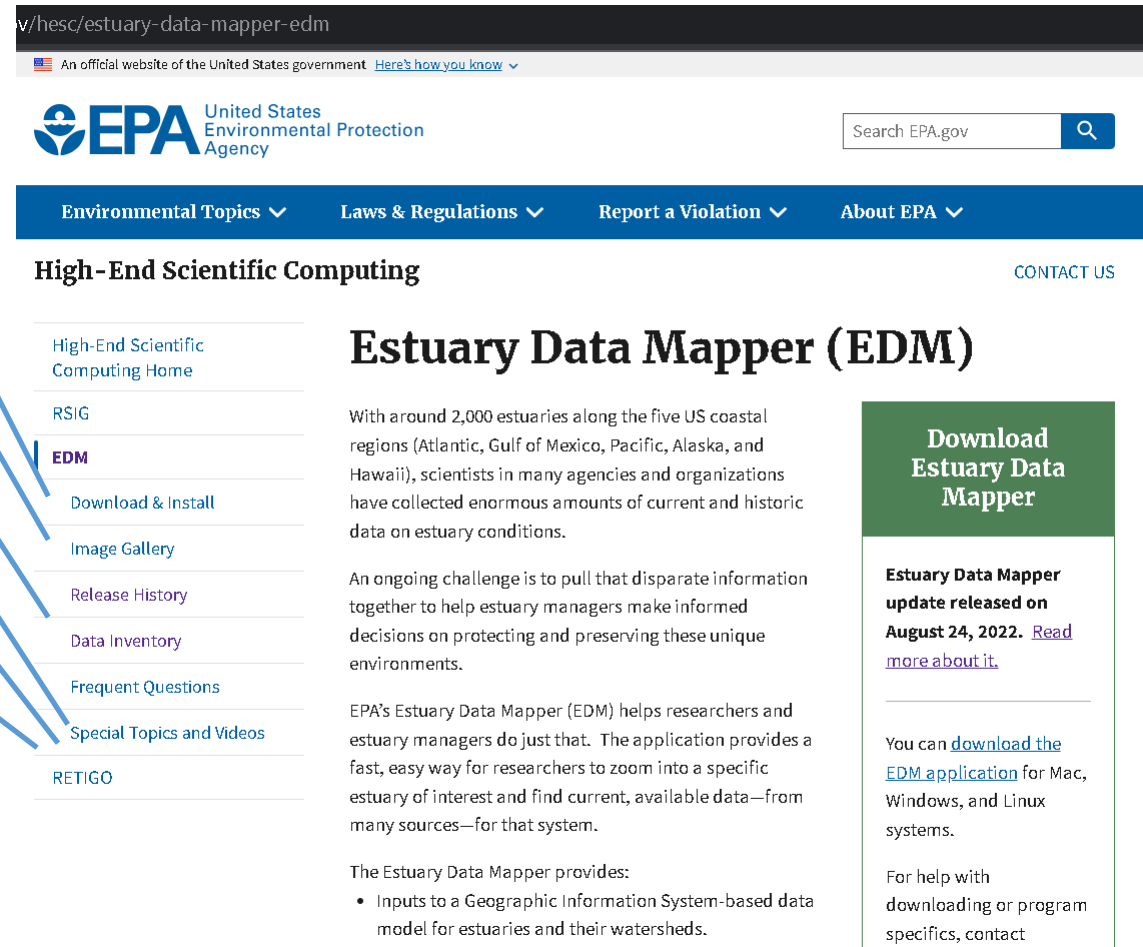
Approach

- EPA developed the [Estuary Data Mapper \(EDM\)](#) application, a virtual portal to data and information on coastal watersheds and estuaries, to deliver data needed by scientists, managers and decision-makers
 - Identify -> Visualize -> Download
 - Nutrient sources and loads – status and trends
 - Factors affecting sensitivity of estuaries to nutrient loading
 - Nutrient response endpoints
 - Water quality (nutrients, dissolved oxygen (DO), transparency)
 - Sediment Total organic carbon (TOC): grain size indicator of enrichment
 - *Chlorophyll a* biomass
 - Submerged aquatic vegetation
 - In development: HABs
 - Inputs to decision support tools for nutrient load reductions



Estuary Data Mapper (EDM) Website

www.epa.gov/edm



v/hesc/estuary-data-mapper-edm

An official website of the United States government [Here's how you know](#)

EPA United States Environmental Protection Agency

Search EPA.gov

Environmental Topics ▾ Laws & Regulations ▾ Report a Violation ▾ About EPA ▾

High-End Scientific Computing [CONTACT US](#)

High-End Scientific Computing Home

RSIG

EDM

Download & Install

Image Gallery

Release History

Data Inventory

Frequent Questions

Special Topics and Videos

RETIGO

Estuary Data Mapper (EDM)

With around 2,000 estuaries along the five US coastal regions (Atlantic, Gulf of Mexico, Pacific, Alaska, and Hawaii), scientists in many agencies and organizations have collected enormous amounts of current and historic data on estuary conditions.

An ongoing challenge is to pull that disparate information together to help estuary managers make informed decisions on protecting and preserving these unique environments.

EPA's Estuary Data Mapper (EDM) helps researchers and estuary managers do just that. The application provides a fast, easy way for researchers to zoom into a specific estuary of interest and find current, available data—from many sources—for that system.

The Estuary Data Mapper provides:

- Inputs to a Geographic Information System-based data model for estuaries and their watersheds.

Download Estuary Data Mapper

Estuary Data Mapper update released on August 24, 2022. [Read more about it.](#)

You can [download the EDM application](#) for Mac, Windows, and Linux systems.

For help with downloading or program specifics, contact

- Download stand-alone application
- View example images
- Data inventory
- Special Topics
 - Training webinars
 - Interoperability - Generation of queries for use in linked apps
 - 508-compliance features
 - Keyboard shortcuts
 - Alternative color visualization schemes

EDM DEMO

- **Locating data**
- **Visualizing data**
- **Downloading data**
- **Special applications**

Assessments: Finding raw data on water and sediment quality

1. Zoom Maps 2. Get Data 3. Save Data 4. Done

_Scenario: Custom

Tidal Gauge Stations (NOAA) MTL

Water Quality NERRS all Station

Buoy IOOS WQP Air Temperature

HDM Stride 1 CBOFS lay 1 NCCCA Air Pressure

Sediment NCCA2 CA Relative Humidity

Soil (STATSGO) Wind

Vulnerability Coastal Wind Direction

Wetlands (USFWS) Depth

Seagrass Density (Gridded) Temperature

Climate (PRISM '71-'00) Precip. Monthly Mean

Topo/Bath Default CRM

Land Use NLCD

Nitrogen Source: Gridded NO23

Satellite Depth 0 MODIS Daytime

Population ICLUS1 A1 Yearly

Date: _Y-M-D 2023 - 06 - 06

Retrieve & Show Selected Data

Play! <Timestep> Stride+ 1

Show Point Data Labels

Version 20220823 (maple)

WQ grab samples

1. Zoom Maps 2. Get Data 3. Save Data 4. Done

_Scenario: Custom

Tidal Gauge Stations (NOAA) MTL

Water Quality NERRS all Turbidity Station

Buoy IOOS IOOS Air Temperature

HDM Stride 1 CBOFS lay 1 GTSPS Air Pressure

Sediment NDBC NERACOOS Relative Humidity

Soil (STATSGO) Organic (%wt) Wind

Vulnerability Coastal CVI (-) Wind Direction

Wetlands (USFWS) Current

Seagrass Density (Gridded) Density (-) Wind Speed

Climate (PRISM '71-'00) Precip. Monthly Mean

Topo/Bath Default CRM

Land Use NLCD 2011

Nitrogen Source: Gridded Crops

Satellite Depth 0 MODIS Daytime

Population ICLUS1 A1 Yearly

Date: _Y-M-D 2023 - 06 - 15

Retrieve & Show Selected Data

Play! <Timestep> Stride+ 1

Show Point Data Labels

Version 20220823 (maple)

