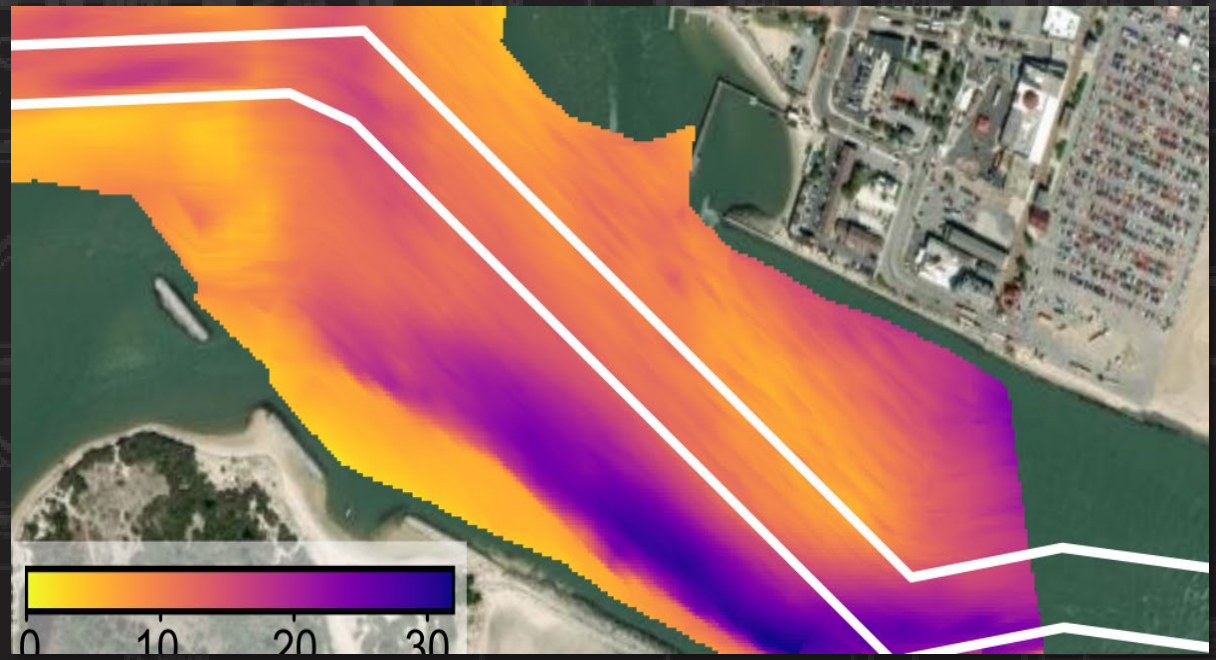
ENHANCING SHOALING ANALYSIS:
UPDATES AND IMPROVEMENTS FOR AN UPCOMING CSAT RELEASE

CSAT Team:

Michael Hartman, Rachel Bain, Anna Dominique Godfrey, Charlene Sylvester, Kaite McPherran, Kate Smith, and Kate Richards

February 25, 2025



COASTAL INLETS RESEARCH PROGRAM

FY25 CIRP Technical Discussion

U.S. ARMY

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MOTIVATION AND PURPOSE

U.S. maritime infrastructure is vital to the nation's economy, facilitating the movement of approximately 2.5 billion tons of cargo annually. This extensive network, consisting of over 300 commercial ports and 25,000 miles of inland and coastal waterways, is essential for industries like manufacturing, agriculture, and energy.

However, the costs associated with maintaining the overall waterborne commerce system have been increasing, exacerbated by issues such as dynamic environmental conditions, aging infrastructure, and availability of resources. These challenges underscore the need for innovative solutions to optimize maintenance and operational strategies.

The Corps Shoaling Analysis Tool (CSAT) is an analytical tool that leverages more than 100,000 hydrographic surveys collected across the USACE portfolio to quantify the rate of navigation channel filling and estimate future channel dredging volumes. CSAT can be used to help predict shoaling issues more accurately, allocate resources better, and minimize navigation system disruptions.

CSAT is an ongoing project in the Coastal Navigation Portfolio Management Work Unit.

Statements of Need:

- NAV-21-1671 "Corps Shoaling Analysis Tool (CSAT) Enhancement"
- 2015-N-15 "Integration of national and local monitoring datasets to support navigation and operations projects"
- 2015-N-40 "Reducing the need for dredging"

FY24 – New CSAT user guide, improved dredge activity detection, handle custom AOIs, new user interface prototype
FY23 – eHydro & JALBTCX data integration, improved CSAT setup experience,
FY22 – New shoaling rate methods

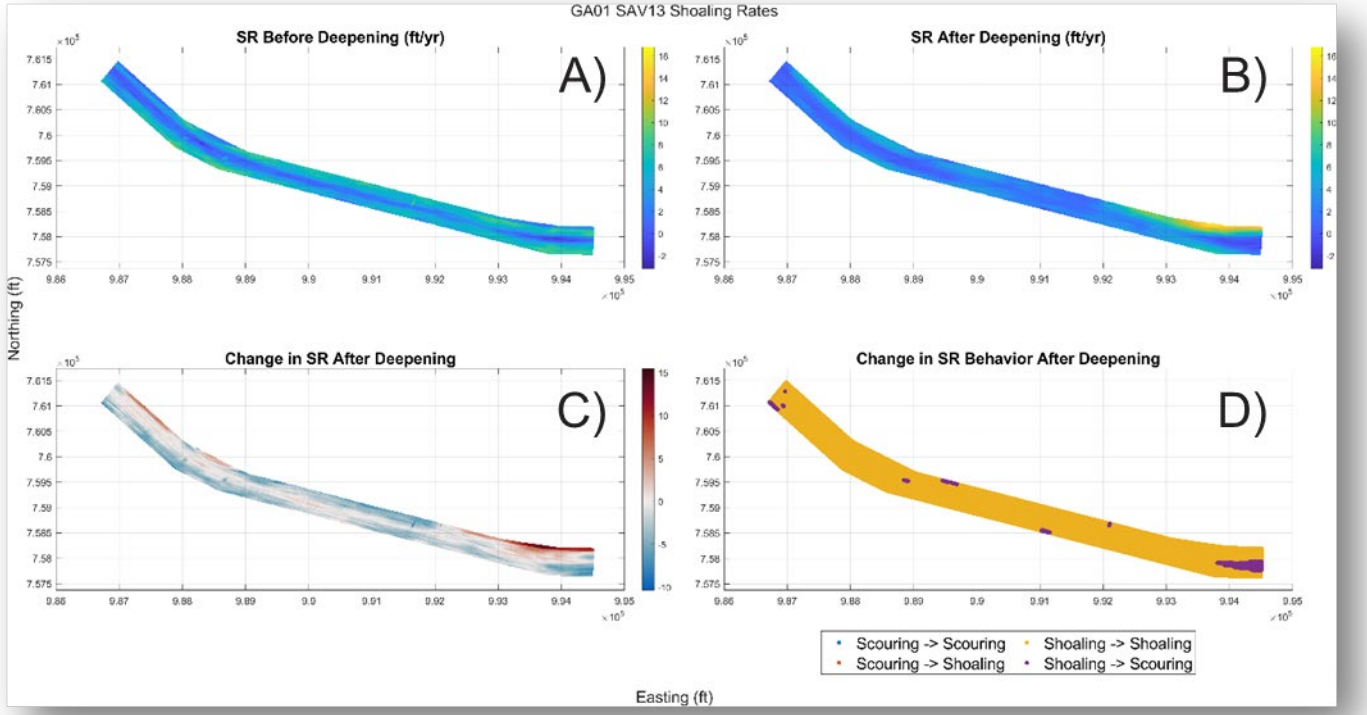
CAPABILITY AND STRATEGIC IMPACT

Capability

- Suite of computational routines for calculating historical shoaling rates from eHydro survey data and forecasting future dredging needs based on observed trends.
- Shoaling is calculated on a 10 ft-by-10 ft grid, with results available for all surveyed reaches in the National Channel Framework.
- Efficient calculations permit enterprise-level rollup using local computing resources.