Buoys: Continuous WQ

1. Zoom Maps 2. Get Data 3. Save Data 4. Done

_Scenario: Custom

Tidal Gauge Stations (NOAA) MTL

Water Quality NERRS all Turbidity

Buoy IOOS Salinity

HDM Stride 1 CBOFS lay 1 Current

Sediment EPA NCA 1990-2006 Sand (%)

Soil (STATSGO) Organic (%wt)

Vulnerability Coastal CVI (-)

Wetlands (USFWS)

Seagrass Density (Gridded) Density (-)

Climate (PRISM '71-'00) Precip. Monthly Mean

Topo/Bath Default CRM

Land Use NLCD 2011

Nitrogen Source: Gridded Crops

Satellite Depth 0 MODIS Daytime

Population ICLUS1 A1 Yearly

Date: _Y-M-D 2023 - 06 - 15

Retrieve & Show Selected Data

Play! <Timestep> Stride+ 1

Show Point Data Labels

Version 20220823 (maple)

Satellite-derived WQ

1. Zoom Maps 2. Get Data 3. Save Data 4. Done

_Scenario: Custom

Tidal Gauge Stations (NOAA) MTL

Water Quality NERRS all Turbidity

Buoy IOOS Salinity

HDM Stride 1 CBOFS lay 1 Current

Sediment EPA NCA 1990-2006 Sand (%)

EPA NCA 2015 Organic (%wt)

USGS SEABED Calculated

USGS SEABED Extracted

USGS SEABED Parsed

TNC Krige

GSM Gridded

Climate (PRISM '71-'00) Precip. Monthly Mean

Topo/Bath Default CRM

Land Use NLCD 2011

Nitrogen Source: Gridded

Satellite Depth 0 MODIS Daytime

Population ICLUS1 A1 Yearly

Date: _Y-M-D 2023 - 06 - 15

Retrieve & Show Selected Data

Play! <Timestep> Stride+ 1

Show Point Data Labels

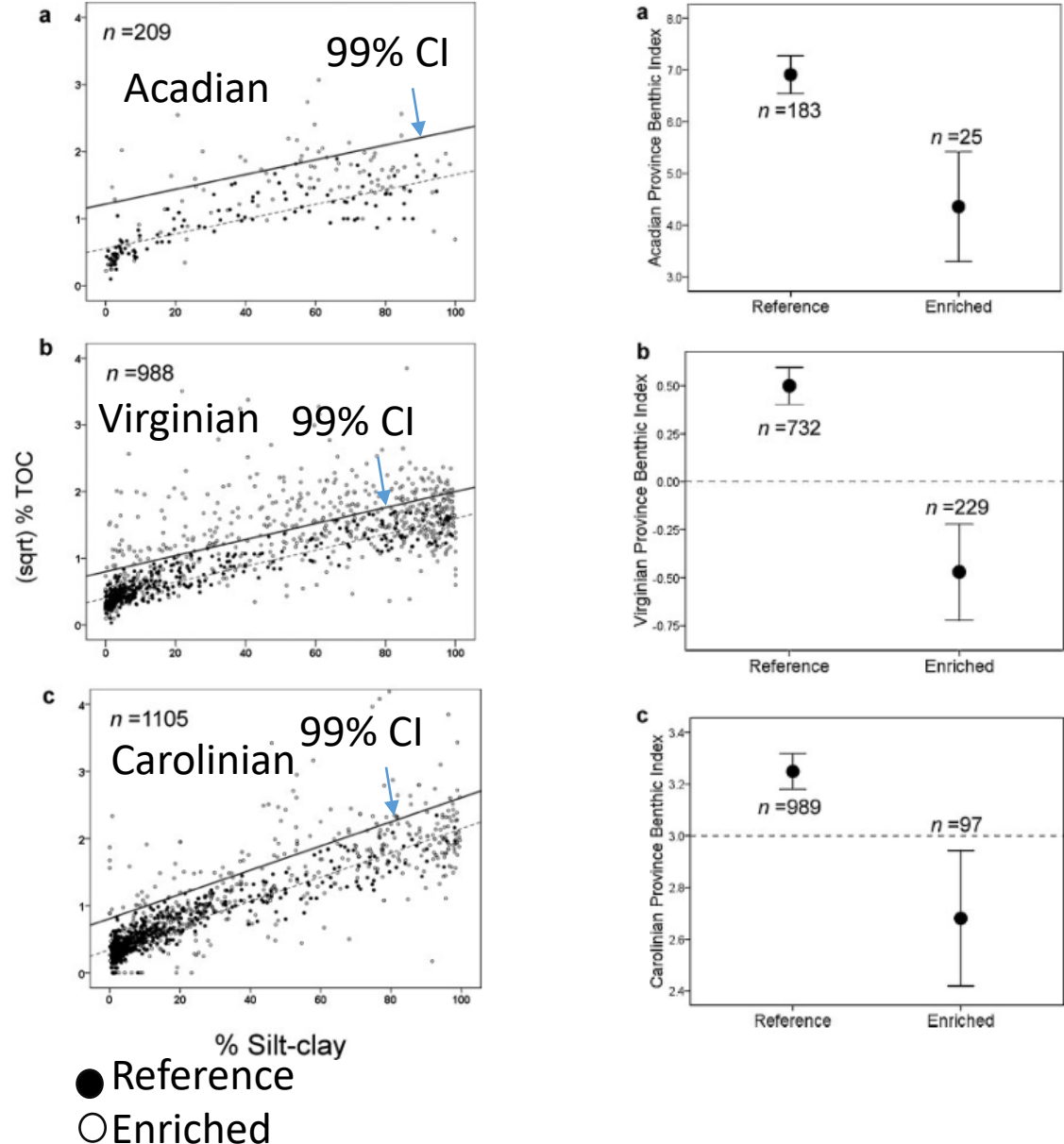
Version 20220823 (maple)

Sediment quality

Application: TOC-grain size eutrophication indicator

- Evaluated relationship between sediment grain size and organic carbon in reference vs enriched systems
- Sediment TOC above 99% confidence interval of predicted value provides evidence of enrichment
- Sediment enrichment indicator was validated by water quality (lower dissolved oxygen, elevated chlorophyll a and nutrients) and benthic condition (poorer index at enriched sites)
- Raw data for application of TOC-grain size indicator available in EDM

Pelletier, M.C., D.E. Campbell, K.T. Ho, R.M. Burgess, C.T. Audette, and N.E. Detenbeck. 2011. [Can sediment total organic carbon and grain size be used to diagnose organic enrichment in estuaries?](#) *Env. Toxicol. Chem.* 30(3):538-47.



Assessing Sources and Trends in Nutrient Loading

1. Zoom Maps 2. Get Data 3. Save Data 4. Done

_Scenario: Custom

Tidal Gauge Stations (NOAA) MTL

Water Quality NERRS all Turbidity

Buoy IOOS Salinity

HDM Stride 1 CBOFS lay 1 Current

Sediment EPA NCA 1990-2006 Sand (%)

Soil (STATSGO) Organic (%wt)

Vulnerability Coastal CVI (-)

Wetlands (USFWS)

Seagrass Density (Gridded) Density (-)

Climate (PRISM '71-'00) Precip. Monthly Mean

Topo/Bath Default CRM

Land Use NLCD 2011

Nitrogen Source: Gridded Crops

Satellite Depth 0 MODIS Manure

Population ICLUS1 A1 Yearly Fertilizer

Date: _Y-M-D 2023 - 06 - 15 Hours 24

Retrieve & Show Selected Data Timeout 300

Play Delay 0

<Timestep> Stride+ 1

Show Point Data Labels

Version 20220823 (maple)

Land-based N loads

1. Zoom Maps 2. Get Data 3. Save Data 4. Done

_Scenario: Custom

Tidal Gauge Stations (NOAA) MTL

Water Quality NERRS all Turbidity

Buoy IOOS Salinity

HDM Stride 1 CBOFS lay 1 Current

Sediment EPA NCA 1990-2006 Sand (%)

Soil (STATSGO) Organic (%wt)

Vulnerability Coastal CVI (-)

Wetlands (USFWS)

Seagrass Density (Gridded) Density (-)

Climate (PRISM '71-'00) Precip. Monthly Mean

Topo/Bath Default CRM

Land Use NLCD 2011

Nitrogen NADP+CMAQ Grid Annual Dry NH3

Satellite Depth 0 MODIS Daytime SST

Population ICLUS1 A1 Yearly Pop. Den.

Date: _Y-M-D 2023 - 06 - 15 Hours 24

Retrieve & Show Selected Data Timeout 300

Play Delay 0

<Timestep> Stride+ 1

Show Point Data Labels

Version 20220823 (maple)

Atmospheric N deposition

1. Zoom Maps 2. Get Data 3. Save Data 4. Done

_Scenario: N-SPECT

Tidal Gauge Stations (NOAA) MTL

Water Quality NERRS all Turbidity

Buoy IOOS Salinity

HDM Stride 1 CBOFS lay 1 Current

Sediment EPA NCA 1990-2006 Sand (%)

Soil (STATSGO) Organic (%wt)

Vulnerability Coastal CVI (-)

Wetlands (USFWS)

Seagrass Density (Gridded) Density (-)

Climate (PRISM '71-'00) Precip. Monthly Mean

Topo/Bath Default CRM

Land Use CCAP 2006

Nitrogen NADP Grid Annual Wet TotN

Satellite Depth 0 MODIS Daytime SST

Population ICLUS1 A1 Yearly Pop. Den.

Date: _Y-M-D 2023 - 06 - 15 Hours 24

Retrieve & Show Selected Data Timeout 300

Play Delay 0

<Timestep> Stride+ 1

Show Point Data Labels

Version 20220823 (maple)

Inputs for NOAA [Nonpoint-Source Pollution and Erosion Comparison Tool](#)

Application: Nationwide Comparison of Exposure

- Regional Spatially Referenced Regressions on watershed models
 - Used to update 2002 delivered nitrogen (N) loads to estuaries of the contiguous US for 2011, supplemented by direct estuarine atmospheric deposition from the Community Multiscale Air Quality Model
- Median 2011 watershed N yields were greatest for the Puget Trough, Virginian, and OR/WA/Vancouver coast marine ecoregions
- Delivered N loads from atmospheric deposition have significantly decreased ($p < 0.05$) for most estuaries on the Atlantic and Gulf coasts for 2002-2012
- Estimated point source delivered N loads for 2002-2012 increased for most estuaries with upstream treatment plants, with estimated loads to only 7 estuaries decreasing by more than 50%
- Loads and source data available in EDM

Detenbeck, N.E., M. You, and D. Torre. 2019. [Recent changes in nitrogen sources and load components to estuaries of the contiguous United States](#). Estuaries and Coasts Vol. 42(8): 2096-2113.

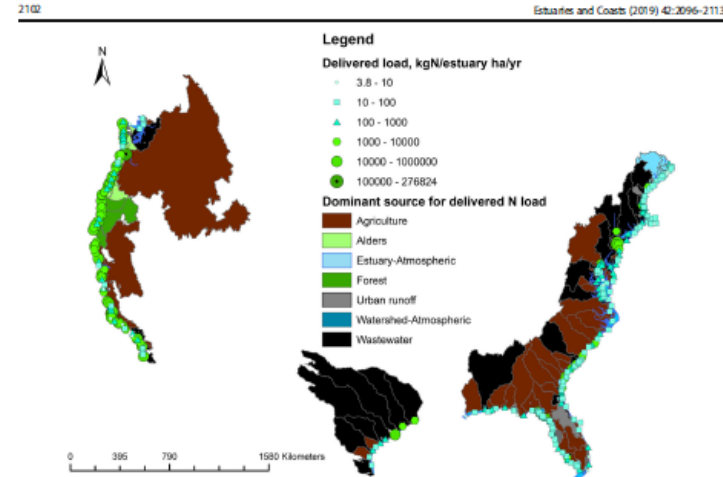
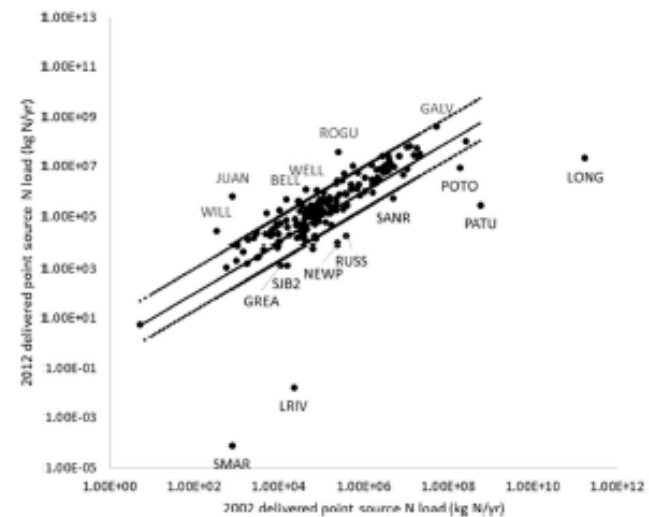


Fig. 4. Delivered loads to each estuary (kg N/ha estuary/year) in the contiguous US with order of magnitude differences indicated by the size of the circle and its color, based on application of regional SPARROW models with updated 2011 source terms. The dominant source for each estuary is indicated by color coding of the associated estuarine watershed. Atmospheric deposition dominates sources in extreme northern New England. Wastewater sources dominate in the northeast, portions of the mid-Atlantic, most Texas estuaries, southern California, and Puget Sound. Agricultural sources dominate through much of the mid to southern Atlantic, eastern Gulf of Mexico, north central and central California, and Columbia River basin. Urban runoff dominates in a few scattered systems mostly in northern Florida. Natural sources (forest and alders) dominate in much of the Pacific Northwest and northern California.

2012 delivered point source load (kg N/yr)



2002 delivered point source load (kg N/yr)

Assessing Sensitivity of Estuaries to Nutrient Loads

1. Zoom Maps 2. Get Data 3. Save Data 4. Done

_Scenario: Nutrient Sensitivity

Nutrient Sensitivity: PRE (days)
(Variables below: NON_TIME_VARYING)

Stream Discharge: Yearly Discharge
ESTCODE: all

Tide Point: Yearly Tide
ESTCODE: all

Tide Current: Monthly Tide
ESTCODE: all

Longshore Current: ESTCODE: all

Estuary Flushing: Yearly Flushing
ESTCODE: all

Salinity Point: ESTCODE: all

Date: _Y-M-D 2023 - 06 -

Retrieve & Show Selected Data Timeout 300

Play Delay 0

<Timestep> Stride+ 1

Show Point Data Labels

Version 20220823 (maple)

- Estuary code (-)
- Estuary Area (km2)
- Mixed Area (km2)
- Sea Area (km2)
- Freshwater Area (km2)
- Mean river flow (m3/day)
- Max. river flow (m3/day)
- Estuary volume (10^9m3)
- Tidal prism (10^9m3)
- Tide height (m)
- Bottom salinity (ppt)
- Surface salinity (ppt)
- Depth (m)
- DCP (mg/L)
- PRE (days)

Summary statistics

1. Zoom Maps 2. Get Data 3. Save Data 4. Done

_Scenario: Nutrient Sensitivity

Nutrient Sensitivity: PRE (days)
(Variables below: NON_TIME_VARYING, TimeVarying)

Stream Discharge: Yearly Discharge USGS Gauges
ESTCODE: all Discharge

Tide Point: Yearly Tide NOAA Gauges
ESTCODE: all ESTCODE

Tide Current: Monthly Tide NOAA Gauges
ESTCODE: all ESTCODE

Longshore Current: ESTCODE: all ESTCODE

Estuary Flushing: Yearly Flushing Time FFM
ESTCODE: all ESTCODE

Salinity Point: ESTCODE: all

Date: _Y-M-D 2023 - 06 -

Retrieve & Show Selected Data

Play Delay 0

<Timestep> Stride+ 1

Show Point Data Labels

Version 20220823 (maple)