Strategic Impact

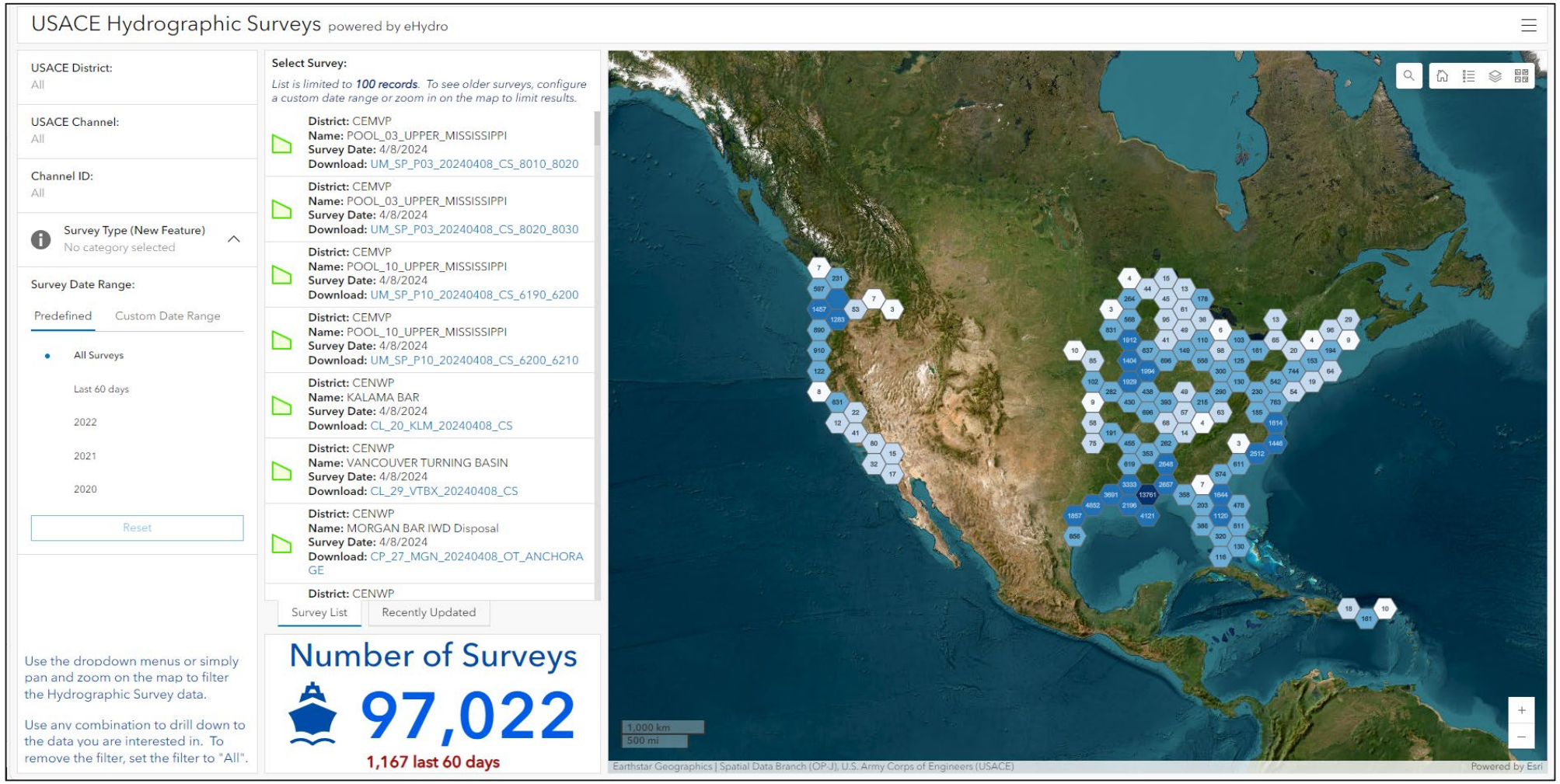
- Districts use CSAT to quantify project-level shoaling rates, identify shoaling hotspots, and plan for future maintenance requirements.
  - *Recent projects include Matagorda (SWG), Houston-Galveston (SWG), Calcasieu (MVN), Southwest Pass (MVN), Gulfport (SAM), King's Bay (SAJ), and **Savannah (SAS; figure at right).***
  - *Our team answered questions for 24 USACE customers across 11 districts during FY24!*
  - CSAT Support - dll-ceerd-csat@usace.army.mil
- Enterprise-level shoaling summaries support planning by USACE Headquarters.
- We regularly support Districts users with training sessions, troubleshooting, and reviewing CSAT outputs.



Maps of Reach 13 in the Savannah Harbor showing the pre-deepening shoaling rates (A), post-deepening shoaling rates (B), change in shoaling rates (C), and change in shoaling rate behavior post-deepening (D)