- Yearly Flushing Time FFM
- Yearly Flushing Time TPM
- Monthly Flushing Time FFM
- Monthly Flushing Time TPM
- Monthly Stratification Froude
- Monthly Stratification QV

Flushing time statistics and time series

1. Zoom Maps 2. Get Data 3. Save Data 4. Done

_Scenario: Nutrient Sensitivity

Nutrient Sensitivity: PRE (days)
(Variables below: NON_TIME_VARYING, TimeVarying)

Stream Discharge: Yearly Discharge USGS Gauges
ESTCODE: all Discharge

Tide Point: Yearly Tide NOAA Gauges
ESTCODE: all ESTCODE

Tide Current: Monthly Tide NOAA Gauges
ESTCODE: all ESTCODE

Longshore Current: ESTCODE: all ESTCODE

Estuary Flushing: Yearly Flushing Time FFM
ESTCODE: all MeanFlushingTime

Salinity Point: ESTCODE: all

Date: _Y-M-D 2023 - 06 - 15

Retrieve & Show Selected Data

Play Delay 0

<Timestep> Stride+ 1

Show Point Data Labels

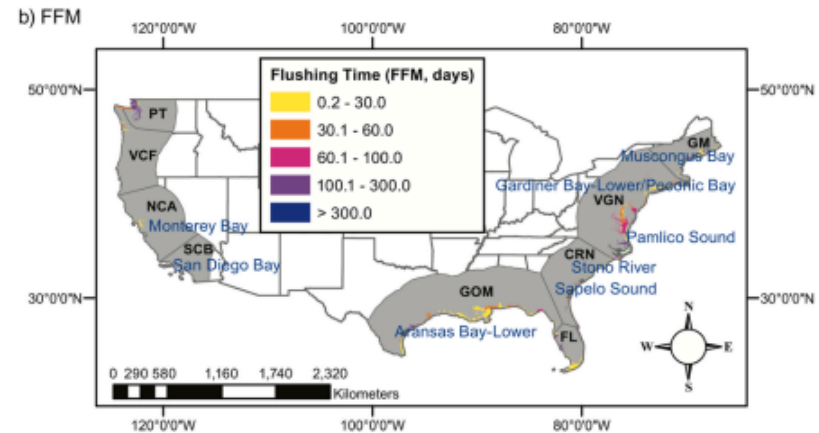
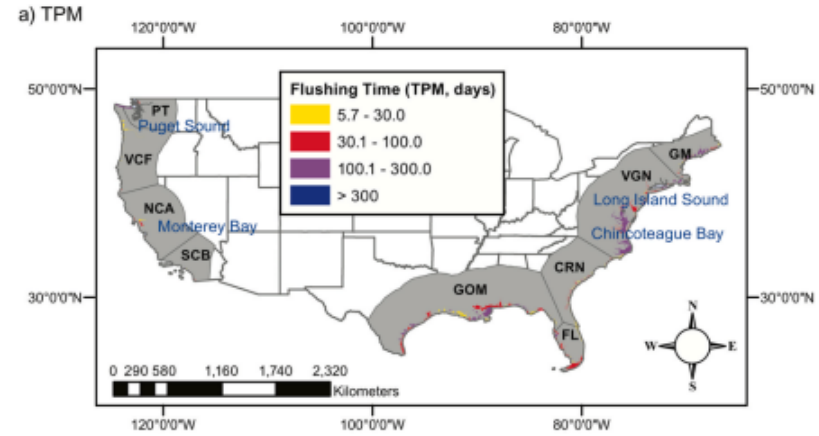
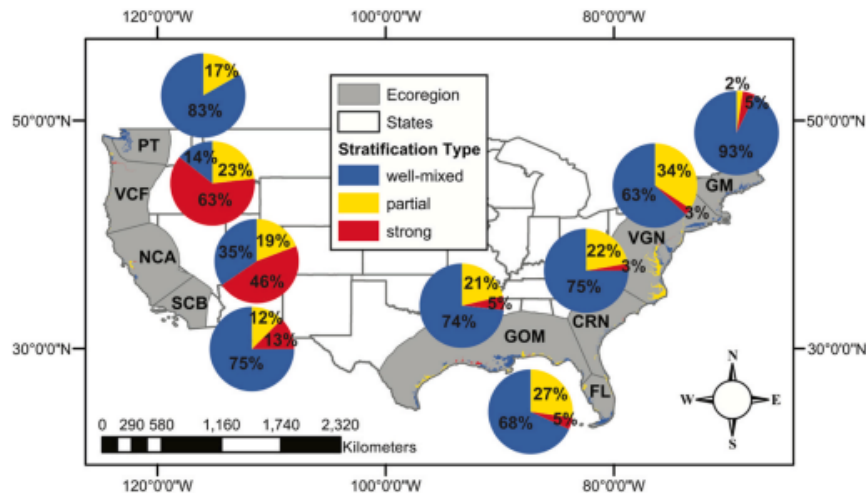
Version 20220823 (maple)

- ESTCODE
- SITE_ID
- SAL_AVG
- SAL_DIFF
- SAL_OCEAN
- FRESH_FRAC
- FRESH_FLOW
- GAUGEDEPTH
- STRATIFY_P

Stratification potential

Application: Comparative Analysis

- Estuarine sensitivity to nutrient loads varies with flushing time and stratification status
- Methods for estimating estuarine stratification and flushing time were applied to estuaries across the US and over a long-term period (1950-2015)
- Most estuaries along East and Gulf coasts well-mixed with stratification more frequent for West coast systems, but varying seasonally consistent w rain patterns



Shen, X., N. Detenbeck, and M. You. 2022. [Spatial and temporal variations in estuarine stratification and flushing time across the continental U.S.](#) Estuarine, Coastal and Shelf Science