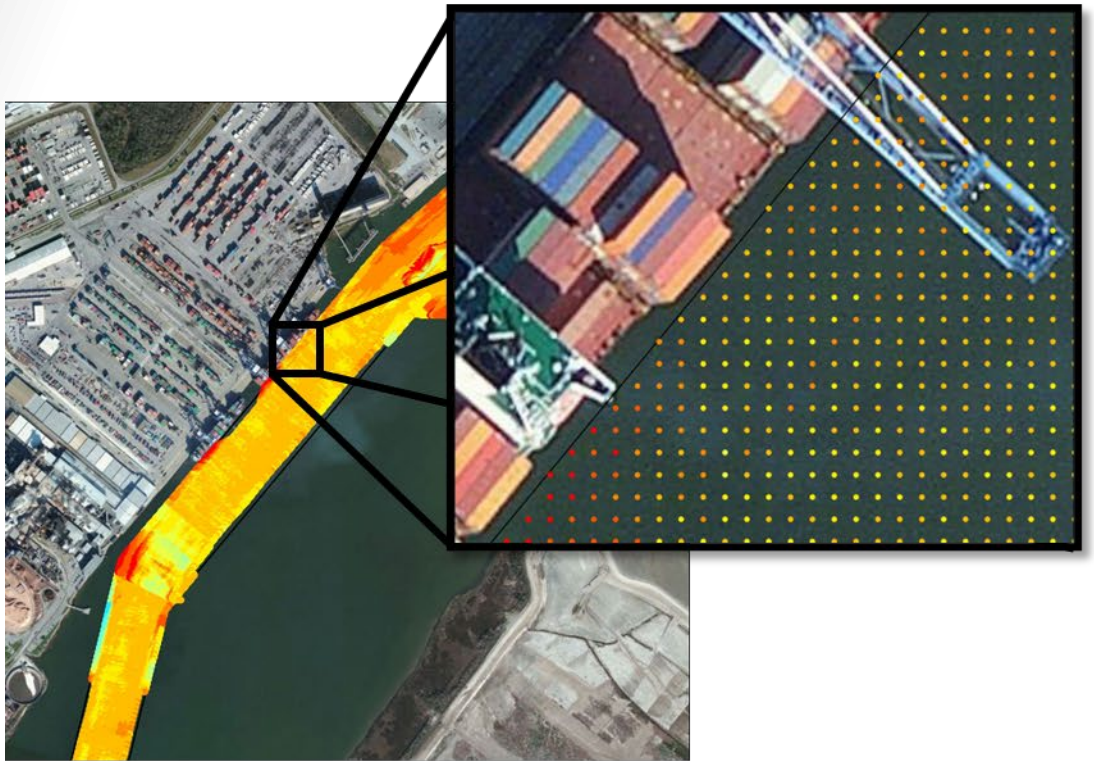
Corps Shoaling Analysis Tool (CSAT) overview

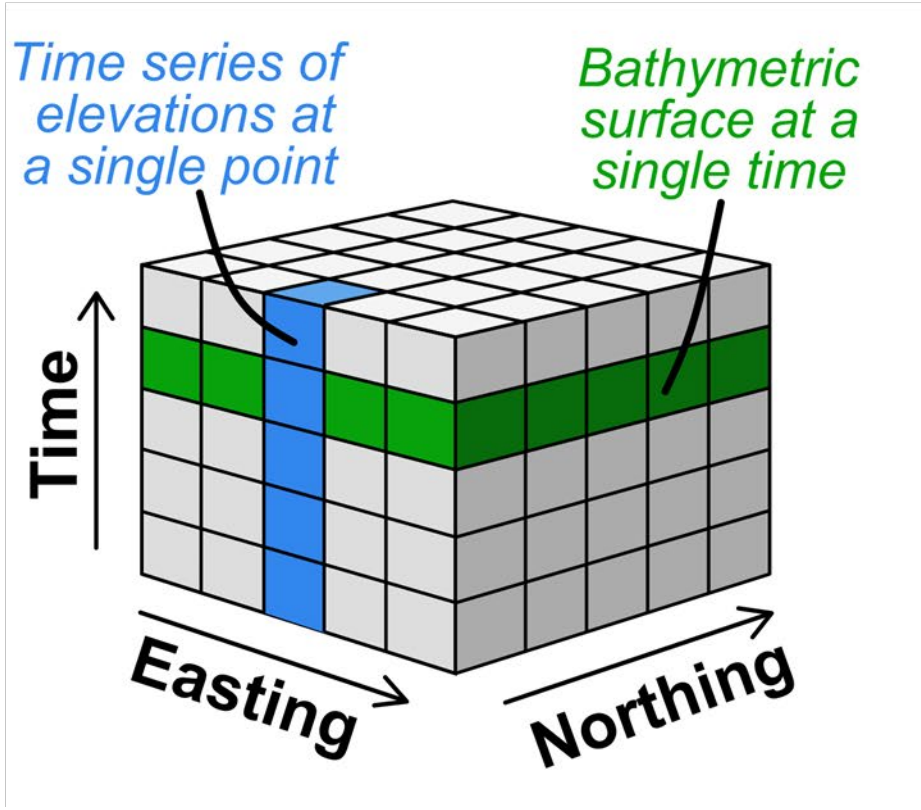
1) USACE Districts upload hydrographic survey data to the **eHydro database** in a standardized format.



Corps Shoaling Analysis Tool (CSAT) overview

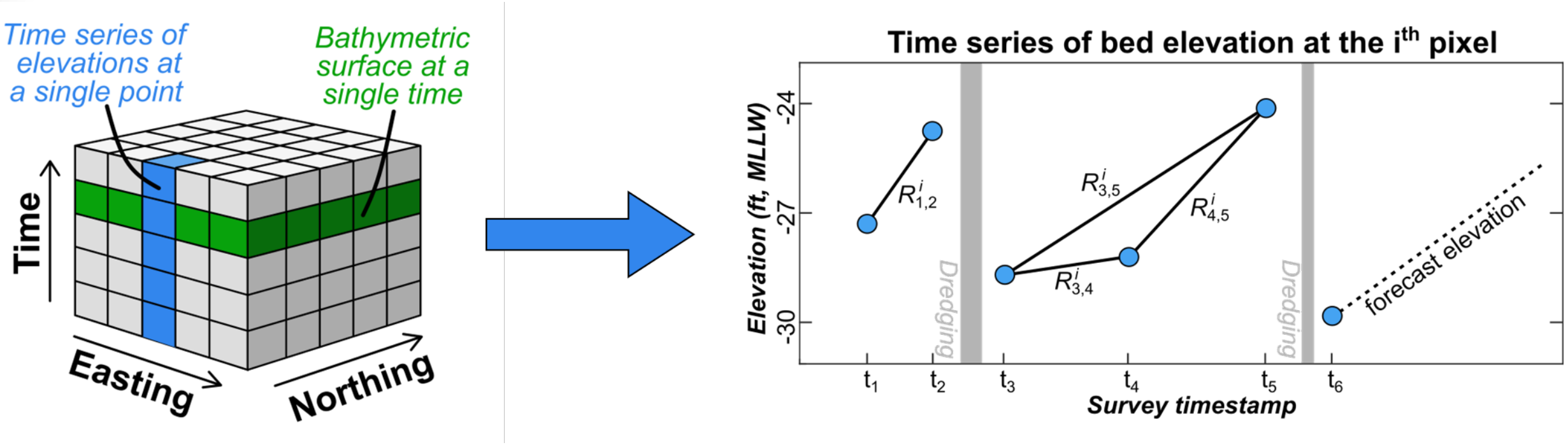
2) The bed elevations are gridded to create a space-time cube.





Corps Shoaling Analysis Tool (CSAT) overview

3) At **each pixel**, the time series of observed bed elevations is used to forecast future bed elevations.
4) Summing the pixelwise predictions generates a shoaling volume forecast for the entire reach.



CSAT – VERSION 2.6.4 – RASTER OUTPUT

Tool and Data Availability

The CSAT tool can be downloaded from the CIRP Website
- https://cirp.usace.army.mil/products/csat.php

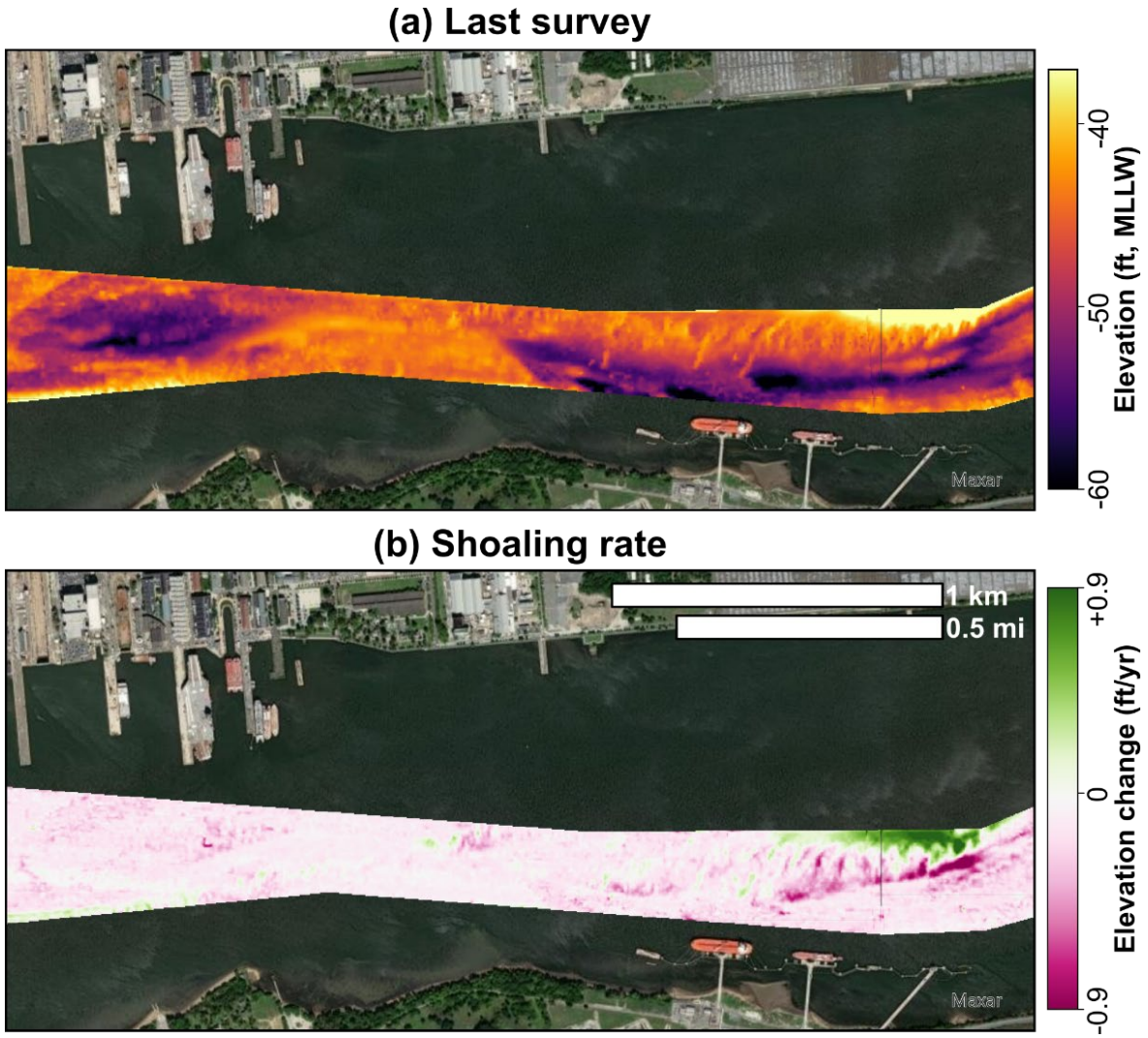
Input survey data is also available for each District
- https://cirp.usace.army.mil/products/csat_districts.php

Output Products

Rasters
- Most recently observed elevations
- Shoaling rates

Reach-level Tables
- Point by point results (_avg_max_min.csv)
- Forecasted dredging volumes (_volumes.csv)
- Survey volume comparisons (SurveyPairVolumeDifference.csv)

District-level Tables
- SPQ Tables
- Reach shoaling summaries



CSAT – VERSION 2.6.4 – REACH-LEVEL TABLES

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Point by Point Results

X	Y	WeightedAvgRate_ftPerYr	MaxRate_ftPerYr	MinRate_ftPerYr	LastZ_ft	Num_Svys	Num_Svy_Pairs
2665244.11	362323.46	-0.227	0.659	-1.169	-22.339	5	10
2665244.11	362313.46	-0.226	0.75	-1.55	-23.602	5	10
2665254.11	362313.46	-0.374	0.616	-1.087	-23.397	5	10
2665234.11	362303.46	-0.205	0.09	-0.451	-24.109	5	10
2665244.11	362303.46	-0.233	0.588	-1.189	-24.274	5	10
2665254.11	362303.46	-0.375	1.162	-2.152	-24.443	5	10
2665264.11	362303.46	-0.561	0.99	-1.913	-24.29	5	10
2665224.11	362293.46	-0.092	0.144	-0.39	-23.781	5	10
2665234.11	362293.46	-0.156	0.003	-0.392	-23.862	5	10

Forecasted Dredge Volumes

dredge_cut_ft	Now	6_months	12_months	18_months	24_months	30_months	36_months	42_months	48_months	54_months	60_months
-21	7,700	8,300	9,000	9,800	10,500	11,300	12,100	12,900	13,700	14,500	15,300
-20	4,700	5,200	5,800	6,400	7,000	7,600	8,300	9,000	9,700	10,400	11,200
-19	2,800	3,200	3,600	4,100	4,500	5,000	5,600	6,100	6,700	7,300	7,900
-18	1,500	1,800	2,100	2,400	2,700	3,100	3,500	4,000	4,400	4,900	5,500
-17	700	800	1,000	1,200	1,500	1,800	2,100	2,400	2,800	3,100	3,600
-16	200	300	300	500	600	800	1,000	1,300	1,500	1,800	2,200
-15	0	0	0	100	100	200	300	500	700	900	1,100

Survey Volume Comparisons

SurveyDateBefore	SurveyDateAfter	NetVolumeDiff_CY	AnnualShoalingRate_ftperyr	AnnualShoalingVolume_CYperyr
20151215	20190523	2,932	0.034	853
20151215	20200803	1,679	0.014	362
20151215	20210521	-6,251	-0.046	-1,150
20151215	20220429	5,409	0.034	848
20151215	20230728	1,494	0.008	196
20190523	20200803	859	0.023	716
20190523	20210521	-11,178	-0.177	-5,597
20190523	20220429	1,759	0.019	599
20190523	20230728	-4,873	-0.037	-1,165
20200803	20210521	-12,036	-0.476	-15,096