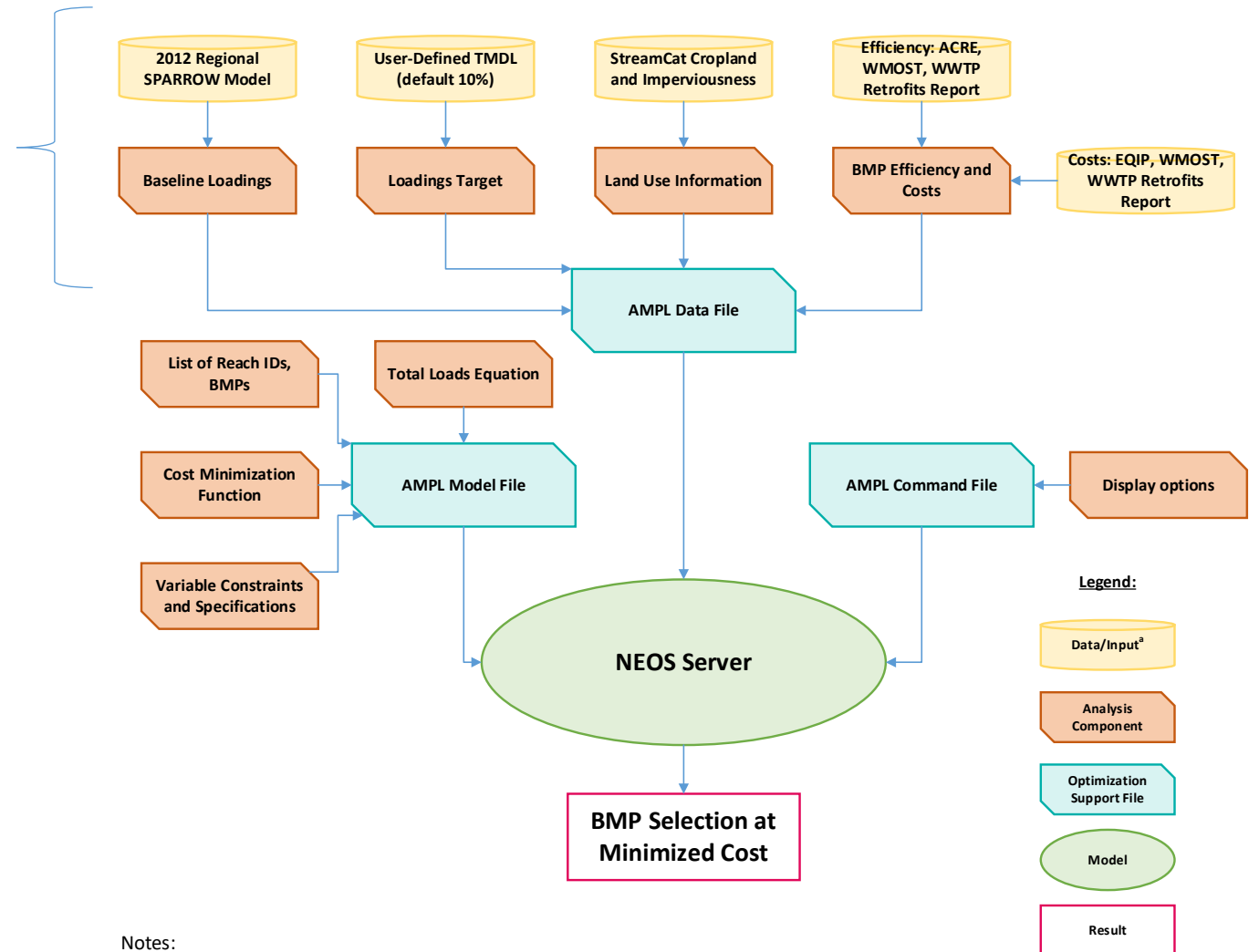
- Flushing times varied by over two orders of magnitude across estuaries
- Well-mixed and partially-stratified estuaries generally had longer flushing times in the dry seasons than in the wet seasons.

Decision Support for Nutrient Load Management

Input datasets available via EDM for sub-watersheds of interest

Chamberlin, C., M. TenBrink, K. Munson, A. Le, and N. Detenbeck. 2021. [River Basin Export Reduction Optimization Support Tool: A tool to screen options for reducing nutrient loads while minimizing cost.](#) JAWRA59(1): 178-196.

Tool and user guide download:
<https://github.com/USEPA/RBEROST>

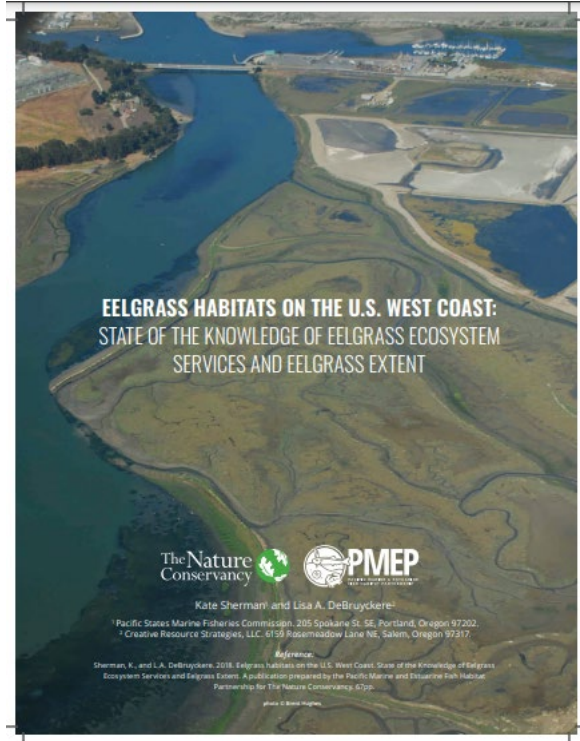


Notes:

SPARROW = SPAtially Referenced Regression On Watershed attributes; TMDL = Total Maximum Daily Load; ACRE = Agricultural Conservation Reduction Estimator; WMOST = Watershed Management Optimization Support Tool; WWTP = Wastewater Treatment Plant; BMP = Best Management Practice; EQIP = Environmental Quality Incentives Program; AMPL = A Mathematical Programming Language; NEOS = Network-Enabled Optimization System.

^aThe data/inputs represented in this diagram are specific to the case study described in Section 3.

Nutrient Response Endpoints: Submerged Aquatic Vegetation (SAV)



1. Zoom Maps 2. Get Data 3. Save Data 4. Done

Scenario: Custom

Tidal Gauge Stations (NOAA) MLW

Water Quality WQP all Secchi Disk Depth

Buoys NDBC Wind

HDM Strige 1 CBOFS lay 1 Current

Sediment EPA NCA 1990-2006 TOC (%)

Soil (STATSGO) Organic (%wt)

Vulnerability Coastal Mean Wave Height (m)

Wetlands (USFWS)

Seagrass Eelgrass (Polygon) HECTARES

Climate (PRISM '71-'00) Prec

TopoBath Default

Land Use CCA

Nitrogen NADP Grid

Satellite Depth 0 WQ

Population ICLUS1 A1

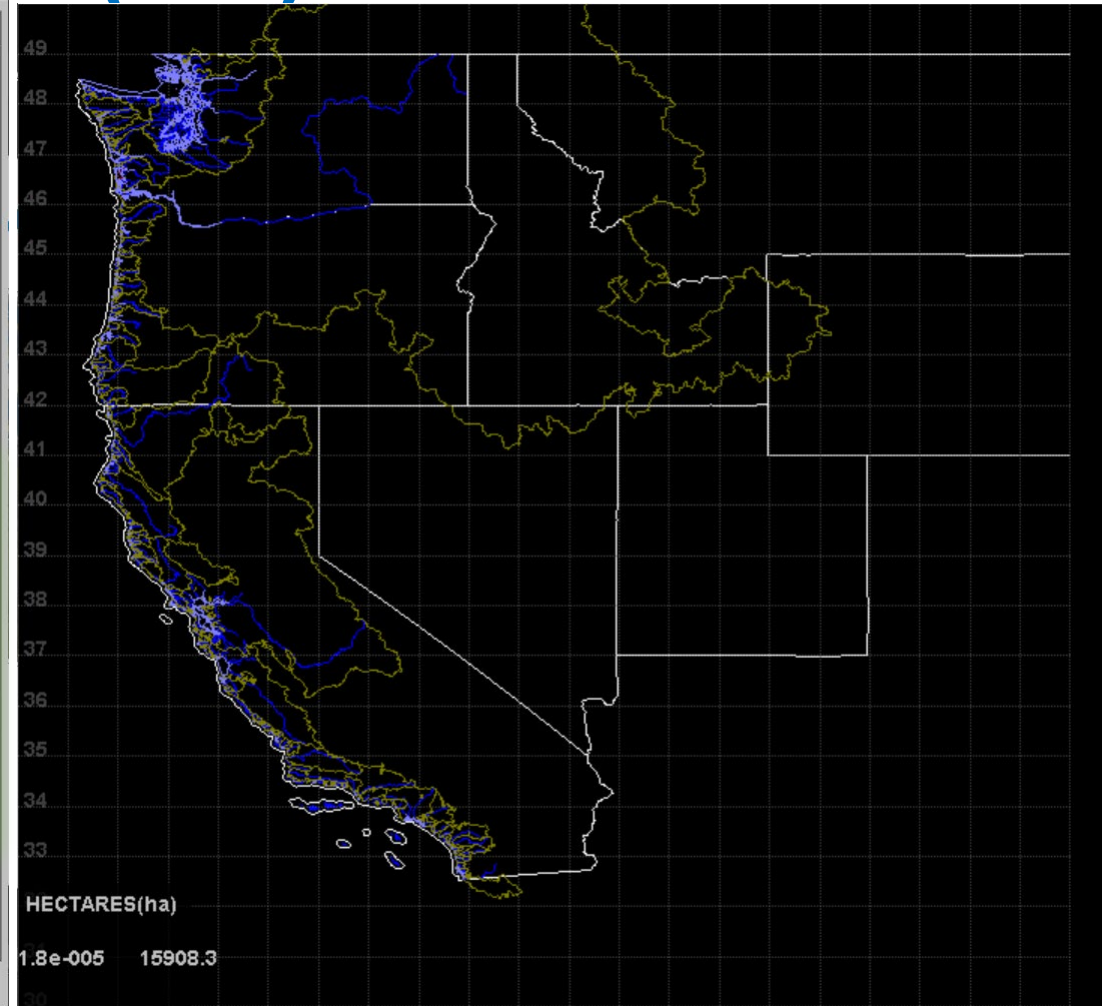
Date: _Y-M-D 2010 - 06

Retrieve & Show Selected Data

Play! Delay 0

Show Point Data Labels

Retrieving Seagrass...
Finished retrieving...