CSAT – VERSION 2.6.4 – DISTRICT-LEVEL TABLES

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District-level Tables

- SPQ Tables
- Reach shoaling summaries

SPQ Table

A	B	E	R	S	T	U	V	W	X	Y	Z	AA	AB
TimeToDredge	Sheet_Name	Depth	VA_p5	VA_p4	VA_p3	VA_p2	VA_p1	VA_p0	VA_s1	VA_s2	VA_s3	VA_s4	VA_s5
0	ALGOMA HARBOR	14	125,596	113,929	102,263	90,596	78,929	67,575	57,506	47,930	38,724	29,955	21,638
6	ALGOMA HARBOR	14	125,974	114,308	102,641	90,974	79,308	67,919	57,797	48,187	38,968	30,193	21,887
12	ALGOMA HARBOR	14	126,353	114,686	103,020	91,353	79,686	68,273	58,099	48,448	39,215	30,437	22,143
18	ALGOMA HARBOR	14	126,731	115,065	103,398	91,731	80,065	68,634	58,410	48,721	39,467	30,686	22,408
24	ALGOMA HARBOR	14	127,110	115,443	103,777	92,110	80,443	69,001	58,727	49,000	39,727	30,939	22,675
30	ALGOMA HARBOR	14	127,488	115,822	104,155	92,488	80,822	69,373	59,049	49,287	39,993	31,198	22,947
36	ALGOMA HARBOR	14	127,867	116,200	104,534	92,867	81,200	69,749	59,376	49,579	40,267	31,466	23,226
42	ALGOMA HARBOR	14	128,245	116,579	104,912	93,245	81,581	70,129	59,705	49,879	40,548	31,742	23,517
48	ALGOMA HARBOR	14	128,624	116,957	105,290	93,624	81,962	70,512	60,038	50,184	40,839	32,026	23,815
54	ALGOMA HARBOR	14	129,002	117,336	105,669	94,002	82,344	70,897	60,375	50,496	41,138	32,317	24,119
60	ALGOMA HARBOR	14	129,381	117,714	106,047	94,381	82,728	71,284	60,717	50,814	41,444	32,616	24,428
0	BIG SUAMICO RIVER	8	71,347	61,232	51,117	41,002	30,887	21,563	15,858	10,742	6,185	2,800	861
6	BIG SUAMICO RIVER	8	72,023	61,908	51,793	41,678	31,563	22,150	16,370	11,222	6,603	3,051	979
12	BIG SUAMICO RIVER	8	72,699	62,584	52,469	42,354	32,239	22,744	16,888	11,706	7,029	3,318	1,109
18	BIG SUAMICO RIVER	8	73,375	63,260	53,145	43,030	32,915	23,346	17,413	12,192	7,463	3,611	1,253
24	BIG SUAMICO RIVER	8	74,050	63,936	53,821	43,706	33,591	23,956	17,943	12,681	7,902	3,937	1,414
30	BIG SUAMICO RIVER	8								13,173	8,348	4,291	1,591

Reach Summary Table

Reach_ID	AverageRate_FtPerYr	MaxAverageRate_FtPerYr	MinAverageRate_FtPerYr
CELRC_LC_06_INH_6	3.331	15.115	-1.39
CELRC_LC_08_MCH_4	1.385	14.159	-0.125
CELRC_LC_03_SBH_3	1.165	22.879	-3.618
CELRC_LC_06_INH_7	1.079	7.745	-3.743
CELRC_LC_11_CHR_1	0.94	4.088	-2.02
CELRC_LC_08_MCH_3	0.743	2.874	-2.943
CELRC_SH_01_BGN_4	0.722	4.129	-0.241
CELRC_SH_01_BGN_1	0.687	8.349	-0.413
CELRC_SH_01_BGN_2	0.686	5.864	-0.326
CELRC_SH_01_BGN_3	0.668	26.407	-0.868
CELRC_SH_01_BGN_5	0.602	6.633	-0.358
CELRC_LC_06_INH_4	0.489	5.146	-4.854
CELRC_LC_08_MCH_1	0.488	1.67	-1.07
CELRC_LC_11_CHR_2	0.444	2.956	-1.155
CELRC_LC_03_SBH_2	0.403	4.831	-1.002
CELRC_PN_01_SKE_1	0.395	2	-0.387

CSAT – VERSION 2.6.4

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Feature Wishlist

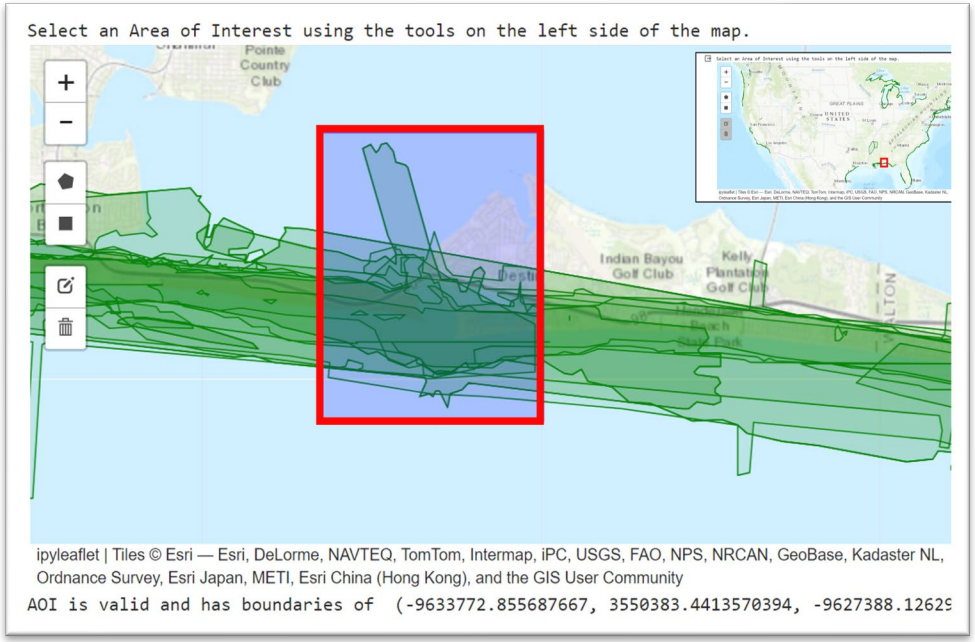
1. Use additional datasets not in eHydro
   - JALBTCX Lidar data
2. Custom study areas
   - Not all projects align with the NCF
   - Some AOIs extend outside a reach, cover portions of many reaches, or subset a single reach
3. Better dredge event identification
   - What about Dredge Quality Management (DQM) program data?
4. Graphical User Interface (GUI)
   - Something more modern than a batch script
   - Setting runtime options
   - Viewing input/output data

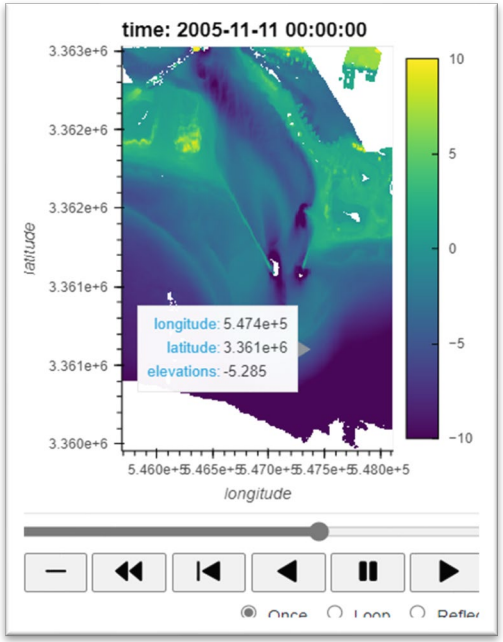
MAKING CSAT BIGGER…

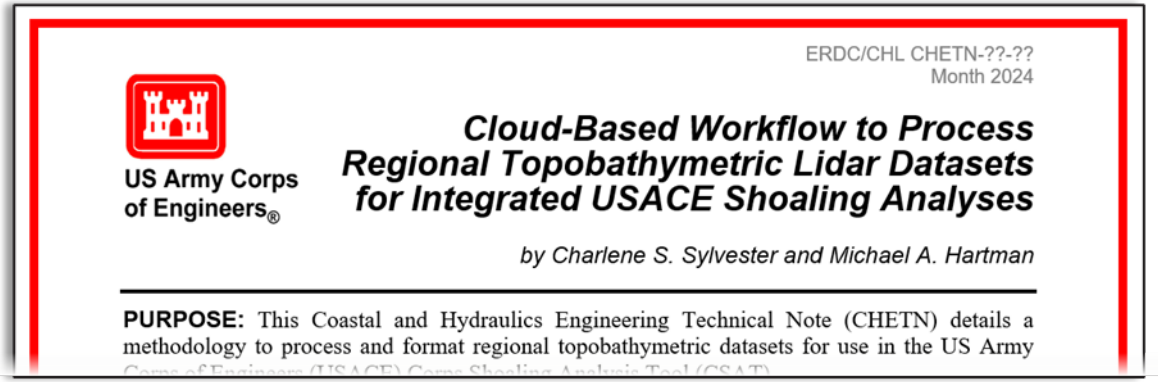
- Districts have requested the capability to perform CSAT-style shoaling rate calculations in regions outside the boundaries of the National Channel Framework.

- CSAT and JALBTCX collaboratively produced an automated workflow which quantifies shoaling inside a user-defined polygon using all available lidar and eHydro surveys.
  - *JALBTCX datasets hosted in AWS by NOAA Digital Coast.*
  - *AOI-based search and discovery.*
  - *On-the-fly DEM generation.*

- **Workflow released as a Jupyter Notebook in the ERDC public Gitlab, with corresponding documentation published.**



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Month 2024

US Army Corps of Engineers®

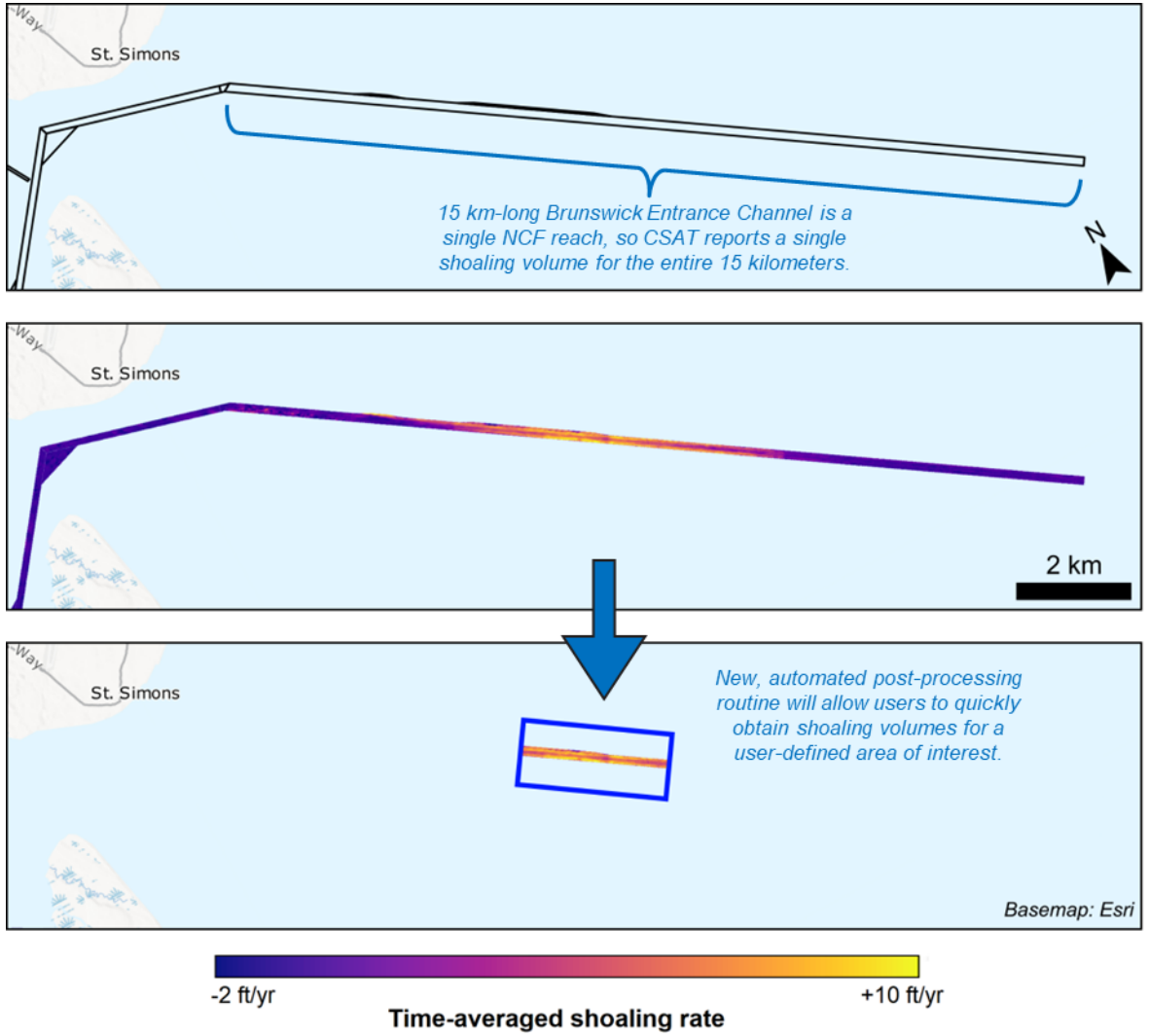
Cloud-Based Workflow to Process Regional Topobathymetric Lidar Datasets for Integrated USACE Shoaling Analyses