Pacific Marine & Estuarine Fish Habitat Partnership Eelgrass Datasets

- Max observed extent
- Time series of extent
- Summaries by estuary

Updates in progress to add comparable data for Gulf and Atlantic coasts

Presentation Outline

- Historic and emerging coastal issues
- Estuary Data Mapper
 - Purpose/scope
 - Demo
 - Types of data included
- **Chlorophyll and Harmful Algal Bloom (HAB) mapping**
 - **Approach**
 - **Tools for use of Sentinel 2 imagery**
- Impact and Conclusions

Problem

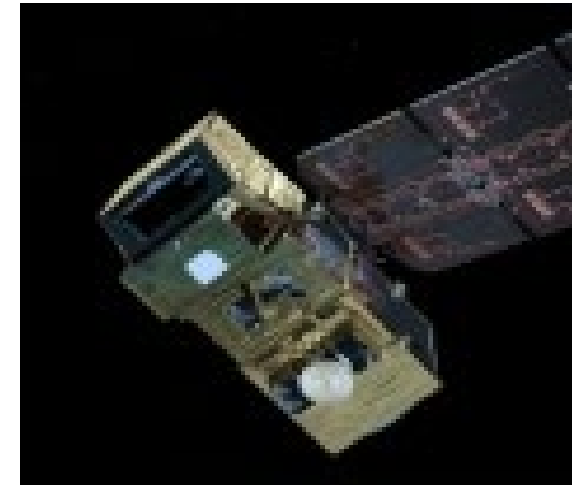
- ***Cyanobacteria blooms are an emerging issue in coastal systems***
- We lack consistent and comprehensive chlorophyll monitoring in coastal systems
- Estuaries and tidal freshwater rivers have unique challenges for interpreting remote sensing imagery
- Only 45% of Pacific coast estuaries are large enough to use Sentinel 3 remote sensing (30m pixels)
- Machine learning can be used to interpret Sentinel 2 imagery, but the data and method have technical challenges



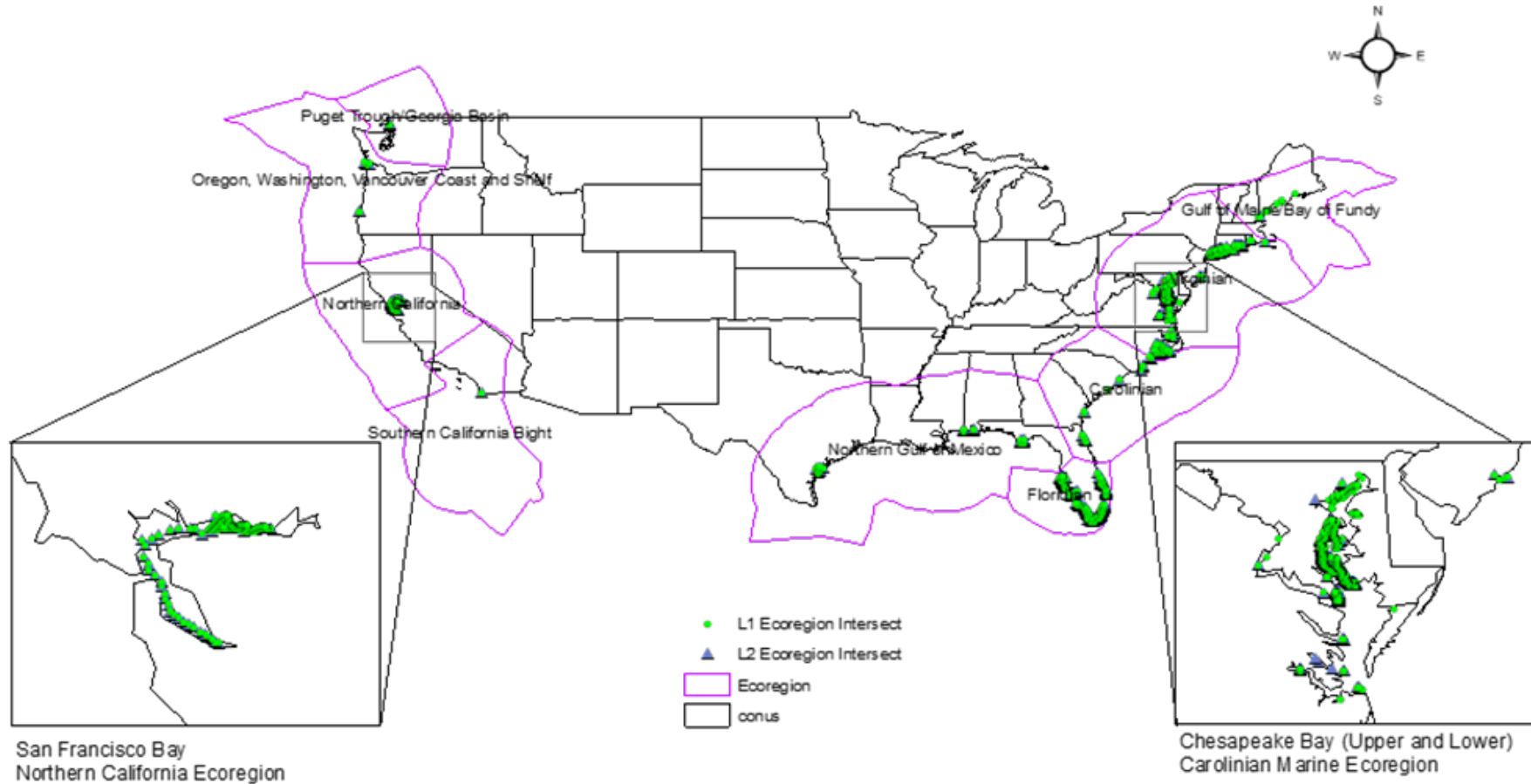
Accumulations of cyanobacterial at the surface of the water and sandy beach within the lagoon of the Santa Clara River estuary. Credit: Avery Tatters, UCLA, now USEPA.