by Charlene S. Sylvester and Michael A. Hartman

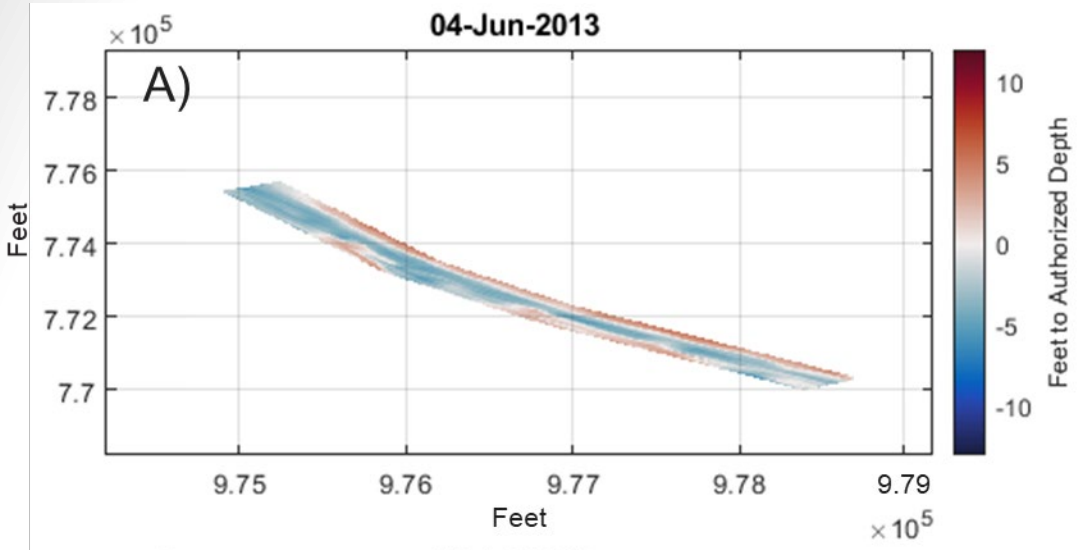
PURPOSE: This Coastal and Hydraulics Engineering Technical Note (CHETN) details a methodology to process and format regional topobathymetric datasets for use in the US Army

… AND MAKING CSAT SMALLER!

- In previous versions of CSAT, results were reported as an aggregated shoaling volume for each reach in the National Channel Framework.
- Within the past year, Chicago District and Galveston District both requested the capability to produce CSAT output with greater geographic specificity (*e.g.*, sub-reach results for a smaller area of interest).
- **A post-processing routine was developed which automatically converts reach-level CSAT output into shoaling volumes inside a polygon drawn by the user.**
- Will be integrated into public-facing CSAT routine in FY25!

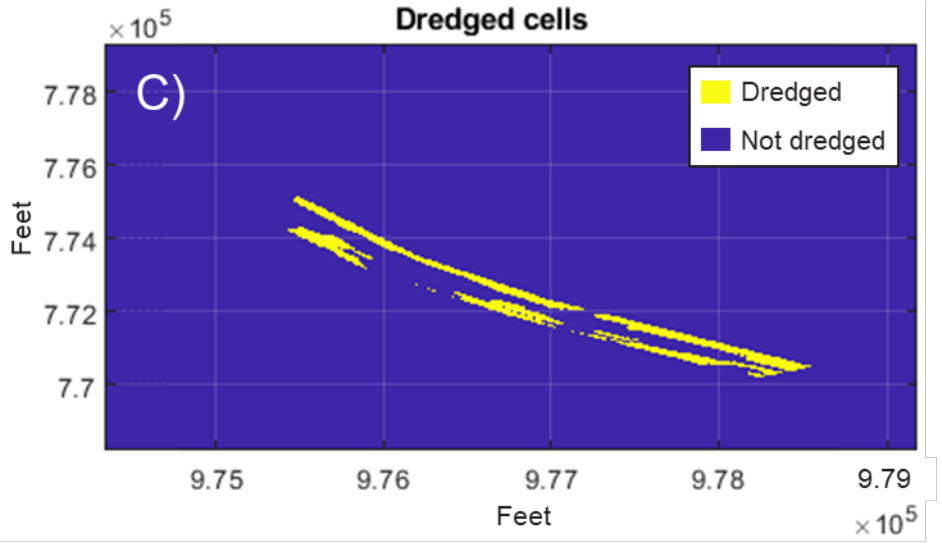


IMPROVING DREDGING EVENT IDENTIFICATION



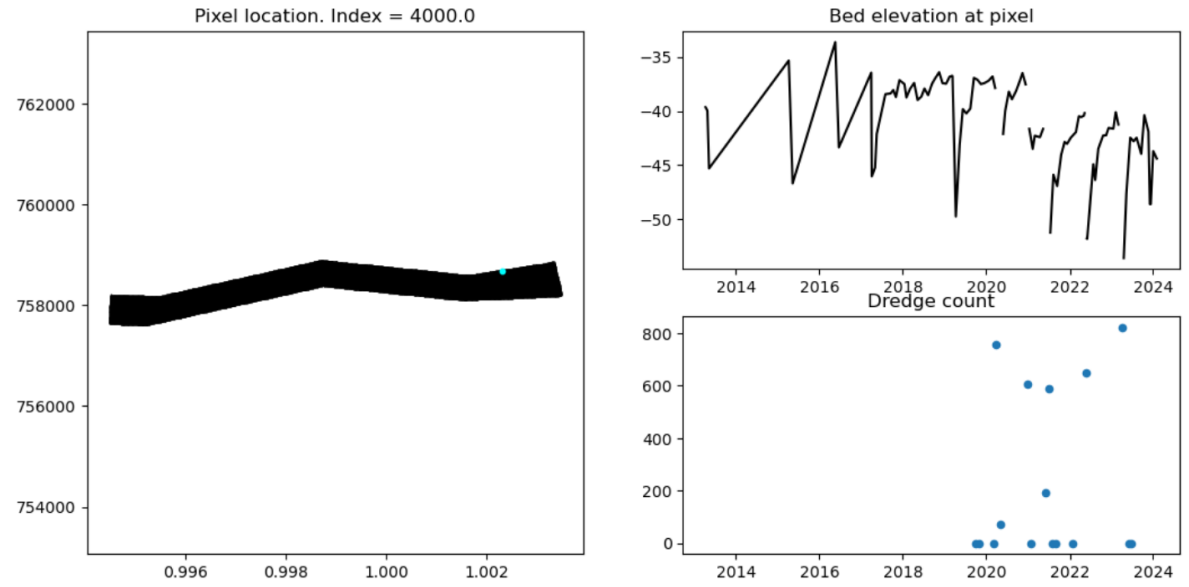
- Dredge events currently identified from SurveyID labeling and reach-level volume change.
  - *Problematic because typically only part of the reach is dredged, so the volume change threshold may vary by reach.*

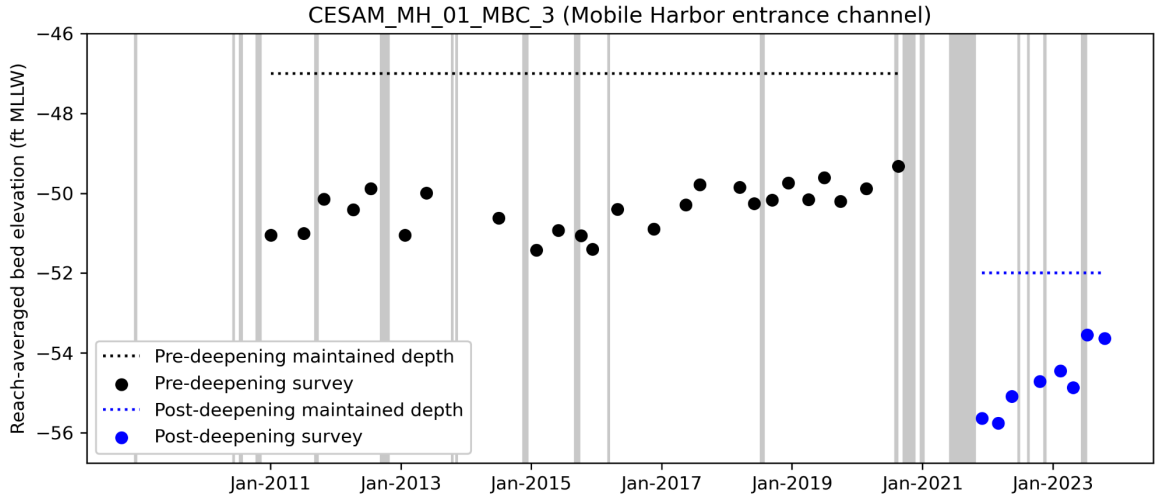
- **New pixel-level thresholding methods are being developed to improve identification of dredge events.**
  - *Example: if >10% of the reach's grid cells experienced >15% elevation decrease between two consecutive surveys, the second survey is flagged as an "after dredge" survey.*