Approach for chlorophyll predictions

- Develop comprehensive database of chlorophyll + ancillary water quality variables for estuaries and tidal freshwater rivers
- Match subset of estuarine chlorophyll observations with Sentinel 2 imagery via Google Earth Engine analysis
- Identify subset of paired Sentinel 2-Water Quality dataset along gradient of chlorophyll, turbidity, and salinity for algorithm testing/development
- Test alternative atmospheric correction algorithms
 - Acolite, Polymer, SIAC
 - Aeronet reference sites
 - Comparison of observed vs predicted chlorophyll
- Compare accuracy of existing chlorophyll algorithms with existing and refined machine learning approach



Nutrient Response Endpoints: Chlorophyll

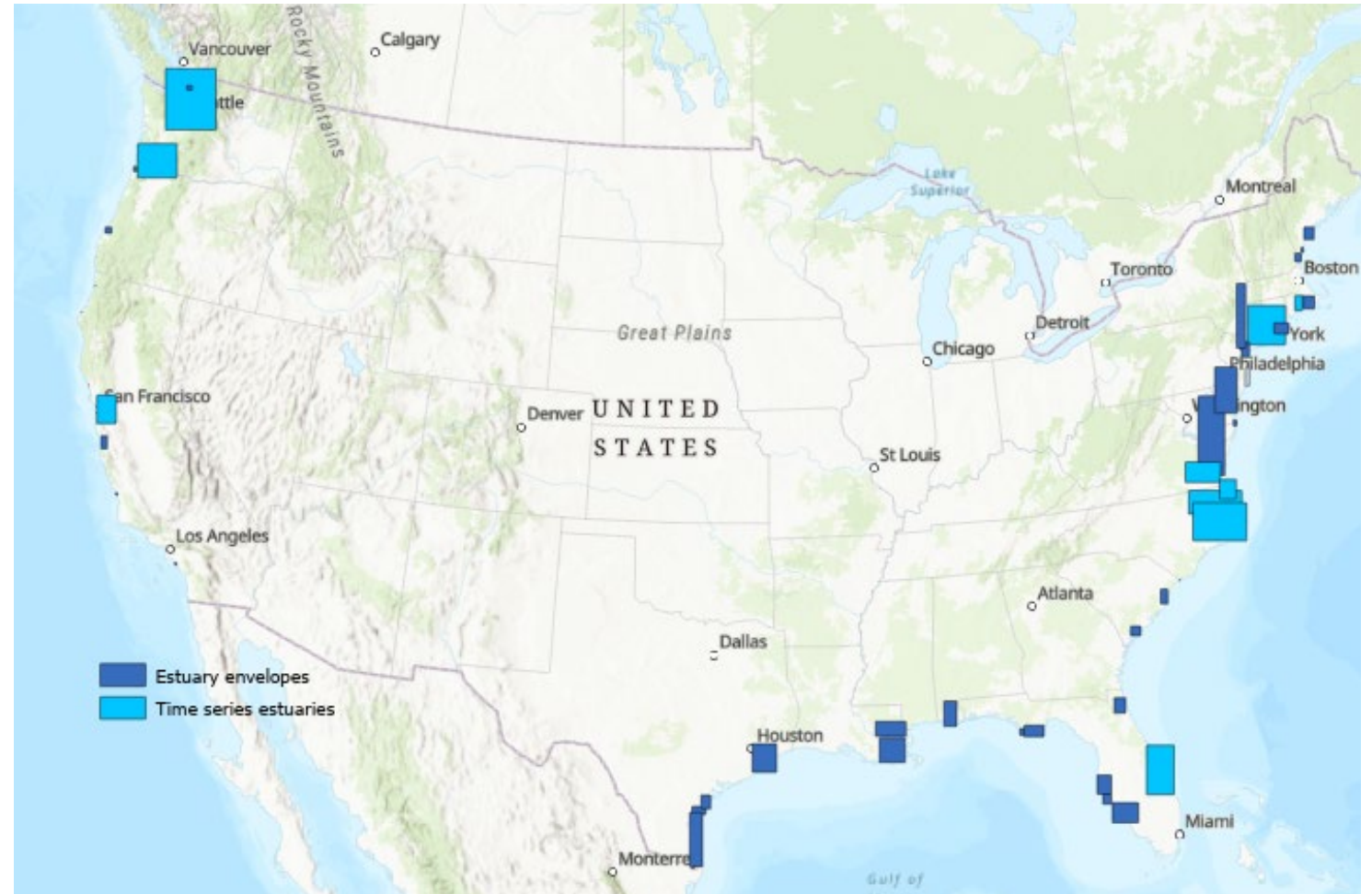


Two chlorophyll (plus ancillary variables) water quality databases compiled:

- 1) Comprehensive: ~300,000 observations, 1980's – 2022
- 2) Paired chlorophyll observations with Sentinel 2 remote sensing imagery to use for refining chlorophyll algorithms to enable mapping and prediction of HABs (n = ~95,000)

Estuaries for chlorophyll algorithm refinement and chl/HABs* time series analysis

- Time series
 - Narragansett Bay
 - Long Island Sound
 - James River*
 - Albemarle/Pamlico/
Currituck Sound*
 - Indian River*
 - San Francisco Bay
 - Columbia River*
 - Puget Sound*



Sentinel 2 processing guidance under development

- Automated matching of Sentinel 2 images with chlorophyll observations via Google Earth Engine (GEE) with R and Python scripts
- Bulk download methods
 - USGS Earth Explorer (now obsolete) => Copernicus
- GEE retrieval of improved “cloudless” indicator for cloud and cloud shadow masks
- Correction of NetCDF output files from Acolite and Polymer
 - Not CF-compliant => Not read in properly to GIS software
 - Not properly geo-referenced
 - Variables not all recognized
 - Acolite extracts area of interest to minimize file size, but Polymer does not
 - Scripts set up for batch processing on supercomputer
- ArcGIS Pro model builder workflow for import of corrected NetCDF files and extraction of values around buffered observation points

USGS Bulk Download Application (BDA)

Level 1 Sentinel 2 images (SAFE format)

Acolite Atmospheric and Sunglint Corrections

Polymer Atmospheric Corrections

Atmospherically Corrected Level 2 Sentinel 2 images (NetCDF format, non CF-compliant)

Post-processing

Atmospherically Corrected Level 2 Sentinel 2 images (NetCDF format, CF-compliant)

ArcGIS Pro extraction/processing

Comparison with AERONET water-leaving reflectances

Refined machine-learning algorithms (Pahelvan et al. 2020)

Google Earth Engine (GEE)

Download scripts

Sentinel 2 S2Cloudless geotiffs (improved pixel-scale cloud probabilities)

FMASK

Cloud and cloud shadow masks

QC filtering (Bailey and Werdell 2006)

Existing chlorophyll algorithms

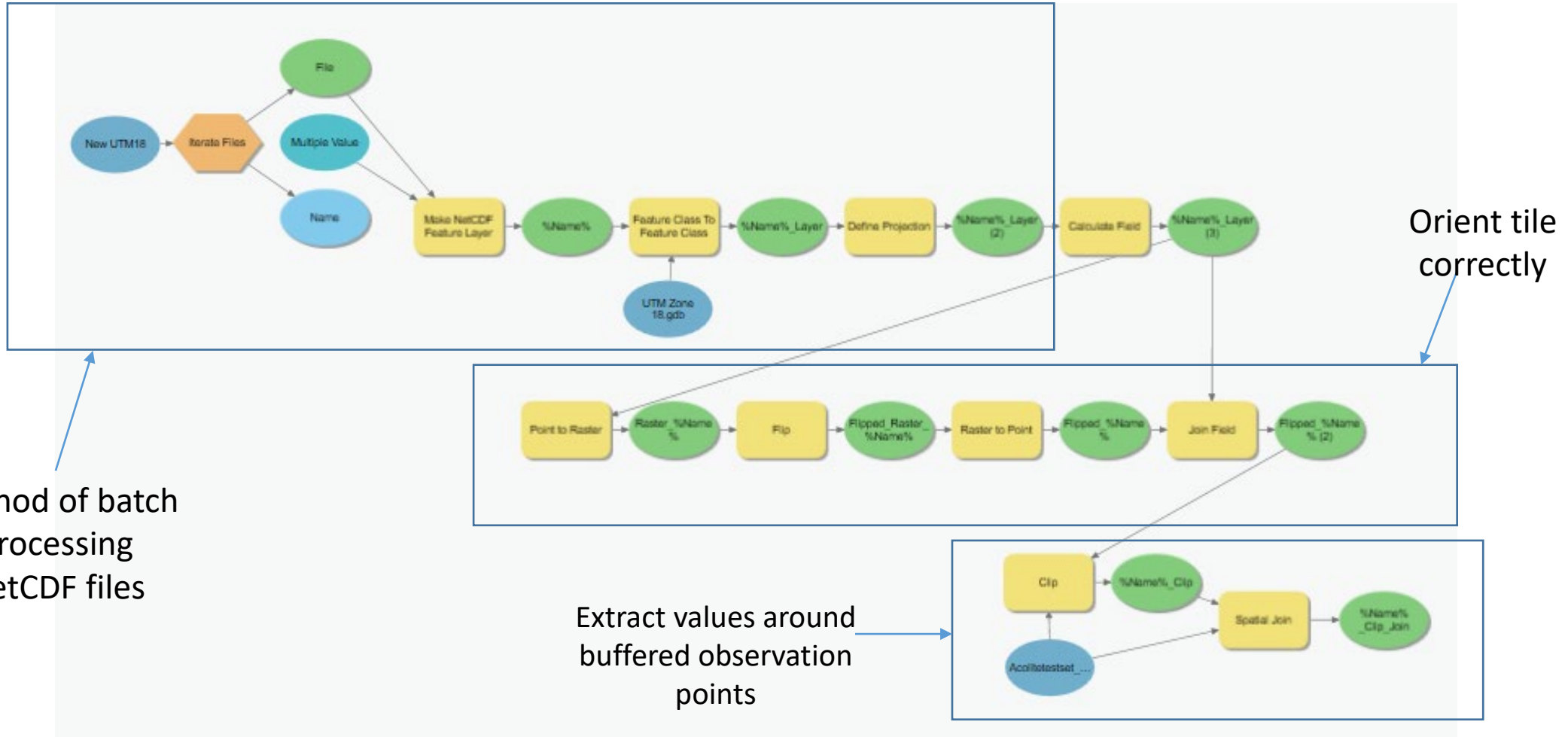
EstuarySAT Coastal WQ Database

Extracted Sentinel 2 data paired with WQ observations in space and time with preliminary cloud and cloud shadow masks applied

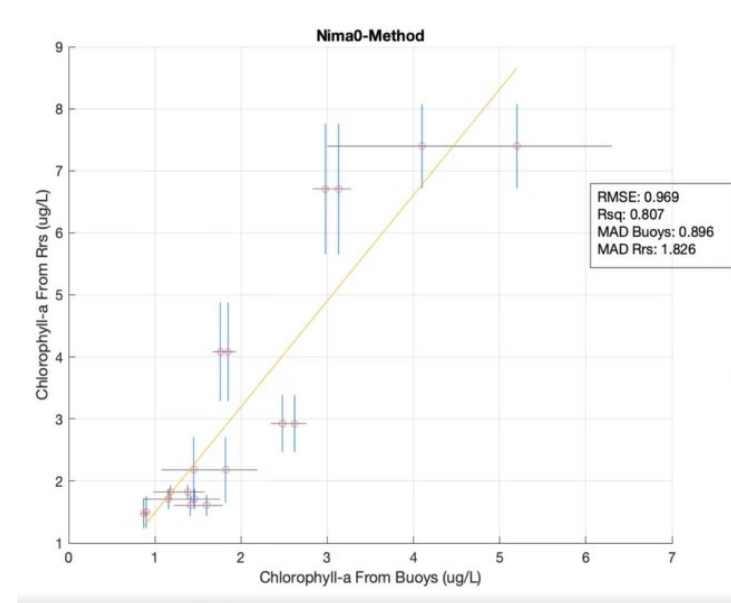
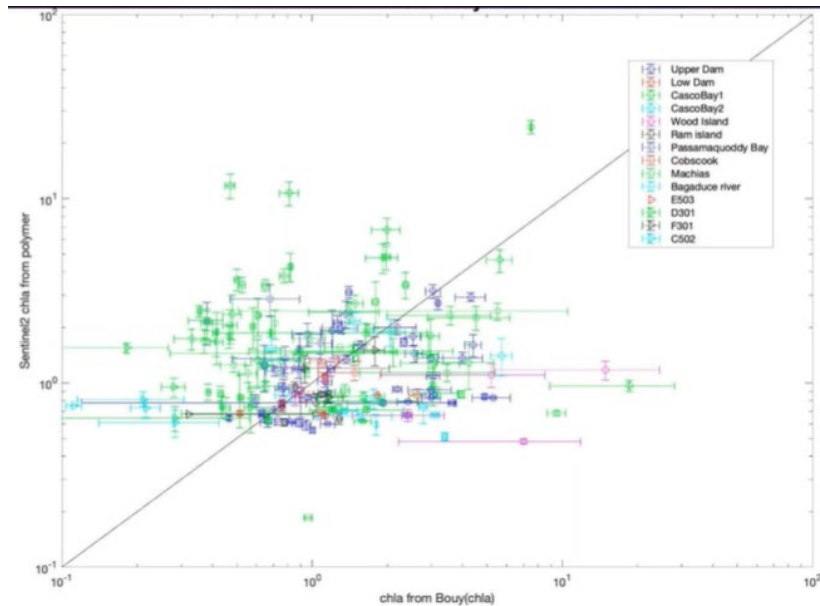
Test set selected along gradient of chlorophyll, turbidity and salinity

Compare to evaluate different atmospheric corrections and algorithms

ArcGIS Pro Model Builder NetCDF Processing



Example: Results from Mixture Density Network (MDN) approach



Initial validation of chlorophyll a data from a) Landsat 8 and b) Sentinel 2 using chlorophyll data from buoys in the Gulf of Maine ([Brady and Boss 2021](#)).

Machine learning (MDN) approach of Pahlevan et al (2020) has been successfully applied in the Gulf of Maine to map chlorophyll, with better success using Sentinel 2 vs Landsat 8 imagery

Approach for HABs Predictions

- Develop logistic models predicting presence/absence of cyanobacteria blooms in estuaries and freshwater tidal systems
 - Database of cyanobacteria endpoints:
 - Potential predictors
 - Chlorophyll
 - Discharge
 - Retention time
 - Temperature
 - Nutrient loading
 - Salinity
 - Stratification
- Initial predictive models may need to be system-specific as endpoints measured differ across systems and in situ measurements of relative fluorescence units (RFUs) with sensors are not comparable across systems

Impact

- EDM provides data for quantitative assessments of trends in eutrophication in estuaries across broad regions of the US
 - Nutrient concentrations
 - Exposure/loading from different sources
 - Diagnostic indicators of enrichment
 - Intra- and interannual variability in factors affecting sensitivity to nutrient loads
 - Nutrient endpoints: chlorophyll, DO, SAV
- EDM provides input data for River Basin Export Reduction Optimization Support Tool (RBEROST), a decision support tool to find the most cost-effective nutrient load reduction management strategies
 - Upper CT River pilot with stakeholders completed, now being expanded to full Long Island Sound (support from LIS NPO)
 - Puget Sound pilot underway with Upper Mississippi (Illinois River Basin) pilot started soon
- Improvements in algorithms for chlorophyll using Sentinel 2 imagery will assist in assessing spatio-temporal patterns in blooms for both large and small estuaries, supplementing limited monitoring data, and ultimately paving the way for near real-time monitoring of blooms
- Development of predictive models for HABs in coastal systems will help to prioritize timely on-the-ground monitoring of hotspots

Take Home Messages

- [EPA's Estuary Data Mapper](#) provides a one-stop-shop for assessing, diagnosing, and managing trophic status and trends in estuaries—with access to raw water quality data, sediment enrichment data, nutrient sources and loads, factors affecting estuarine sensitivity to nutrient loads, effect endpoints, and inputs to decision support systems
- Cyanobacteria blooms are an emerging issue in coastal systems. Remote sensing is needed for improved monitoring and prioritization of potential threats to human health and aquatic resources

Contacts

Naomi Detenbeck, PhD

Ecologist

US EPA Office of Research and Development

detenbeck.naomi@epa.gov

401-207-0880

Steven Rego

Biologist, co-PI Chlorophyll/HAB studies

US EPA Office of Research and Development

rego.steven@epa.gov

401-782-3177

Tori Wolters

ORISE participant (Chlorophyll/HAB studies)

US EPA Office of Research and Development

wolters.tori@epa.gov

401-782-3172