Bathymetry (feet to authorized depth) for Savannah Harbor Reach 15 before (A) and after (B) a dredge event. C) Grid cells that were dredged are marked in yellow.

IMPROVING DREDGING EVENT IDENTIFICATION, CONT.





- Dredge Quality Management (DQM) program data is a treasure trove of the dredging activity information CSAT could benefit from.
- A recently established DQM API has enabled the CSAT team to retrieve aggregated dredging activity.
- What is the optimal way to use the DQM data?
  - Option 1: Check for DQM activity in the reach footprint and modify the SurveyUpdate file by setting surveys to AD - enforcing at the reach level.
  - Option 2: Use the dredge activity to enforce AD labels only in the vicinity of the DQM data points

Option 1 is easier to enforce but overrepresents dredging activity on larger reaches. Make this an opt-in feature?

Option 2 involves larger changes behind the scenes and might make explaining shoaling results more difficult.

We are open to suggestions and feedback from users.

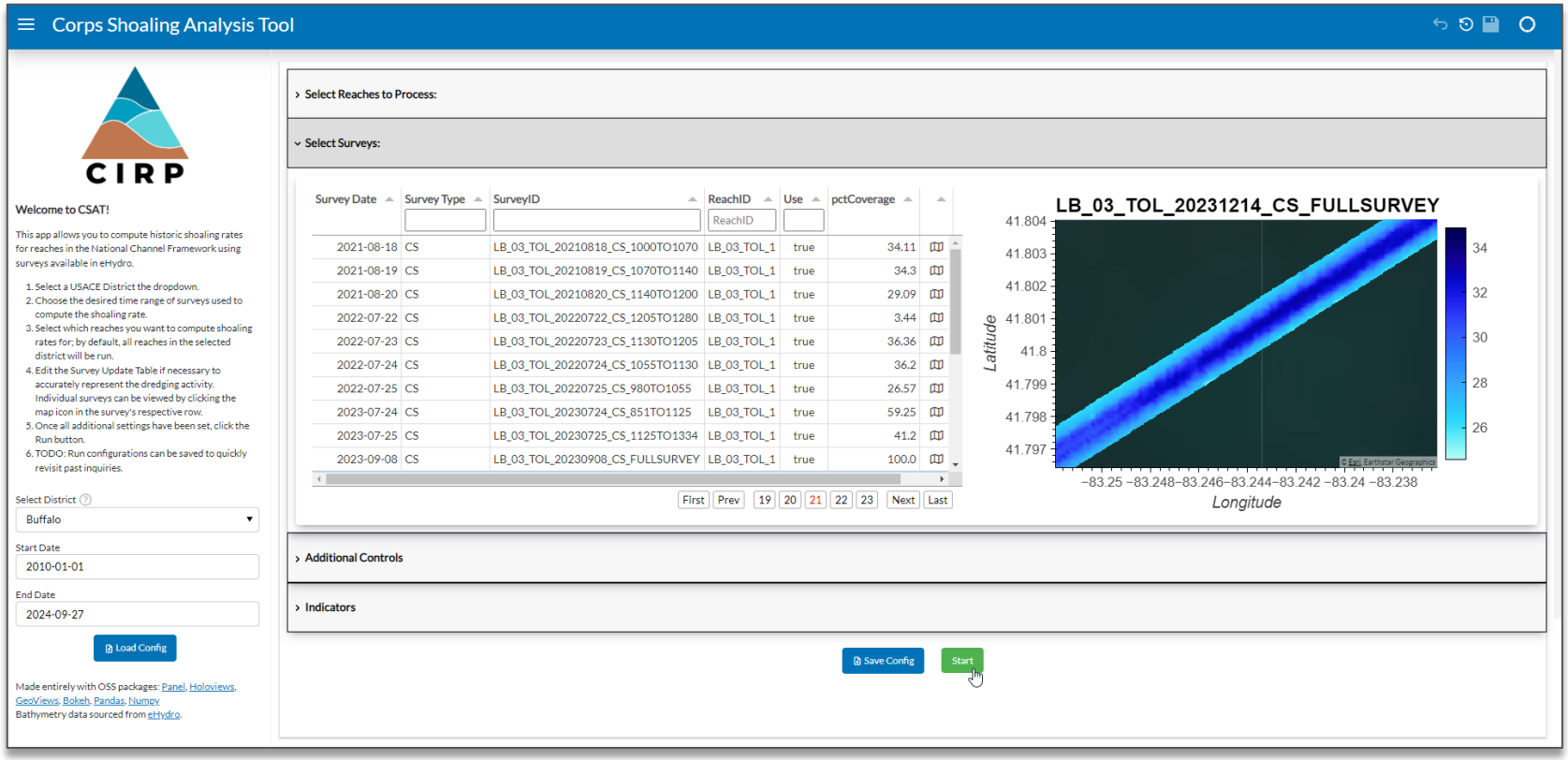
ENHANCING THE CSAT USER EXPERIENCE

A brand-new user interface!

- GUI runs in local web browser
- Offers same control as batch script
- Choose a reach study area, select surveys which survey data to use, and set runtime options all in one place.

Key Improvements

- Dropdown menus for options
- Interactive tables for reach/survey selection
- Map-based reach selection
- Survey data visualization
- Save/Load configuration for reuse



Currently, the GUI handles setting CSAT runtime configurations, reviewing input survey data, and running CSAT. Additional features are being added in FY25 to help explore the CSAT results.

Please let us know if you are interested in testing out the new GUI.
Send an email to CSAT Support - dll-ceerd-csat@usace.army.mil

SUMMARY

Capability Roadmap

Available Now: CSAT User Guide

Next update (this week)**:** Installation method changes due to software licensing requirements. ArcGIS Pro is being suggested as a temporary workaround until a long-term solution is approved by ACEIT. Slight changes to the CSAT **Setup** and **Run** batch scripts.

Mid FY25:

- Beta release of CSAT GUI, including modularization of CSAT code.
- Post-processing algorithm for quantifying shoaling volumes within a user-specified area of interest (*e.g.*, sub-reach CSAT results).

Late FY25:

- Algorithm for identifying dredging events via pixel-level elevation thresholding (DIG-funded).
- Validation routine to quantify CSAT's forecasting accuracy.